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RADIO BROADCAST

VOLUME XI

MAY, 1927, to OCTOBER, 1927

GARDEN CITY NEW YORK
DOUBLEDAY, PAGE & COMPANY
1927

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INDEX

(*Illustrated Articles. Editorials in Italics)

PAGE

*A B, C Device, A lamp Socket (Gilbert Edgar) 153
*A, B, C Power-Supply Unit for 201-A Type Tubes, An (Roland F. Beers) 155
*A Battery? What About the (Edgar H. Felix) 26
Advertising Over the Air from Corsets to Calliopes, Direct 81
*A. C. Filament Supply, Problems of (Roland F. Beers) 101
*A. C. Mains, Filament Lighting from the (Roland F. Beers) 33
*A. C. Operation, Receiver Design for (Howard E. Rhodes) 157
*A. C. Set, Your (Edgar H. Felix) 374
"A. C. Supply" Units, A New Term for 19
*A. C. Vacuum Tubes, Three-Element (B. F. Miessner) 302
*Amplification, Use of Tubes Having High (A. V. Loughren) 238
*Analyzing the Power Amplifier (D. E. Harnett) 111
*Antenna, How to Design a Loop (Homer S. Davis) 104
*As the Broadcaster Sees It (Carl Dreher) 36, 106, 167, 235, 293, 376
*Aurora and Fading, The (Austin G. Cooley) 135
Australia, Radio Control Unsettled in 141

*B SOCKET power Device, Perfecting the (Howard E. Rhodes) 43
*Balanced Short-Wave Receiver, A (Frank C. Jones) 24
*Balsa Wood Loud Speaker, The (The Laboratory Staff) 211
*Battery Charger, A Low-Cost (James Millen) 143
Book Reviews:
Practical Radio Construction and Repairing, by Moyer and Wostrel (Edgar H. Felix) 416
Radio Encyclopedia, The, by S. Gernsback (Edgar H. Felix) 110
Theory of Vibrating Systems and Sound, by Irving B. Crandall (Carl Dreher) 110
Using Radio in Sales Promotion, by Edgar H. Felix (Carl Dreher) 369
Broadcasters in New York Organize 268
Broadcasting Situation, Stabilizing the 79
*Building an Electrical Phonograph (James Millen) 86
*Building the Laboratory "Super" (Ernest R. Pfaff) 280

CANADIAN Demand for More Wavelengths? What About the 80
"Canned" Programs Good and Bad 206
*Causes of Poor Tone Quality (Edgar H. Felix) 296
*Charger, A Low-Cost Battery (James Millen) 143
"Christian" Mud Throwing 18
*Coil Design, Some Facts About (Ross Gunn) 40
Combined Push-Pull Power Amplifier and Socket B Device, A (The Laboratory Staff) 163
Commission Regulates Broadcasting for the Broadcasters Not the Listener, The 204
*Condenser, Coil, Antenna Measurements (Keith Henney) 227
Conditions for Long-Distance Receiving Do Vary 81
*Cone, How to Build a 36-Inch (Warren T. Mithoff) 148
*Constructing a Five-Tube Neutrodyne (Howard E. Rhodes) 232
*Constructing Transformers and Chokes for Power Supply Devices, Home (Homer S. Davis) 274, 379
*Crystals, Piezo-Electric (M. Thornton Dow) 271

DANGER of Direct Advertising on the Air, The 346
Davis Resigns, Judge 269
*Description of a Short-Wave Station (C. R. Runyon, Jr.) 171
Direct Advertising Over the Air from Corsets to Calliopes 81
Directory of Manufactured Receivers, "Radio Broadcast's" 316, 402
Discovering Ore Deposits by Radio 267
*Discovery That Newton Missed, A (James Stokley) 263
DX Listening, What Commissioner Bellows Thinks About 205

*ELECTRICAL Phonograph, Building an (James Millen) 86
*Electrical Phonograph, The (James Millen) 20
*"Equamatic" Receiver, The 1928 (Julian Kay) 364
*Equipment for the Home Constructor (The Laboratory Staff) 58, 120, 182

*FILAMENT Lighting from the A. C. Main (Roland F. Beers) 33
*Filament Supply, Problems of A. C. (Roland F. Beers) 101
*Five-Tube Neutrodyne, Constructing a (Howard E. Rhodes) 232
*Five-Tube Receiver, A Super-Sensitive Shielded (Herbert J. Reich) 229
*Flexible Short-Wave Transmitter, A (Howard E. Rhodes) 213
Freedom of Speech Impossible, Radio 138
Frequent Misuse of the Word "Broadcasting," The 141

*HAVE You a Roberts Reflex? (John B. Brennan) 208
*"Hi-Q" Has an Extra R. F. Stage, The (John B. Brennan) 348
*Home Constructing Transformers and Chokes for Power Supply Devices (Homer S. Davis) 274, 379
*Home Constructor, Equipment for the (The Laboratory Staff) 58, 120, 182
*Home Laboratory, An Instrument for the (Keith Henney) 92
*How to Build a 36-Inch Cone (Warren T. Mithoff) 148
*How to Design a Loop Antenna (Homer S. Davis) 104

*INSTRUMENT for the Home Laboratory, An (Keith Henney) 92
*Interference, Suppressing Radio (A. T. Lawton) 299
International Short-Wave Test 60

JUDGE DAVIS Resigns 269
*Judging Tone Quality (Edgar H. Felix) 224

KEY to Recent Radio Articles, A (E. G. Shalkhauser) 60, 126, 255, 326, 398
Kit Shall I Buy? What 125, 190, 254, 324, 396

*LABORATORY Information Sheets, "Radio Broadcast's:"
A Battery Chargers 246
Analysis of Voice Frequencies 56
Audio Amplifiers 246
Audio Amplifying Systems 54, 116
Audio Transformers 119
B Power Units 312
Care of Power Supply Units 390
Carrier Telephony 392
Characteristics of the 171 Type Tube 310
Circuit Diagram of the "Universal" Receiver 118
Closely Coupled Circuits 392
Condenser Reactance 312
Condenser Reactance Table 312
Curves of the 171 Type Tube 310
Data on Honeycomb Coils 388
Data on the "Universal" Receiver 118
Dry-Cell Tubes 180
Efficiency of Amplifying Systems 119
Hertz Antenna, The 308
High Voltage Supply for 210 Type Tube 178
Index 180
Lightning Arresters 118
Loop Antennas 52
Loud Speaker Horns 392
Measuring R. F. Resistance of a Coil 176
Methods of Generating High-Frequency Energy 116
Morse Code, The 310
Neutralization 178
Output Circuits 242
Principles of Reflexing, The 56
Radio-Frequency Choke Coils 246
Resistance-Coupled Amplifier 390
Resistance-Coupled Amplifier Circuit 390
Short-Wave Coils 52
Simple Tube Tester, A 54
Socket Power Units 119
Static 244
Storage Batteries 56
Super-Heterodynes 244
Testing Radio Receivers 308

583650
Periodical
MA 26 '28

PAGE
Threshold of Hearing and Feeling in the Ear, The........ 178
Transmission Unit, The...... 242
Type 874 Glow Tube, The.... 388
Ux-240 Type Tube, The...... 176
Wave Traps................ 244
*Laboratory, "Strays" from the 146, 222, 284
*Laboratory "Super," Building the (Ernest R. Pfaff)................ 280
*Lamp Socket A, B, C Device, A (Gilbert Edgar).................... 153
Latest Television Developments......... 81
Law, A Profound Study of Radio....... 345
*Light Socket, Servants of Your....... 356
Listeners' Organizations? Where are the 141, 269
*Listeners' Point of View, The (John Wallace)........29, 97, 159, 218, 286, 372
Listeners, Why We Need More......... 206
Listening to World-Wide Broadcasting is Near.......................... 345
Long-Distance Receiving Do Vary, Conditions for...................... 81
*Long-Wave Receiver, A Portable (Keith Henney)................. 165
*Loop Antenna, How to Design a (Homer S. Davis)................ 104
*Loud Speaker, The Balsa Wood (The Laboratory Staff)................ 211
*Loud Speakers, 1928............... 370
*Low-Cost Battery Charger, A (James Millen)........................ 143

MAKING Radio Installations Safe (Edgar H. Felix).............. 410
Manufacturers' Booklets Available 61, 123, 186, 248, 314, 394
*Manufactured Receivers for the Coming Season....................... 351
Manufactured Receivers, "Radio Broadcast's" Directory of...250, 316, 402
*March of Radio, The 15, 78, 138, 203, 266, 344
*Measurements, Condenser, Coil, Antenna (Keith Henney)............ 227
*Methods of Measuring Tube Characteristics (Keith Henney)........... 46
Methods Which Fail to Materialize, Revolutionary...................... 203
Modern Radio Receivers Are a Good Investment.......................... 344
Month in Radio, The 19, 82, 142, 206, 269, 346
Mud Throwing, "Christian".......... 18

*NEUTRODYNE, Constructing a Five-Tube (Howard E. Rhodes).. 232
*Neutrodyne Group, The............. 354
Never Again Without Radio!.......... 206
*New Offerings for the 1928 Season, Some........................... 360
*New Principle of R. F. Tuning, A (David Grimes).................. 367
*New Receiver Offerings for the Fall (The Laboratory Staff)............. 298
*New Regulator Tube, A (James Millen) 363
New Term for "A. C. Supply" Units, A 19
*1928 "Equamatic" Receiver, The (Julian Kay)..................... 364
*1928 "Hi-Q" Has an Extra R. F. Stage, The (John B. Brennan)............ 348
*1928 Loud Speakers................ 370
*1928 Radio Receivers of Beauty and Utility.......................... 352
*Now—You Can Receive Radio Pictures (Keith Henney)............. 341

OBJECTIONS to the Radio Law.... 17

PATENT Licensing Points to a Bright Radio Future.................. 79
Patent Tangle, Unsnarling the......... 206
*Perfecting the B Socket Power Device (Howard E. Rhodes)............... 43
*Phonograph, Building an Electrical (James Millen).................. 86
*Phonograph, The Electrical (James Millen)......................... 20
*Pictures by Radio................. 279
*Pictures, Now—You Can Receive Radio (Keith Henney)............. 341
*Piezo-Electric Crystals (M. Thornton Dow)........................... 271
Please for a Blue Radio Sunday........ 80
*Poor Tone Quality, Causes of (Edgar H. Felix)........................ 296
*Portable Long-Wave Receiver, A (Keith Henney).................. 165
*Problems of A. C. Filament Supply (Roland F. Beers)................ 101
Profound Study of Radio Law, A...... 345
Programs, Good and Bad "Canned".... 206
Prosperous Radio Year Forecast, A..... 267
*Push-Pull Power Amplifier and Socket B Device, A Combined (The Laboratory Staff)...................... 163

*QUALITY, Causes of Poor Tone (Edgar H. Felix).............. 296
Question of Vested Rights, The.... 17

RADIO Broadcast's" Directory of Manufactured Receivers...250, 316, 402
*"Radio Broadcast's" Laboratory Information Sheets (See Laboratory) 52, 116, 176, 242, 308, 388
Radio Commission Is Accomplishing, What the........................ 138
Radio Control Unsettled in Australia.... 141
Radio Engineers, There Are No........ 19
Radio Freedom of Speech Impossible.... 138
*R. F. Tuning, A New Principle of (David Grimes).................. 367
*Radio Interference, Suppressing (A. T. Lawton)........................ 299
Radio Installations Safe, Making (Edgar H. Felix)................. 410
Radio Law, Objections to the.......... 17
Radio Needs No Yearly Models........ 266
*Radio Pictures, Now—You Can Receive (Keith Henney)............. 341
Radio Receivers Are a Good Investment, Modern......................... 344
*Radio Receivers of Beauty and Utility, 1928............................ 352
Radio Reception Is No Longer Seasonal.. 141
*Radio Waves in Transit? What Do We Know About (R. W. King)......... 75
*Radiolas for 1928................. 358
Recent Radio Articles, A Key to (E. G. Shalkhauser)........60, 126, 255, 326, 398
*Receiver Design for A. C. Operation (Howard E. Rhodes).............. 157
Receiver Offerings for the Fall, New (The Laboratory Staff)............ 298
*Receivers for the Coming Season, Manufactured.......................... 351
*Regulator Tube, A New (James Millen) 363
Revolutionary Methods Which Fail to Materialize........................ 203
*Roberts Reflex? Have You a (John B. Brennan)......................... 208

*SALESMEN, We Need Better Radio (Carl Dreher).................. 283
*Servants of Your Light Socket....... 356
*Shielding? Why (Edgar H. Felix)..... 83
*Short-Wave Receiver, A Balanced (Frank C. Jones).................. 24
*Short-Wave Station, Description of a (C. R. Runyon, Jr.)............... 171
Short-Wave Test, International....... 60
*Short-Wave Transmitter, A Flexible (Howard E. Rhodes).............. 213
*Short Waves? Why Not Try the (Keith Henney).......................... 290
*Should the Small Station Exist? (John Wallace)........................ 372
*Single Control, Something About (Edgar H. Felix)................. 151
*Socket Power Device, Perfecting the B (Howard E. Rhodes)............. 43
*Some Facts About Coil Design (Ross Gunn)............................ 40
*Some New Offerings for the 1928 Season............................. 360
Stabilizing the Broadcasting Situation... 79
Standards, Unnecessary Duplication of Radio.......................... 140
Stations Shall Be Eliminated? What.... 139
*"Strays" from the Laboratory.146, 222, 284
*"Super," Building the Laboratory (Ernest R. Pfaff)................. 280
*Super-Sensitive Shielded Five-Tube Receiver, A (Herbert J. Reich)...... 229
*Suppressing Radio Interference (A. T. Lawton)......................... 299
Survey of Radio Conditions, A......... 19

TELEVISION Developments, Latest. 81
There Are No Radio Engineers.... 19
*Three-Element A. C. Vacuum Tubes (B. F. Miessner)................. 302
*Tone Quality, Causes of Poor (Edgar H. Felix)........................ 296
*Tone Quality, Judging (Edgar H. Felix) 224
*Transformers and Chokes for Power Supply Devices, Home Constructing (Homer S. Davis)..............274, 379
*Tube Characteristics, Methods of Measuring (Keith Henney)......... 46
*Tubes Having High Amplification, Use of (A. V. Loughren)............... 238
*Tuning, A New Principle of R. F. (David Grimes).................. 367

UNNECESSARY Duplications of Radio Standards............... 140
Unsnarling the Patent Tangle.......... 206
*Use of Tubes Having High Amplification (A. V. Loughren)............. 238

*VACUUM Tubes, Three-Element A. C. (B. F. Miessner).............. 302
Vested Rights, The Question of......... 17

*WE NEED Better Radio Salesmen (Carl Dreher) 283
*What About the A Battery? (Edgar H. Felix)........................... 26
What About the Canadian Demand for More Wavelengths?................. 80
What Commissioner Bellows Thinks About DX Listening.............. 205
*What Do We Know About Radio Waves in Transit? (R. W. King).... 75
What Does the Listener Want? Let Him Speak........................... 15
What Kit Shall I Buy? 125, 190, 254, 324, 396
What Stations Shall Be Eliminated?.... 139
What the Radio Commission Is Accomplishing......................... 138
Where Are the Listeners' Organizations? 141
Where Are the Listeners' Organizations?. 269
Why Important Events Can't Always Be Broadcast......................... 141
*Why Not Try the Short Waves? (Keith Henney)......................... 290
Why Radio Home Construction Continues to be Fascinating............ 78
*Why Shielding? (Edgar H. Felix)..... 83
Why We Need More Listeners......... 206
Which Stations Shall Broadcast?....... 16
Will Telephotography Be the Experimenters' Next Field?............. 266
Wisely Chosen Radio Commissioners, The 80
*With Macmillan to the Arctic (Austin G. Cooley)........................ 11
World-Wide Broadcasting is Near, Listening to........ 345

AUTHORS

Beers, Roland F...................33, 155
Brennan, John B.................208, 348

Cooley, Austin G...................11, 135

Davis, Homer S...............104, 274, 379
Dow, M. Thornton.................. 271
Dreher, Carl
36, 106, 167, 232, 283, 293, 369, 376

Edgar, Gilbert....................... 153

Felix, Edgar H.
26, 83, 151, 224, 296, 374, 410, 414

PAGE
Grimes, David........................ 367
Gunn, Ross........................... 40

Harnett, D. E........................ 111
Henney, Keith.....46, 92, 165, 227, 290, 341

Jones, Frank C....................... 24

Kay, Julian.......................... 364
King, R. W........................... 75

Lawton, A. T......................... 299
Loughren, A. V....................... 238

Miessner, B. F....................... 302
Millen, James..........20, 86, 143, 199, 363
Mithoff, Warren T.................... 148

Pfaff, Ernest R...................... 280

Reich, Herbert J..................... 229
Rhodes, Howard E.........43, 157, 213, 232
Runyon, C. R. Jr..................... 171

Shalkhauser, E. G......60, 126, 255, 326, 398
Stokley, James....................... 263

Wallace, John.....29, 97, 159, 218, 286, 372

PORTRAITS

(*Portraits in "The March of Radio")

PAGE
Ahkla, Trixie........................ 373
Atkinson, Eva Gruninger.............. 30

*Baker, L. S......................... 142
Blackford, Frank..................... 30
Blight, Arthur....................... 30
Bushman, Annette R................... 287

Coates, D. R. P...................... 289
*Cohen, Louis........................ 269
Combs, R. H.......................... 30
Cook, Lucile......................... 288
Cook, Nell........................... 288
*Crandall, Irving Bardshar........... 141
Crosley, Powel....................... 288

Damonte, Jerome...................... 160
Dobbs, Hugh Barrett.................. 218
Dozier, Lydia........................ 288

*Edwards, C. P....................... 142
Edwards, C. P........................ 346

Grimes, David........................ 367

Harper, Clair........................ 289
*Hartley, Herbert.................... 268
Heerman, Emil........................ 288

Hogan, Park V........................ 221
Holub, Josephine..................... 30

Katzman, Louis....................... 99
King, Mildred........................ 160

La Pee, Honarine..................... 30
*Lindbergh, Charles.................. 344

McKee, Mickey........................ 219
McLeod, Keith........................ 30
Mallory, Walter...................... 221
*Manley, Edward...................... 347
*Manson, Ray H....................... 82

Olson, Vivian........................ 289

Pearson, James....................... 30
Pellettieri, Vito.................... 160

Rianhard, Conrad..................... 29
*Rice, Martin P...................... 344

Shannon, Marguerite.................. 289
*Shinn, B. L......................... 18
*Shumaker, Edward E.................. 19
Stockman, Edward..................... 160

*Waller, Alfred E.................... 207
Watt, Lillian........................ 160
Weagant, Roy A....................... 237
Wessell, Isaac....................... 286
White, Lee........................... 289

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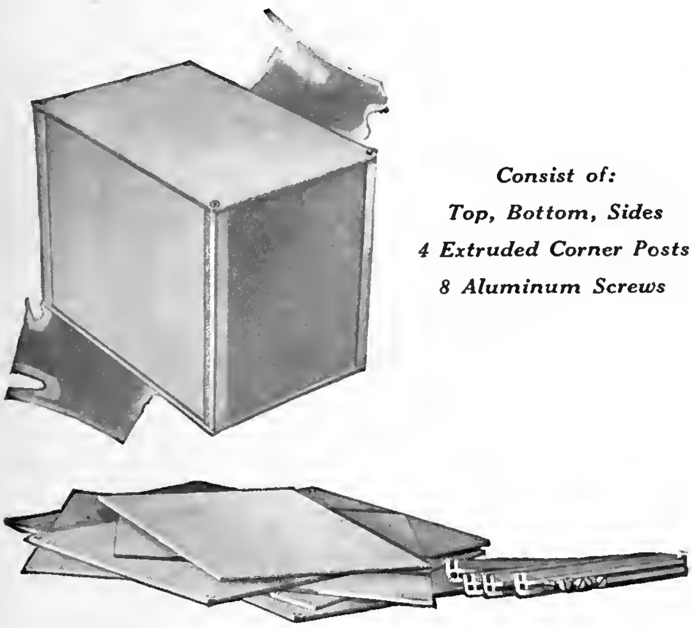

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RADIO BROADCAST

WILLIS K. WING, Editor

MAY, 1927

KEITH HENNEY, Director of the Laboratory — JOHN B. BRENNAN, Technical Editor

EDGAR H. FELIX, Contributing Editor

Vol. XI, No. 1

CONTENTS

Cover Design - - - - - - - From a Painting by Fred J. Edgars

Frontispiece *The Towers of Station WOW, at Omaha, Nebraska* 10

With MacMillan to the Arctic - - - - *Austin G. Cooley* 11

The March of Radio - - - - - *An Editorial Interpretation* 15

What Does the Listener Want? Let Him Speak
Questionnaire: Which Stations Shall Broadcast?
Objections to the Radio Law
The Question of Vested Rights
"Christian" Mud Throwing
A New Term for "A. C. Supply" Units
There Are no Radio Engineers
A Survey of Radio Conditions
The Month in Radio

The Electrical Phonograph - - - - - - - - - *James Millen* 20

A Balanced Short-Wave Receiver - - - - - *Frank C. Jones* 24

What About the A Battery? - - - - - - *Edgar H. Felix* 26

The Listeners' Point of View - - - - - - - - *John Wallace* 29

How Long Will Radio Broadcasting Prosper?
Why a Good Program Was Good
Thumb Nail Reviews
Microphone Miscellany
Communications
What the Listener Likes and How He Likes It

Filament Lighting from the A. C. Mains - - *Roland F. Beers* 33

As the Broadcaster Sees It - - - - - - - - - *Carl Dreher* 36

One Explanation of the Plethora of Broadcasting Stations
Broadcasting and Social Upheavals
Glad Tidings From the West
The Radio Club of America
Technical Operation of Broadcasting Stations (Volume Indicators)
Something About Gain Control

Some Facts About Coil Design - - - - - - *Ross Gunn* 40

Perfecting the B Socket Power Device - - *Howard E. Rhodes* 43

Methods of Measuring Tube Characteristics - - *Keith Henney* 46

"Radio Broadcast's" Laboratory Information Sheets - - - - - 52

No. 89 Short-Wave Coils
No. 90 Loop Antennas
No. 91 A Simple Tube Tester
No. 92 Circuit Diagram of Tube Tester
No. 93 Audio Amplifying Systems
No. 94 The Principle of Reflexing
No. 95 Storage Batteries
No. 96 Analysis of Voice Frequencies

Equipment for the Home Constructor - - - - - - - - - - - 58

A Key to Recent Radio Articles - - - - *E. G. Shalkhauser* 60

International Short-Wave Test - - - - - - - - - - - - - - 60

Manufacturers' Booklets Available - - - - - - - - - - - - 61

AMONG OTHER THINGS. . .

WITH this issue, RADIO BROADCAST starts its sixth year of publication. The five years just concluded have seen many changes in the radio industry and among radio experimenters and fans. American radio magazines of to-day are quite different from those of 1922; RADIO BROADCAST has changed considerably, both in physical appearance and in type of contents, since those days. We believe the changes are improvements, for certainly our files are filled with countless letters of approval. The aim of Doubleday, Page & Company has been to publish the highest class radio magazine possible. This we have attempted to do, first, in setting the standard of physical appearance of the magazine where it now is, and secondly, to spare no pains or expense in making our technical material as completely accurate and helpful as possible. Two large laboratories are maintained in Garden City where practical and theoretical experiments are constantly under way; and our advertising pages are carefully supervised.

MANY editorial features in RADIO BROADCAST have given the magazine a unique position in its field. The "March of Radio" provides an editorial comment and suggestion about all branches of radio. "The Listeners' Point of View" stands alone as a national review of broadcasting, particular and general. "As the Broadcaster Sees It" has turned out to be a unique department (prepared, incidentally, by one of the ablest broadcast engineers in the country) where engineer, program director, listener, and general reader alike, may meet. The review of current radio periodicals, the Laboratory Data Sheets, the listing of informative manufacturers' booklets, all furnish valuable information for our readers. Our constructional articles are chosen carefully for accuracy and greatest help and interest for the reader. We are at work on an editorial schedule now which holds much for everyone interested in radio in all its branches. Unfortunately there is insufficient space here to outline that schedule, but we prefer to let each issue of RADIO BROADCAST speak for itself in that connection.

PRINTERS' INK, in its tabulation of advertising lineage for March magazines, shows that RADIO BROADCAST led the field with a total of 20,621 lines, followed by *Radio News* with 18,930 lines, *Popular Radio* with 14,872, *Radio* with 12,770, and *Radio Age* with 4395.

IN THE June RADIO BROADCAST, a fine story for the home experimenter is scheduled, describing the construction and use of a modulated oscillator. Other articles deal with short waves, the problems of series filament connection for 201-A type tubes, how to use new apparatus, technical problems for broadcast operators and others, and many other features of unusual interest.

WILLIS K. WING.

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Short Stories
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Look for that RCA mark! You'll find it on Radiotrons for every purpose.

RCA

RADIO CORPORATION OF AMERICA
New York Chicago
San Francisco

The stations are there get them !

You're not getting the most out of that storage battery set of yours. The *set* has a bigger distance reach . . . all it needs is a different tube in the detector socket. Put in the RCA super-detector—Radiotron UX-200-A. You'll get more stations—get the far-away ones more regularly and more easily! It's a small change, but it brings big results.

Bring your storage battery set up-to-date with
a *power* RADIOTRON UX-171 or UX-112
a *detector* RADIOTRON UX-200-A
and RADIOTRONS UX-201-A for all-round quality.
Bring your dry battery set up-to-date with
a *power* RADIOTRON UX-120
and RADIOTRONS UX-199 for all-round quality.

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MADE BY THE MAKERS OF THE RADIOLA

THE TOWERS OF STATION WOW, AT OMAHA, NEBRASKA

Formerly known as WOAW, this station has enjoyed a wide national popularity. In April, this station celebrates its fourth anniversary. The illustration shows the hoisting of a large section of plate glass, which now forms the front of a unique studio atop this 19-story building. The studio is arranged as a stage, properly insulated against sound inside, but with a front panel of glass to allow those seated in a small auditorium to watch and to hear the broadcasting as it occurs

RADIO BROADCAST

VOLUME XI NUMBER 1

MAY, 1927

With MacMillan to the Arctic

Tales from the Pen of the* Sachem's *Radio Operator—Not so Stupid, These Eskimo Flappers—Some Notes on the Aurora, Mirages, and Radio—Abe Puts One Over!

By AUSTIN G. COOLEY

TAKING up the threads of our story from where we dropped them last month, we on the *Sachem* and our friends on the *Bowdoin* find ourselves at Godhaven, Disko Island, the northernmost port of call of the expedition.

Let us deviate a little, though, to tell of the inhabitants of these arctic regions, for an account of an expedition into the land of the Eskimos is not complete without some mention of these most interesting people. Although the full-blooded Eskimos are few and far between, their habits and methods of living are preserved by those who possess considerable Danish blood. They are all wards of the Danish Government and are well cared for, and every effort is made to preserve their native customs and practices.

The Eskimo flappers are not so stupid; in fact, they have many of the same instincts that are common among the American beauties. In the matter of short skirts, they are years ahead of the best of our stenographers. The complete absence of skirts is due in a large measure to the Danish rulings that prevent them from changing from their native custom of sealskin pants and boots. They take great pride in making their boots the most attractive in the settlement. Generally they are dyed with a brilliant white or bright red. The girls all make large bead collars for themselves of their own design, with beads imported from Denmark. Ordinarily it is very difficult to obtain these collars but this year a few were purchased for thirty kroner (Danish money). Many of the girls, if they have considerable Danish blood in them, are quite pretty; otherwise they look too much like Eskimos.

A few of the Eskimos live in small frame houses or shacks while the others have their homes built of sod. These houses, or igloos, are built very scientifically with a selected sod that is a good heat insulator. The walls are built very thick and the doors all have tunnel approaches built of sod, entering at an angle to the door. Each igloo has a bed consisting of a raised platform large enough to accommodate the entire family. The Greenland Eskimos, and the igloos that we saw, were very clean.

Many of the expedition found it great sport trading with the Eskimos for souvenirs, such as harpoons, bird spears, model kyaks, etc. In Sukkertoppen, Mrs. Metcalf wanted to get a model of a woman's skin boat. She asked some of the Eskimos in their language if they had any "coumiaks." Considerable laughter among the Eskimos immediately resulted. Abe Bromfield, Commander MacMillan's interpreter, had to come to her assistance. It was an "umiak" she wanted. "Coumiak" is the Eskimo word for "lice"!

CAPTAIN "MAC" AND ABE

The latter was the Eskimo interpreter of the Expedition. He returned with the others to America when the *Sachem* and *Bowdoin* came back and, among many other things, saw a train for the first time in his life

For exchange, the Eskimos generally wanted tobacco and calico, although some asked for kroner which could be used at the stores run in the large settlements by the Danish government. The Danish money used in Greenland bears pictures of animals, such as polar bears, whales, seals, and ducks, so that the value may be recognized by the Eskimos.

During certain seasons, the Eskimos work in fisheries operated by the Government, and at other times they are busy sealing and hunting. The womens' work includes the chewing of seal skins so as to soften them, and the making of boots and clothing.

Anyone espied walking ashore with a camera was sure to have a large following, for the Eskimo girls are as anxious to have their pictures taken as are some American girls to appear in the movies. When preparing for a shore trip with the cameras, I always considered a supply of gum and cigarettes as important as the films. After taking pictures, these would be passed around to the eager natives, who were especially anxious for cigarettes; even the babies in their mother's arms made manifest a desire to smoke. They seemed to enjoy smoking as much as their grandmothers.

The Eskimo's Santa Claus is more of a fact than a myth. His phase angle displacement is 180 degrees from ours! He comes from the south in the summer time in a white schooner, and brings toys and candy for the bad little boys and girls as well as the good ones. He is known to them as "Captain Mac." Captain Mac's own generosity is always backed up by various candy manufacturers who see that the expedition does not leave American shores without a plentiful supply of all kinds of candy for the natives. The toys distributed by Captain Mac are generally of the nickel and dime variety, but some of the most deserving Eskimo men receive presents of excellent jack knives.

Some of the unfortunate Eskimos receive presents of lemons and a pleasant visit by the expedition's doctor—Doctor Thomas of Chicago. Doctor Thomas treated a number of cases among the Labrador Eskimos and in one instance performed an operation.

At practically all of the settlements at which we stopped, Captain Mac put on movie shows for the natives. The attendance was always one hundred per cent. "Robbie," the mate of the *Bowdoin*, was skilled in packing whole settlements into a small room so as to give each Eskimo a good view of the screen.

WE START OUR TRIP HOME

COMMANDER MacMillan planned on running south from Godhaven, Greenland, to Holsteinborg, then across to Baffin Land, but the problem of replenishing our fuel supply required some changes in the schedule. We went south to a whaling station at Edgesminde where ten barrels of fuel oil were obtained, but this was not enough to take us home. Using the engines seemed more desirable than the sails, so we went further on, to Sukkertoppen, where a larger supply could be had.

This southbound trip included a few days' stop at Holsteinborg, formerly a center for American halibut fisheries. In the cemetery were found a number of graves of Gloucester fishermen. All foreign fishermen are now barred from the coast of Greenland and the Danish Government is operating the halibut fishing industry at Holsteinborg with great success. During our stay at this port, we enjoyed many meals of halibut. It was delivered to the ship at a price corresponding to one cent a pound.

Except for the fog at sea, the weather we experienced in Greenland was of the best. During the day, the temperature generally ran around 70 degrees. This weather, on the middle western Greenland coast, is due to a warm ocean current which prevents the winters from being any more severe than they are in Maine.

Our call at Sukkertoppen for fuel lasted only a few hours. Before leaving, plans were made to set a course for Cape Murchison, Bevoort Island. If the ice was not too heavy, we planned to run up Robinson Sound, between Bevoort Island and Baffin Island, and anchor in a harbor that was dotted in on the chart. The dots meant: "Harbor about here."

The radio conditions during our last few days in Greenland were very poor. Even the powerful commercial stations faded out completely at times. While going across to Baffin Land it was hardly possible to get through any amount of traffic to the States because of complete fading. Radio 1 AAY (Kenneth M. Gold, Holyoke, Massachusetts) was worked a couple of times but it was only possible to get one complete message of about fifty words from him. Other stations were worked but communications only lasted a few minutes before they faded out completely.

Davis Straits had received considerable publicity as being a "blind spot" because it so happened that short-wave radio communication could not be established from this location on the previous year. On the recent outward trip, Paul J. McGee, the operator at WNP, the *Bowdoin*, succeeded in transmitting to the States a 200-word message when going north through the Straits. At the same time I observed that the signals from the States were coming through with good intensity. Why the conditions on our return trip were so poor seemed to have some connection with the aurora because strong displays of the northern lights were visible as we left Sukkertoppen at 2 A.M. on Friday, August the thirteenth.

On the return trip, both McGee and I seemed to have considerable trouble with swinging waves. When we reached the ice fields off the Labrador coast we were hardly able to get through any communications although, after considerable effort, we exchanged position messages. The ice was fairly heavy but we considered it not too bad to prevent us from making Cape Murchison. About 8 P.M. on the fourteenth, we sighted the cape through the fog about a half mile off.

The weather kept getting thicker and colder and a strong gale came up that increased the danger of navigating these uncharted waters. The harbor where we were to meet the *Bowdoin* was full of ice. The storm became more severe and the night was very dark, so it was considered too much of a risk to try to anchor the ship even though we could find a harbor. A broken reverse gear added to the hazards. The entire crew stood watch that night. We all wore all the clothes we had aboard under our oilskins, together with hip boots so as to offer maximum resistance to the cold rain, sleet, and snow that was driven hard by the gale.

Radio communication was established with radio 1 AAY, and as I was asking him to give our position to the *Bowdoin* if he could, all signals faded out completely. At frequent intervals I called WNP, the *Bowdoin*, but I received no answer.

As the day started to break, two harbors were located. One was well sheltered but we could not get in because the entrance was blocked by a few large icebergs. The other was full of rocks and bergs but, with the skillful handling of the ship, a reasonably safe place was located and then the hook dropped. Dropping the hook was not so easy. The gale was still strong and the water twelve fathoms deep, and we had to let out about forty fathoms of anchor chain. The last twenty fathoms came out of the chain locker in installments of one and two feet at a time while it was being untangled and untwisted.

Communication was established with WNP that afternoon on a schedule. His wave was swinging badly but I was able to learn his position and that he was headed for Hall Island, near the southern end of Baffin Island. Apparently the *Bowdoin* got the worst of the storm as they stayed at sea and rode it out, for Commander MacMillan considered the ice too heavy to attempt to run into the Sound. The danger of the ice was that, if the wind changed, it might pack in on us and push the vessel on to the beach.

The following morning we pulled in our 40 fathoms of anchor chain and headed for Hall Island.

While passing through the ice, we saw many seals, and after clearing it, walruses were plentiful. After quite an exciting time with artillery, harpoons, and killing irons, we managed to get one of the latter aboard that weighed about 1500 pounds.

Upon arriving at Hall Island that evening, a radio message was received from the Commander advising us that he had gone on and that we should meet him at Saglek Bay, Labrador. At four o'clock the following morning, we started out on this long trip across the Hudson Straits. Fair weather permitted us to make Saglek Bay by six P.M. the following day.

OBSERVATIONS ON RADIO FADING

OUR activities at Saglek Bay deserve considerable mention. The *Bowdoin* had gone up far into one arm of the bay so that the scientists could make a collection of some kind of field mice that exist there. Some of the other boys found sport hunting caribou but they did not enjoy the success the scientists had.

McGee planned on setting up a receiving set ashore that night so that Kennett Rawson, a member of the *Bowdoin* crew, could hear his father who was scheduled to broadcast from WJAZ, Chicago. An elaborate installation was made with the help of "Ken," who was so strong he stretched the antenna wire enough to break it. The heavy equipment had been carried about two miles up into the hills to an "ideal" location. All this work did not even result in a squeal from WJAZ. This was most disappointing as reception in Greenland from this station had been quite successful at times.

During the time that McGee was trying to receive WJAZ, I was trying to receive anyone I could. At times signals seemed fairly good, and then they would fade out completely. Someone informed me that the aurora was quite strong. I went on deck to investigate. Never before had I ever seen such a violent and brilliant display of the northern lights.

At times we were completely surrounded by the bright blue bands of aurora, and streamers from all around the horizon would shoot up to the zenith, making a complete umbrella of aurora. In places, the bands were fringed with a dark red.

Until making this trip, I felt that no relation existed between the aurora and radio conditions, as I had made rough observations during the part of one winter in Alaska and was able to detect no connections between the two on wavelengths of six hundred meters or higher (500 kc. or less). No one seemed to really know whether any relation existed although some were quite certain that it did and others were more positive that it did not.

An excellent opportunity was offered me to gather some data that might throw a little light on the subject, so I started work, but in a rather crude fashion. My notes consisted of brief descriptions of the aurora together with a log of the stations that were coming through and remarks as to intensity. For three hours I kept running up and down the companionway taking notes on the aurora and then listening to the radio. I was thoroughly convinced after these notes had been gone over that a definite relation did exist between the aurora and radio conditions.

The following night we were at sea, bound for Nain. The aurora appeared in thin bands sweeping across the sky from the northeast. I took data as on the night before. Mr. Warren was at the wheel at the time and noticed compass variations of five or six degrees as the bands of aurora passed over us.

We were following the *Bowdoin* along the half-charted coast of northern Labrador when our engines stopped. The chief engineer found the fuel pipe lines full of water. A little over an hour was required to take down all the lines and drain about a barrel of water out of the fuel tank that had been filled at Sukkertoppen. The *Bowdoin* was a mile or two ahead of us when we stopped and her lights soon dropped out of sight altogether. There was a light breeze up so we were able to keep clear of the rocks with the use of the sails. Nain was no easy place to find as it was hidden away somewhere among a great conglomeration of islands and bays not appearing on the charts with which we were supplied.

The following afternoon we ran into an entrance that appeared to be the correct one for Nain. After hours of sailing around islands and into bays that all looked alike, we came to anchor. Commodore Metcalf, the Captain, and the Chief immediately set to chasing a large bear we sighted along the shore.

One time that afternoon, while we were sailing up a wide clear channel at full speed, we hit a rock. The ship lurched a little to one side as we slid over it and went right on. The hull was well built and especially constructed to stand any shock of hitting rocks or running on to ice, so we were none the worse for the mishap.

Locating Nain was no problem for Commander MacMillan on the *Bowdoin* as he knew the Labrador coast equally as well as the streets of his home town, but while originally acquiring his familiarity of the country he tells how he spent two weeks locating this settlement.

The Moravian missionaries here had a motive in locating their station in a place so difficult to find. Before the fishermen began intruding upon this coast, the Eskimos were a strong healthy lot of people making a prosperous living from fishing and hunting. Fighting took place between the Eskimos and fishermen at their first appearance. To protect the Eskimos and

SOME PICTURES TAKEN IN ARCTIC REGIONS

The upper circle shows an Eskimo boy in his kayak at Sukkertoppen, Greenland. The top left "snap" was taken at the northernmost port of call of the Expedition—Godhaven. The Eskimo girls are interested in the camera and are not a bit bashful. The pile of sod in front of them is being dried for use in the construction of an igloo. This material is also used for fuel. The *Bowdoin* and *Sachem* are shown at anchor at the foot of the towering rocky coastline at Godhaven in the top right-hand picture. The inner circle depicts Maude Fisher at the wheel of the *Sachem*, cheerful despite a painfully swollen face caused by Labrador mosquitoes. The *Sachem* is at anchor in Battle Harbor, Labrador, in the lower left-hand picture. The group of three to the right includes: Captain Crowell, skipper of Commodore Metcalf's *Sachem*; Marion Smith; and Maude Fisher prevent their annihilation, Moravian missionaries from Germany risked and sacrificed their lives for the cause. They have been able to keep the race alive for over a hundred and forty years by their persistent, self sacrificing work. Protection from the diseases of the fisherman has been one of the most important problems they faced, and their station at Nain was hidden away so as to make its approach by the white man very difficult.

In hunting for Nain, Commodore Metcalf had given way to the opinions of others as to where we should head the *Sachem*. His good sense of direction finally won the courage of his convictions when he informed us that we would hoist anchor at five A. M. and arrive at Nain at eight. At 8:20 we dropped the hook alongside the *Bowdoin* at Nain.

In going south from Nain to Battle Harbor, we stopped nearly every night. We had two days at Jack Lane's Bay where Abe Bromfield lived. Arrangements were made to take him to the States for the winter. We were all as much interested in his trip to civilization as Abe himself. Abe had never seen a railroad train, an automobile, a horse, or many of the other things that are so common to us. Just how he would be impressed by all these things was a matter of much speculation on our part.

Some of our stops on the Labrador coast represented agony because of the flies and mosquitoes. At one place I arranged to set up some apparatus for measuring earth currents that exist during aurora displays. I soaked myself with Flit and went ashore to locate a suitable place. The effect of the Flit did not last long. I was compelled to retreat to the ship with all the speed I could put behind the dory I was in. The swellings and itching from the fly bites lasted for days.

In comparison with what the three women who were with us on the *Sachem* suffered from the flies, I had no reason to complain. They went ashore, protected by head nets, but the flies easily worked their way through. Miss Fisher's face was swollen up like a toy balloon while Miss Smith suffered with hundreds of bites but was not affected by such swelling.

I was able to get additional data on the relation between the aurora and radio every night. In addition to the aurora data, notes were taken on the barometer readings and on the mirages that were so common. At times we were able to get photographs of the ice mirages. After reporting to RADIO BROADCAST about the mirages, the editor sent me a message quoting a press report that read as follows: "Captain Rose, of Steamer *President Adams*, at 8 P.M. July 15, in Mediterranean Sea, bound for Port Said, states they saw 'large field of floating ice cakes suspended above horizon and presently a number of small pieces drifted into view followed by a large one. The latter was so clear we could see blue and green veins in the ice.'"

Early in the trip, Commander MacMillan said that if conditions were right, it would be possible to see mirages of images half way around the earth. Considering light and radio waves to be the same thing, except for difference in frequency, it seemed that there might be some connection between the mirages and radio phenomena.

In the data collected, there appeared to be a rather definite relation between barometric pressure, mirages, aurora, magnetic storms, and radio fading. The data is by no means complete but the observations substantiate the following statements:

1. Mirages and aurora only occur with heavy air pressure.
2. The relation between the aurora and radio fading depends upon the following:
   (a). Formation of aurora and its location in respect to the approaching radio wave and the receiving station.
   (b.) Frequency of the radio signal.

In accounting for the fading, the temperature is an important factor in the formulas already worked out for mirages. A more detailed account of the data and the conclusions drawn will be taken up in a later article.

It might be well to mention here that communication between the *Bowdoin* and *Sachem* was never hampered due to "skip distance" effect. The distance between the two ships varied between three feet and three hundred miles during the trip and we always communicated on waves between thirty-two and forty-two meters (9370 and 7140 kc.).

We found Battle Harbor filled up tight with eighteen fishing vessels, and we were compelled to anchor in what is known as "Outer Harbor." We had prepared to wait there until the mail boat arrived on the following day hoping that a new reverse gear would be aboard for us. According to calculations, the chances seemed very poor and the next boat was not due for two weeks.

The story about the reverse gear, however, displays the efficiency of modern means of communication. The extent of the damage done to the gear which was caused when we ran aground on the Arctic Circle, was not determined until an examination was made at Holsteinborg. A radiogram was sent through on the night of the examination to the offices of John G. Alden, the ship's designers, in Boston. This message was received by them when the offices were opened at nine in the morning. A wire was sent from there to the makers of the gear but not knowing the type used, they wired the builders of the engine in Columbus, Ohio, for this information. By noon a wire was received at the Alden offices from the makers of the gear that a new one had been shipped express, special handling. Only by a margin of a few hours, the gear reached the mail steamer before sailing, and we received it the morning after arriving at Battle Harbor.

It was not until we reached Battle Harbor that I put any broadcast music on the loud speaker for the entertainment of the crew. I held back on the broadcast music because we had an excellent Sonora portable phonograph with a large number of records and because the reception up to that time did not have much entertainment value. It was possible to hear broadcast stations faintly as they faded in and out but to try to get them regularly seemed only a waste of time.

I noticed that many of the missionaries in Labrador and governors in Greenland have receivers that had been given them the previous year by Commander E. F. MacDonald. With their large antennas, they are able to hear stations in the States reasonably well in the summer. Winter reception is reported as excellent.

The 63-meter (4760-kc.) signals from KDKA came in well during most of the summer but were subject to bad fading. The $32\frac{1}{2}$-meter (9225-kc.) signals from WGY appeared very steady and fairly strong while we were in Greenland.

BACK TO CIVILIZATION

IF YOU want to find out how great a fine big juicy beef steak can taste, just take a three months' trip into the north and live on canned goods as we did. When we loaded up with fresh supplies on our arrival at Sydney, Nova Scotia, we all ate like wild men. With the crew fed up on red meat, the captain was afraid to let the men handle the lines for fear of breaking all we had.

On the last leg of the voyage before reaching the States, we ran into some very heavy weather off the Nova Scotia coast. Most of us on the *Bowdoin* and *Sachem* experienced seasickness but it did not last long on the *Sachem* as Commodore Metcalf put aboard a supply of "seasick pills" at Sydney which served their purpose nicely. I believe their trade name is "Sea Oxyl." This is not a free advertisement—it is sympathetic advice.

Our arrival at Wiscasset on September the eleventh does not end the story. Abe Bromfield has to be accounted for. At Sydney, Abe appeared to be most interested in the railroad whistle and a long train of cars. At Wiscasset, he could not understand why they had small lighthouses in the middle of the streets.

Commander MacMillan was engaged to speak at the New York Radio Show. Abe went with him. In a day and a half Commander E. F. MacDonald showed Abe more of New York than I had seen in a year and a half. Abe remembers every detail of this trip, for his memory is remarkable. Reporters all shot the stock question at him: "What do you think of American flappers?" Abe's confidential report is that the Wiscasset girls are much prettier than the ones in New York.

Abe is a great one for shaking hands. I am sure he would enjoy exchanging places with President Coolidge at times. On one occasion, Abe was following Commander MacDonald into the New York Radio Show when the ticket taker put out his hand. Abe shooks hands with him. This first attempt at crashing gates was a grand success as the ticket taker almost passed out while Abe walked on in.

THE MARCH OF RADIO

News and Interpretation of Current Radio Events

What Does the Listener Want? Let Him Speak

THE Radio Act of 1927 provides that "the licensing authority shall make such a distribution of licenses, bands of frequency or wavelengths, periods of time for operation, and of power among the different states and communities as to give fair, efficient, and equitable service to each of the same." Licenses shall be issued and renewed only "if public interest, convenience, or necessity are served thereby."

These are the sole bases in the new radio law upon which broadcasting stations shall be distributed and licensed. The criterion, then, by which a station's right to broadcast is to be judged is its service value to the listening public in its own service area and the effect of its operation upon broadcasting in other areas.

What a trail of broken hearts must follow in the wake of that formula! Even now we can hear the groans and lamentations of the disappointed, who have pleaded in vain before the relentless Commission. Here is a reformer, who spent the hard-earned money of generous contributors, to broadcast messages of uplift to an immense audience, an enthusiastic audience which bought so many of his expensive little pamphlets in the past; we see his bowed form as he staggers dizzily out of the offices of the Radio Commission, realizing that his work of saving the public soul can no longer be continued behind the comfort of the microphone. There is a philanthropic business man who, out of the goodness of his great heart, has spent thousands and thousands of his excess profits to spread gladness and cheer and—advertising, to a receptive public. And here is a little fellow, so he says, who has erected a modest little station, but a nice little station nevertheless, just to make folks happy but, he sobs, the accursed monopoly has bought the souls of the Radio Commission; they get their place in the ether without a struggle; he must put his tubes and condensers back in stock now and sell them to his unsuspecting customers, not without a little free monopoly publicity in the home town paper though, to help him on his way.

Gentlemen of the Radio Commission, let but one voice rule you! The voice of the broadcast listener! Give him fair, efficient, and equitable service! Remember, not one of those who seek to broadcast has anything but a selfish purpose, however disguised, in seeking a place in the ether. Big and little, alike, have something to sell, whether it be a cause depending upon contributions for revenue, a commodity feeding its sales through goodwill, or a community encouraging capital and population to its territorial limits.

The most important evidence to guide the commissioners in determining what is fair, efficient, and equitable service to the different states and communities will be the expressions of the listening public of their desires. The broadcast listener must become articulate if this wise provision in the law is to have the opportunity to mean what it says.

Already there has been recognition of the necessity for listener organization. We noted, for instance, in a recent issue of the *Northwest Radio News*, the official organ of the Northwest Radio Trade Association, a strong plea that the trade support radio listener organizations. It urges such listener groups to consider questions of receiver operation and repair, to conduct set building contests, to give opportunity for unbiased demonstration of commercial sets and accessories, to criticize, condemn, or commend sales methods and radio advertising, to encourage new uses for radio, to improve radio reception conditions by exposing broadcasting station interference, discouraging radiating receivers, and locating power line leaks, and, most important

The illustration forming the heading shows a general view of the first international radio telegraph station at Alfragide, nine miles west of Lisbon, Portugal. On December 5, 1926, direct high-speed service to London opened. The station will also communicate with East and West Africa, and with South America. The short-wave "beam" is used.

of all, to voice constructive criticism and crystalized opinion on broadcasting conditions.

Listener clubs are successful in a few isolated instances. In Scranton, the Lackawanna Radio Club, two years ago, had forty-seven members. It now has 680 and is growing so rapidly that it expects soon to reach a total of 1500. In British Columbia, the Victoria Radio Club is an active organization and has eliminated serious power line interference with the aid of apparatus and engineering talent paid for out of the club's treasury.

Although listener clubs are likely to attract only the most enthusiastic, if but five per cent. of the listening audience became articulate through such organizations, the problems of the Radio Commission in determining listener sentiment would be immeasurably reduced. Frankly, we are a little pessimistic about the probabilities of powerful listener organizations because radio is a pastime which does not lend itself easily to group enjoyment. Radio listening is a personal, or a family affair. The membership of camera clubs and automobile clubs, facing similar conditions, is restricted only to the most enthusiastic. But only by extensive listener organization is it possible to ascertain with certainty what the listener wants.

It requires no power of divination to decide that all heterodyning and overlapping of stations must be eliminated but, beyond this, the Radio Commission has little upon which to base its policy. It may designate broadcasting stations so that the maximum number are crowded in the ether bands without interference or it may decide upon the minimum number of stations for each area which give sufficient variety of service, which leave the widest possible gaps for distant stations, and offer the listener the choice of the greatest possible number of program sources.

Radio Broadcast seeks to aid the Commission by securing a definite expression of the station or stations desired by listeners of various areas. We urge our readers to fill in the questionnaire which appears on this page. The questionnaires returned to us will be carefully tabulated and the result will be presented to the Radio Commission for its information.

The expressions of the listening audience, so far demonstrated in a wholly unorganized and spasmodic way, have already shown their effectiveness in securing desired action. When Senators Pittman, Howell, Copeland, and Heflin endangered the passage of radio legislation by their continued wrangling over the bill, listener

Which Stations Shall Broadcast?

The answers to the few questions below, if answered and returned to Radio Broadcast at once, will form the basis for a presentation to the Federal Radio Commission. The Radio Act of 1927 provides that the Commission shall assign licenses to broadcast stations in the light of "public interest, convenience, and necessity." Unless the Commission has some means of determining the feeling of radio listeners in each of the five new radio districts, that task is going to be nearly impossible. The importance of terse, complete answers to the questions below is apparent. If our readers desire to make their wishes articulate, we believe that an answer to these questions will enable us to help them and to aid the Radio Commission.

Please typewrite your answers wherever possible. If you do not desire to cut this page from the magazine, please answer the questions in order on another sheet and mail it to us. Many readers complained when answering the recent questionnaire in "The Listeners' Point of View" that they were loath to cut up their copy since each was carefully preserved. Mechanical difficulties make it impossible to insert this questionnaire in any other part of the magazine.

Please fill in the answers at once and mail to:

The Editor,
Radio Broadcast,
Garden City, New York.

Please Answer These Questions

1. List local stations (within 100 miles) you wish retained on the air *in order of your choice:*

2. List favorite stations which are now excluded to you by radio interference:

3. List favorite out of town stations you wish retained:

4. Do you prefer a maximum number of local (within 100 miles) stations to the exclusion of the greatest number of out-of-town stations?
(A.) Yes. (B.) No. (C.) Maximum number of "locals"________

5. List the stations you wish eliminated, the most unpopular ones first. (Please list present call letters only).

6. What kind of receiver have you? (Please be brief: neutrodyne, tuned r.f., etc.)

7. Name ____________________
Town ____________________
State ____________________

8. Additional remarks and suggestions should be made on a typewritten sheet attached to this questionnaire.

City listeners can answer completely all of the questions in the above list. Those listeners who have no local stations can indicate their opinion satisfactorily by answering all questions except No. 1; it is particularly valuable, however, to have their opinions on No. 4.

protests came in such numbers that these very vocal Senators were forced to capitulate. But there was no truly organized listener opinion represented. Indeed, Senators clutched upon the feeblest ray of evidence to cite listener opinion in support of their various arguments. For example, references appear in the *Congressional Record* to a protest against the Radio Bill made by one C. Wood Arthur, speaking for a so-called Radio League of America. Letters from this magazine addressed to Mr. Arthur have received no acknowledgment or reply. Nor have we been able to learn from any other source who Mr. Arthur represents beside himself. In the absence of a recognized listener organization, anyone, however unknown and unrepresentative, may take it upon himself to influence the course of legislation and the future action of the Commissioners. The lack of organization of broadcast listeners is a menace to their interests, a condition which would be quickly alleviated by the formation of a truly nationwide listener organization.

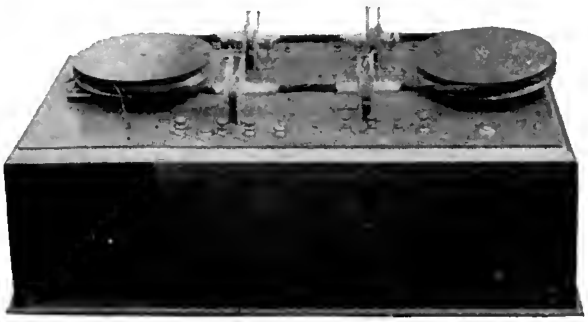
Objections to the Radio Law

WHILE the Radio Act was the subject of debate in the House and Senate, certain objections were brought to its provisions which, were they valid, would undoubtedly be serious reflections upon the soundness of the Act. It is worth while to consider some of these points lest confidence in the Radio Law be undermined.

The radio listener has every reason to be congratulated on the fine piece of legislation which Senator Dill so ably marshalled through the Senate. We regret, of course, that the original White Bill, which did not provide the cumbersome and expensive radio commission, was not passed, but the ingenious compromise worked out is the best law which could be hoped for. The commission, we fear, is a permanent expense. It will probably remain in session practically all the time even after the first year, since anyone questioning the Department of Commerce's rulings automatically brings his case before the Commission.

Some of the objectors to the bill apparently failed to read it carefully or they have no adequate understanding of the English language. One provision of the Act states that broadcasters cannot acquire or construct wire lines of their own for the purpose of securing unfair advantage over rival broadcasters. Senator Copeland (D. New York) spoke harshly against this provision, stating that the telegraph and telephone companies (against whom this provision is directed) make so much money now out of telegrams sent in response to radio programs that they fear broadcasters might take away this business by means of a communication system of their own!

He also stated that light, heat, and power would "soon be transmitted by radio" and that, therefore, licenses should not be granted for three years. The Act specifically provides that a station's license may be revoked if it is used for a service differing in any way from that for which the license was granted. This same provision is adequate protection against the transmission of "scrambled" programs for which the listener would be compelled to use a special



THE ORIGINAL MAGNETIC DETECTOR USED BY MARCONI

patented receiver. The Commission has full power to limit and prescribe the kind of equipment to be used in transmission. Fortunately, no specific barrier to charging for programs was incorporated in the law because it is quite conceivable that there may, some day, be demand for high-grade programs for which the listener might be asked to pay. On the other hand, such a private service could not be undertaken, under the Act, if it did not meet the requirement that it was fair and equitable service to the listener. One Representative created quite a splutter by insisting that, as soon as the "interests" were licensed under the new Act, they might begin transmitting scrambled programs, so that the listener would have to pay for them or else junk his set. Such transmission could not be undertaken without express permission of the Commission, which would be derelict in its duty if it granted that permission without public demand for it.

The Question of Vested Rights

THE only serious criticism of the Act in the Senate centered upon the point that no declaration was made in the law to the effect that the ether is owned by the people. The law ignores the matter of ether ownership but asserts unequivocally the full power of the government to regulate its use. Ether ownership is a subject of considerable legal complexity, since we cannot accurately define what the ether is. The "ether" is international and hence cannot be owned by any one nation or any individual. If the ether were considered as "property," divestment of a station of its frequency would automatically make it a matter of property confiscation. As a matter of fact, had broadcasting stations, by any legal interpretation, possessed vested rights prior to the passing of the Radio Act, the mere statement by Congress that they did not possess such rights would not automatically dissolve them. The inclusion of a declaration of ownership of the ether by the people would have in-

TWO WELL-KNOWN RADIO EXECUTIVES

Powel Crosley, Jr., President of the Crosley Radio Corporation, and his newly appointed assistant, R. H. Langley. For the last six years, Mr. Langley has been in charge of receiving set development for the General Electric Company and is widely known in radio engineering circles. The first American airplane transmitter is credited to Mr. Langley volved the law in precarious legal entanglements. Confinement of the Act's scope to regulation of any and every device using ether waves in no way jeopardizes or weakens its effectiveness. If you have entire control of the use of a thing, its technical ownership becomes of minor importance. If the government can prescribe when, where, and for what purpose you may use your motor car, it, in effect, can exert all of the advantages of complete ownership.

Legal experts state that a vested right could be secured to a wavelength, provided unrestricted ownership had been exercised for a period of many years. In historic covered wagon days, a prospector had only to stake out his claim and to occupy his property to obtain a good title to it. His occupation and improvement thereof eventually gave him legal possession. Complete possession and utilization, without existence of any rights conflicting with it, might in time bring about the establishment of a vested right to a radio frequency. But no such condition obtains with respect to broadcasting frequencies. The right of the government to regulate interstate radio communication is clearly given in the Constitution and the government asserted and exercised that right long before the first broadcasting station went on the air. No broadcasting station at any time has operated without first securing a government license and, in so doing, it has recognized the government's power to regulate the use of the ether.

Undoubtedly there will be efforts on the part of disgruntled stations to prove that their investment in radio transmitting equipment is, in effect, confiscated if they are not allowed on the air. They will therefore demand compensation as is guaranteed under the Constitution when private property is confiscated. But they will be wasting their time and money in seeking compensation because the government's power to revoke a license for the general good, even if it involves depreciation or destruction of private property, has been abundantly established by endless court decisions. One need only recall the actions brought many years ago when local option closed saloons. Although a license to sell intoxicating liquor was property so tangible that it could be sold, mortgaged, and subjected to execution, the courts decided that a license to sell liquor is not a vested right and the state could, in the exercise of its police power, revoke it. Revoking broadcasting licenses is not different. Although revocation of a license may involve making a radio transmitter valueless, the license is nevertheless subject to revocation for the good of the people as a whole. It is extremely unlikely, particularly since broadcasting stations were officially warned that the ether lanes were overcrowded, that any of the existing stations whose licenses must be revoked will be able to obtain compensation on the grounds of confiscation.

We are indebted to the Hon. S. H. Rollinson, an eminent New Jersey lawyer, who has made a thorough study of the legal aspects of the broadcasting stituation, for other examples of a governmental police power, the exercise of which has involved what amounts to, but is not, confiscation of property. The State of New Jersey passed a law prohibiting the use of repeating firearms capable of firing more than two shots. This rendered useless repeating rifles possessed by many sportsmen and, in the legal action which followed as a result, brought by sportsmen and manufacturers of firearms, the state proved its complete right to regulate the matter of firearms under the law. Likewise, the government may or may not grant charters to national banks, as its chooses. If it does not consider it in the public interest to license an additional national bank in any locality, it need not do so. It is empowered to revoke the charter of a national bank in the public interest. A reckless automobile driver may have his license revoked in the maintenance of law and order, even though, in effect, it makes a valuable and expensive piece of property useless to him. The regulation of the ether is a police power which cannot be overthrown upon any grounds of vested rights and cannot be hampered by demands for compensation. We are convinced that the actions brought by broadcasting organizations for compensation or broadcasting rights will be unsuccessful, unless and only if they can show that failure to license them is denying the public fair, efficient, and equitable radio service.

The case of the disgruntled broadcasting station must be overwhelming proof that closing it down is contrary to the public interest. The personal desire of those maintaining the station is of absolutely no value under the law. The Radio Act of 1927 has wiped the broadcasting slate clean for the Radio Commission. At this writing, no broadcasting station is licensed for more than sixty days. Let the Commission have courage! The vast majority will support it to the limit in its difficult task of reducing the number of broadcasting stations by at least sixty per cent. A noisy and selfish minority will always oppose and criticize it. Let the clamoring be outweighed by an organized and powerful listener sentiment and there will be no difficulty in deciding what is meant by fair, efficient, and equitable radio service.

B. L. SHINN

New York City

Associate Director, National Better Business Bureau. Especially written for RADIO BROADCAST:

"Many radio firms as well as radio dealers and manufacturers have written to the National Better Business Bureau to express appreciation of its work in promoting the accurate retailing, advertising, and selling of radio storage batteries. This appreciation is most welcome, and in acknowledging it, I take the occasion to point out that this is but one of a number of instances in which the Bureau has worked out, with the engineering and advertising leaders in the radio industry, methods of selling, which have assisted the public to obtain accurate and dependable facts regarding radio products. Even the woods appearing on exposed surfaces of radio cabinets and consoles are now accurately described by most manufacturers, instead of by only a few, because of the activities of this Bureau.

"The Better Business Bureau's service to industry and the public, however, is by no means limited to radio. There is scarcely an important item of merchandise in your home in whose advertising, branding, and marketing the influence of the Bureau's recommendations are not felt. If you have saved money for investment, the National Better Business Bureau and forty-three local Bureaus stand ready to supply reliable and disinterested information upon the security which you are considering."

"Christian" Mud Throwing

WE WERE pleased to receive a complete disclaimer from the Christian Science Mother Church in Boston, stating that the destructive propaganda sent out by WHAP in New York is in no way sanctioned by and does not in any way represent the views of that organization. Station WHAP has used its broadcasting station to disseminate large quantities of mud, trained largely against Catholicism. The action of WHAP has disgusted listeners of every shade of religious belief. Broadcasting, fortunately, has been very largely free of intolerance, every kind of religious belief having free access to the microphone to spread its thought constructively. Broadcaster WHAP, disregarding its obligation to the diversified radio audience, has chosen a course of intolerance and villification. Its attacks on Catholicism can not be condoned, and tend to undermine the faith of impressionable persons in any religion. For the good of radio, let us hope that it will no longer be used as a means of breaking down anyone's belief, be it Catholicism, Protestantism, Buddhism, Christian Science, or atheism. A cardinal virtue of Christianity is tolerance. No doubt we will be suspected by intolerant WHAP of being subsidized by the

Pope, but this item is written by a non-Catholic who resents, as do all liberals, the besmirching of any religious belief, his own or some one else's. Let us have no more of WHAP.

A New Term for "A. C. Supply" Units

THE National Better Business Bureau has endorsed the use of the term "socket power unit" to describe devices for the purpose of furnishing A or B power for radio sets. The term "A eliminator" or "B eliminator" is declared as obsolete as the term "horseless carriage," which was at first applied to the motor car. "Socket power" may be applied to describe devices employing combined storage batteries and chargers, thus powering the set indirectly rather than directly from the light socket. It thereby covers the numerous trickle charging storage battery combination units now being so widely sold. We suggest the general acceptance of a term such as "electric set" in order that one may differentiate between receivers using trickle charger—storage battery devices and those powered directly from the light socket through filtering devices without the aid of a secondary battery.

Our attention has been called to advertising, having wide publication, describing A battery devices which "banish the storage battery forever," "eliminate A battery troubles," and similar claims. Investigation has proved that these devices frequently comprise storage batteries combined with trickle chargers. The implication of these phrases in advertising is that the device eliminates the storage battery. Combination trickle chargers and A batteries reduce maintenance attention to a very desirable minimum but we believe the declaration that they completely eliminate it is both exaggerated and misleading.

There Are No Radio Engineers

FROM D. A. Johnston of New Britain, Connecticut, we receive a comment on our item in a previous issue, urging that the education of radio engineers be better balanced with respect to economic and commercial phases of their work:

"Insofar as radio engineers are concerned, I am not quite convinced that there is any such thing. Engineering is very nearly an exact science and an engineer should be able to tell on paper what his product will do so that another engineer can tell exactly whether his product is better or not. Did you ever see any firm producing radio apparatus who would give you information comparing to that which you would expect in buying an electric motor? For example, how many engineers working on sets know what the curves of their particular set look like? I doubt if many of those producing simple articles like battery chargers do know what actual efficiency is. The few who do know these things are not sufficiently satisfied with the product to be willing to say much about them."

This comment is often made by engineers in fields better established than radio. The fact is that we have no standardized method of rating the efficiency or selectivity of receiving sets, which nets down to a figure of merit of standardized valuation.

EDWARD E. SHUMAKER

New York

President of the Victor Talking Machine Company:

"The question as to who is to pay for radio broadcasting appears to have been temporarily solved. The bills are being met by those who benefit directly from it. While I do not believe that the broadcasting of radio entertainment can be made to take the place of other established forms of advertising, it is an additional medium for creating demands for some products, and a good-will builder when properly used. We have found that the broadcasting of Victor recording artists results in an immediate and traceable demand for their records. We are convinced, also, that anything we may do to raise the standards of radio programs will be reflected in a healthier condition in our business and in other branches of the music industry.

"Radio and the talking machine may at times appear to overlap somewhat. In actual practice they do not overlap. Each has its own place as an instrument for home entertainment. This is borne out by the experience of more than 6000 Victor dealers in the United States. It is also a fact that thousands of new talking machines which are not equipped with radio receiving sets are being sold annually in homes which also contain radio sets.

"In 1924, and the early part of 1925, when the talking machine industry was at a low ebb due to its failure to improve its products, the general impression was that recorded music was being replaced by radio broadcasting. Subsequent developments have demonstrated clearly that such was not the case."

A Survey of Radio Conditions

RADIO RETAILING has issued a report on the broadcasting situation based upon telegraphic summaries from 21 cities, scattered throughout the United States and Canada. Washington, District of Columbia, and Portland, Oregon, were the only two districts reporting satisfactory conditions, but it was noted that almost every center of population has one or two high-grade stations which are not being interfered with seriously. The most enterprising leadership in handling the situation was demonstrated on the Pacific Coast, where the Pacific Radio Trade Association not only secured pledges from broadcasting stations that they would abide by the district radio inspector's decisions as to changes in wavelengths, but exerted strong influence in having them observed. Twenty-five per cent. of the midwest stations conflict with local wavelengths in San Francisco on sets of average sensitiveness. From this report and other sources, we learn that among the important stations seriously heterodyned are KOA, WCCO, WOR, WEAF, WTAM, WHN, WEEI, WNAC, CKCL, and KFKX. *Radio Retailing* is to be congratulated upon the excellence and thoroughness of its survey.

The Month In Radio

THE sales of combination radio and talking machine instruments made by the Victor Company during 1926 had a retail value of something over seventeen million dollars and amounted to one sixth of the total business of the company.

FROM Mr. C. R. Cuchins, Vice President of the First National Bank of Bessemer, Alabama, we learn that the Birmingham *News* decided, upon suggestion from broadcast listeners who forwarded copies of RADIO BROADCAST'S editorial on the subject, to resume running radio programs in its columns in a manner which makes them intelligible to the listener.

PORTLAND, Oregon, has passed an ordinance making it unlawful to operate without a permit any apparatus generating high-frequency oscillations which interfere with broadcast reception. Violet ray machines, quenched spark devices, and X-ray machines must be licensed and may not be used, except in emergencies, between the hours of seven and eleven. Power interference, being a local matter, appears to be suited to local regulation.

A NEW transmitter for WEAF will be erected at Bellmore, Long Island. Bellmore is on the south shore of Long Island, the nearest towns being Freeport, Hempstead, and Farmingdale. An advantage of this location is the relatively small population which suffers from proximity to the station and the fact that the new station will impress the strongest signal where ship interference is most likely to mar its programs. Plans for the new station have been drawn by Dr. Alfred N. Goldsmith, Chief Research Engineer of the Radio Corporation of America, Dr. E. F. W. Alexanderson, of the General Electric Company, and Frank Conrad, Assistant Chief Engineer of the Westinghouse Company. This station may be in operation by October, 1927.

RADIO beacons have been installed at McCook Field, Dayton, and at the Detroit Ford airport for the guidance of the Stout-Ford commercial airplane between those two points.

The Electrical Phonograph

A Non-Technical Explanation of the Principles Involved in Electrical Recording and Reproduction—The New "Panatrope" and "Electrola"—Data for the Home-Constructor Wishing to Build His Own Electrical Phonograph

By

JAMES MILLEN

Radio Broadcast Photograph

THE "PANATROPE"

An entirely electrically operated phonograph. Provision is made so that the amplifier system, including the baffleboard loud speaker, may be used for radio purposes after the detector in any radio circuit. This photograph was taken in the Radio Broadcast Laboratory

A MOST fascinating experience for one interested in radio—especially one who has long been connected with its development—is to spend an evening with the early issues of some of the older radio magazines.

A study of the advertisement section not only recalls the queer contraptions that were looked upon in their day as the acme of engineering perfection, but also throws light upon the founding and first products of small companies, regarded now as leaders in the radio industry. Not only do large things often develop from a humble start, but also large concerns of one decade often pass into oblivion by the next.

Aside from this, we may also read what the "prophets" of but just a few years ago outlined for the future of the radio industry. For instance, in the November, 1922, issue of this magazine, appeared an article entitled: "Will Radio Replace the Phonograph?"

Apparently there existed some doubt in the mind of the public as to whether the new novelty, radio, could ever reach the "perfection" of the phonograph as regards tone quality, service, and reliability. Now, on the other hand, there appears to be some doubt in the mind of the public regarding the same question, but from a different angle: "Can today's phonograph compete with the radio in tone quality, service, and reliability?"

But, why not, from comparisons of the two, draw one's own conclusions? It is not at all a difficult or costly task to construct a truly fine electric phonograph. Before going into the construction of such devices, however, let us first find out just what this new instrument, known commercially as the "Panatrope" and "Electrola," really is, and just how it works.

The grooves in a phonograph record are so cut as to cause the needle to vibrate from side to side. In the old phonograph these transverse vibrations of the needle were conveyed mechanically by a system of multiplying levers to a mica diaphragm located at the small end of a horn. The vibration of the needle caused vibration of the diaphragm which set the air column in the horn moving, and thus produced sound.

Such a system, while low in manufacturing cost and reliable in operation, resulted in considerable distortion. The horn was resonant at certain frequencies and the diaphragm at others. Thus some notes were greatly over-emphasized while others were entirely missing.

The new electric system depends for its operation upon the vibrations of the needle to produce a constantly varying electric voltage. The minute electric voltage generated by the movement of the needle is amplified by a high-quality audio-frequency amplifier, such as is a component part of the better radio sets, and then converted into sound by a loud speaker.

While the new phonograph will play the old records, the results are not the same as when the new Orthophonic (correct-tone) type records, made especially for the purpose, are used. In former years, records were made mechanically by a machine much resembling the old-style phonograph, into the horn of which orchestras played while closely and uncomfortably huddled together.

Now, however, studios much the same as those of modern broadcast stations, are employed for record making. Standard radio microphones, as many as needed, are so placed as to properly blend all the instruments of even a large symphony orchestra. No longer must the player in front play softer than natural in order not to "drown out" those in back. Everyone plays as if giving a regular recital, and the various microphones are so placed as to produce the proper results.

In fact, the output of the electric phonograph, when one gets right down to the matter, is but a standard broadcast program which, instead of being sent over the air, is recorded and delivered to the consumer without picking up static, heterodyne whistles, and other disturbances en route.

The acoustical difference between the same piece played by the same orchestra over a high-grade broadcast station on a quiet night and played on an electric phonograph, is nil, assuming, of course, that the same quality audio-frequency amplifier and loud speaker are used in both instances.

With these improvements, and one other—the elimination of the record scratch—the modern phonograph becomes a highly desirable companion to the modern radio receiver. Static and sos signals no longer need spoil an evening's entertainment. Favorite selections, beautifully rendered and reproduced, are available at a moment's notice when the radio program is not tempting.

Even the inconvenience of constantly changing records seems soon to be done away with according to recent announcements, of some of the leading phonograph concerns.

But do not understand this article to be an argument in favor of the phonograph over the radio. The phonograph can never take the place of the radio. First, the radio brings news and entertainment into the home as it is actually occurring—banquets, speeches, sporting events and many others; and second, radio supplies its own program: its *repertoire* is not limited by the number of records in the album.

But, as a companion to modern radio, there is a distinct service to be performed by the electrically operated phonograph.

THE NEW PHONOGRAPH

BEFORE considering the re-vamping of the old-style phonograph, perhaps a brief semi-technical description of the "Panatrope" or the "Electrcla" may not be amiss. In order to make such a description more clear and to better "tie it up" with what is to follow, the complete device will be divided into its various sub-units.

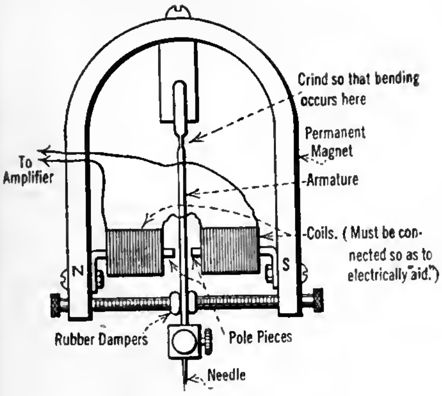


FIG. 1

Details of a home-made pick-up. It consists essentially of a permanent horse-shoe magnet, an armature, and two small electromagnets. The armature is reduced in cross section at its upper end by grinding. The purpose of this is to provide a hinge-like action at this point

First there is the turntable upon which the record is placed. As all of the present models are designed solely for a. c. operation, the motor employed to drive the turntable is generally of the induction type, which, due to lack of the sparking brushes and commutator of the motor, will not cause any pseudo static disturbances in the loud speaker.

Then there is the pick-up, which converts the mechanical vibrations imparted by the record to the needle into electrical impulses.

As will be seen from Figs. 1 and 2, the pick-up consists of a permanent magnet, to which is bolted two pole pieces, two small electromagnets, and a movable armature. Movement of the armature, at one extremity of which is located the needle, results in a variation of the electromagnetic flux passing through the cores of the electromagnets. This variation in flux induces a varying or alternating voltage in the coils of the electromagnets. The home constructed pick-up illustrated in Fig. 1 clearly indicates the form of construction employed in several high-grade units. Some commercial pick-ups employ variations of the design, such as the use of but one coil, that coil being wound on the armature rather than the pole pieces of the permanent magnet.

Although but few readers will have the facilities for making their own pick-ups, a brief description of an electromagnetic unit should prove interesting to even those who intend purchasing a unit.

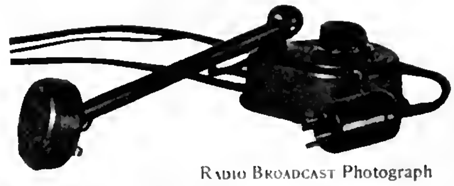
A pick-up, as will be seen from Fig. 1, consists of a special shape and size horse-shoe type permanent magnet to the ends of which are attached pole pieces carrying coils of fine wire. Between the pole pieces is the reed, or armature, which carries the needle.

The permanent magnet should be made from tool steel, cut, drilled, and formed, before being hardened. The larger the cross section of the magnet, the more volume, within limits, that will be obtained from the pick-up. An excessively large magnet will press too heavily upon the record. To magnetize, when a magnetizing machine is not available, wind about a hundred turns of heavy cotton-covered wire around the steel horse-shoe and connect the ends of the wire across a six-volt storage battery for a few minutes. Fewer turns of wire than specified will draw an excessive current from the battery.

The pole pieces and coils may be taken from a radio headset. The headset should be of fairly high impedance and good make.

The armature should also be made of hardened steel, and may either be pivoted or spring mounted. In order that there may be no sustained resonance effect from the armature or reed, it is necessary that it should be mechanically damped. The greater the mass and stiffness of the reed, the greater must be the damping if transient free vibrations are to be quickly checked. The elasticity can be made very small by pivoting the reed, but if the mass is too much reduced, the sensitivity is lowered by the consequent reduction of the iron circuit. Rubber may be used for damping.

Proper adjustment of the completed pick-up is important. The faces of the two pole pieces and the armature must be parallel. The armature must be centered between the pole pieces, and the pole pieces must be as close together as possible without danger of the armature hitting. Damping should not be greater than necessary.



Radio Broadcast Photograph

THE "MEROLA" PICK-UP

An adapter makes possible the use of this device in combination with any good quality amplifier. Merely plug the adapter into the detector tube's socket in the receiver and connect a second lead to the B battery 45-volt post

A COMBINATION OF RADIO AND PHONOGRAPH

Representing the ultimate in luxury so far as home entertainment is concerned. This "Electrola" retails for a sum not considerably below a thousand dollars. The reproduction from the records is by electrical pick-up, electrical amplification, and a cone loud speaker

ELIMINATING NEEDLE SCRATCH

ASIDE from tone quality, one of the outstanding achievements of the new phonograph is the elimination of surface noises and needle "scratch." The use of a new material for the manufacture of records has done much to eliminate this annoyance of the past but the final and complete elimination is accomplished by means of an electrical filter circuit so tuned as to suppress frequencies in the neighborhood of the scratch frequency. Such an electrical filter is quite simple,

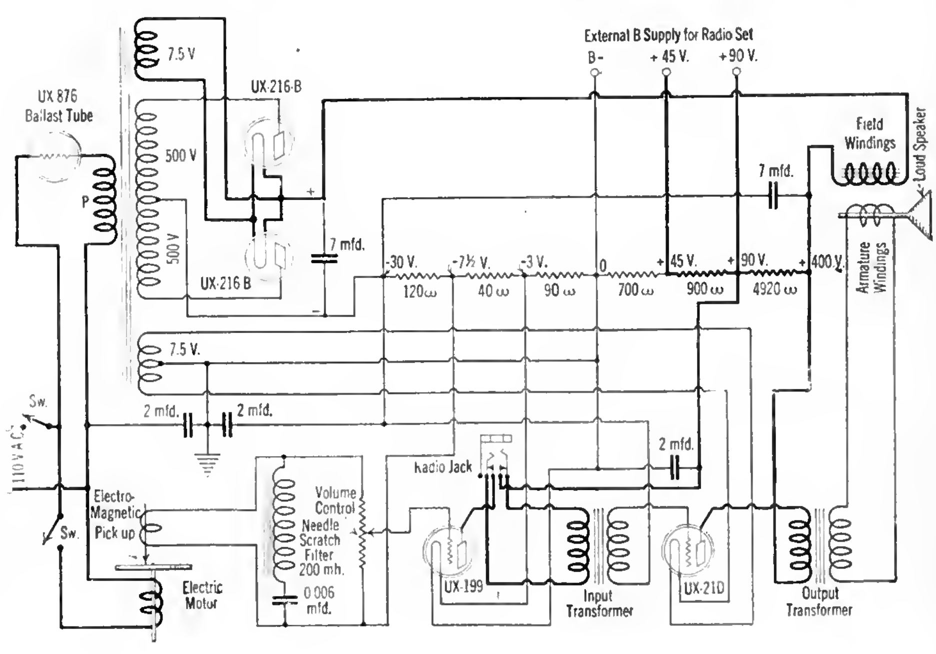


FIG. 2

The circuit diagram of the "Panatrope." The purpose of the five tubes employed is as follows: The two UX-216-B's are wired to form a full-wave rectifier system. The UX-876 is a ballast tube connected in the a. c. line to compensate line voltage variations. The UX-199 is the first stage audio amplifier while the UX-210 is a power output tube—the second audio stage

RADIO BROADCAST Photograph

THE GRIMES PICK-UP

An excellent example of the electro-magnetic type of pick-up

as will be seen from Fig. 3, and is connected between the pick-up and the amplifier. The filter is so located before, rather than after the amplifier, in order to prevent unnecessary overloading of the amplifier.

The volume is controlled by a wire-wound potentiometer which permits the audio-frequency voltage supplied to the amplifier to be made any desired fraction of the pick-up output.

The amplifiers employed in the present commercial models of the electric phonograph operate entirely from a. c. The circuit, as will be seen from Fig. 2, comprises a stage of voltage amplification, using a UX-199 tube with filament lighted from rectified a. c., and a stage of power amplification using a UX-210 tube with filament lighted from raw a. c. This power tube is supplied with a potential of close to 400 volts, and the requisite negative grid bias. Transformer coupling is employed between the two stages of amplification as well as between the amplifier output and the loud speaker.

The power supply, which is the same as that employed in the RCA-104 loud speaker, embodies several unique features.

First, a line ballast tube is employed to compensate variations in line voltage so as to prevent changes in filament current of the 199 tube, and to adapt the complete phonograph to power lines of various voltages located in different sections of the country.

Second, the field winding of the baffleboard type of Rice-Kellogg cone loud speaker is used as the filter choke for the B supply.

Third, the necessity of a ground connection is eliminated by the use of a 2-mfd. condenser between one side of the 110-volt line and the center-tap of the power tube filament winding. In inserting the 110-volt plug in a socket or other outlet, the plug should first be tried one way and then the other as best results are generally secured when the grounded side of the line is the side to which the condenser is connected.

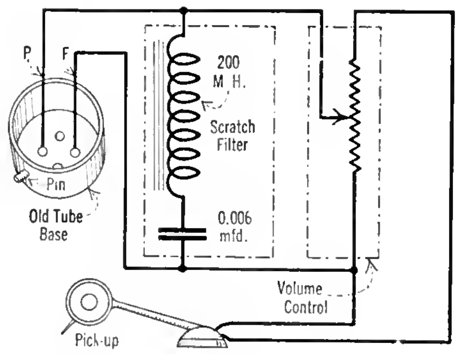


FIG. 3

The electrical connections of the pick-up, scratch filter, volume control, and adapter. The scratch filter as shown is tuned to approximately 4600 cycles

A special input jack makes the amplifier—loud speaker unit available for operation directly from the detector output of any radio set, or better yet, a small two- or three-tube set, such as the two-tube R. B. "Lab." receiver, described in the January RADIO BROADCAST by John B. Brennan, may be built just for the purpose.

Terminals are also provided on the phonograph for supplying B power to the radio receiver.

The loud speaker, as already mentioned, is of the cone type and is electrically "tied into" the amplifier due to the use of its field winding as a filter inductance.

RADIO BROADCAST Photograph

WITHIN THE "PANATROPE"

The rear of the baffleboard loud speaker is seen in the center of this picture. A metal funnel is placed over the UV-876 tube to deflect the heat

RADIO BROADCAST Photograph

THE HANSCOM "SUPERUNIT"

This pick-up is constructed from a Baldwin phone unit

PICK-UPS

THERE are at least four different types of pick-ups. The electro-magnetic and the crystal types function by generating voltages, while the condenser and the carbon forms operate by variations of impedance.

Of these four, the only one of commercial importance, and, it would seem, the most practical, is the electromagnetic form. To this class belongs those used in the "Electrola," "Panatrope," and the "Vitaphone." This latter is in reality a special electric phonograph designed for synchronization with a motion picture projector.

One of the large corporations interested in the development of radio is experimenting with a pick-up of the crystal type but as yet this unique device is still in the experimental stage.

Pick-ups of the carbon type have been in existence for a number of years but only recently has one capable of high-quality reproduction been perfected. This is the "Bristophone," shown in a photograph on page 23.

This pick-up, which depends for its operation upon the change of its electrical resistance with vibrations of the needle, is in a somewhat different class than the others as it is designed to operate a loud speaker without the use of an amplifier.

Some pick-ups are made of the same parts as used in the construction of an ordinary radio type head telephone. That such should be the case is quite reasonable, for the function of the pick-up is exactly the reverse of the loud speaker unit or telephone receiver.

Generally, however, such devices tend to overemphasize certain notes and, unless used in connection with a "trick" amplifier, will sound "flat." An exception is the unit from the Western Electric 540 AW cone loud speaker. This unit can be converted into a very fine, but needlessly expensive, pick-up. One of the tricks to such a conversion is the counter balancing of the tone-arm so that the unit, which is quite heavy, does not press too hard on the record.

As a rule, however, for best results, a unit designed from the "ground-up" as a high grade pick-up should be used. Several units of this type are now being manufactured.

USING A PICK-UP WITH ANY SET

BY REMOVING the base from an old 201-A tube (this may readily be accomplished by heating over a gas flame to melt the cement in the base and the solder on the prongs), and connecting the leads from a pick-up to the plate and filament prongs, as shown in Fig. 3, the home-made pick-up shown in Fig. 1 may be used with the amplifier in any radio set. Merely remove the detector tube and in its place insert the "adapter." Fig. 3 also shows the inclusion of a scratch filter and volume control.

The audio amplifier channels of many radio sets in use to-day are so poor as to make such a system of using the pick-up most undesirable. There is little good in purchasing or constructing a pick-up for obtaining the same quality from a phonograph as from a radio set if the audio quality of the radio set is poor.

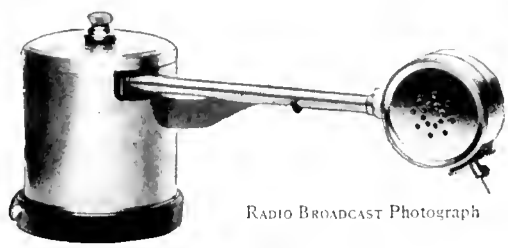
RADIO BROADCAST Photograph

A HOME-CONSTRUCTED PHONOGRAPH-RADIO COMBINATION

Built by the author. A more detailed description of this particular instrument is scheduled to appear in RADIO BROADCAST for next month

A desirable thing to do is to construct a new high-quality lamp socket operated audio channel of the type described by the writer in recent issues of RADIO BROADCAST so as to secure well nigh perfect phonograph and radio quality.

Where the amplifier in the radio set is to be used with a pick-up, the following essentials of good quality should be kept in mind:



RADIO BROADCAST Photograph

THE "BRISTOPHONE"

A pick-up of the carbon type which operates a loud speaker without using an amplifier

1. Use of high-grade coupling mediums. The use of the new large-size audio transformers, resistance coupling, or impedance coupling, is to be recommended.
2. Use of a power tube in last audio stage with proper B and C voltages to prevent overloading.
3. Use of an output device. Inductance-capacity units are, in the author's opinion, preferable to the transformer units.
4. Use of a high-grade loud speaker.

SCRATCH FILTERS

WHILE an electrical filter circuit of the type indicated in Fig. 3 will remove all objectionable scratch from the music issuing from the loud speaker, it will not prevent one hearing the un-amplified scratch noise directly from the record. For this reason the lid of the turntable compartment should be kept closed while records are playing.

A high-resistance potentiometer, such as the Centralab or the type L Electrad Royalty unit, makes a very excellent volume control, when wired as indicated in Fig. 3. As a rule, it will generally be found rather convenient to mount this volume control on a small square or disc of bakelite in the turntable compartment of the phonograph. This same panel may also well contain the amplifier control switch.

To get the full benefit from a home-constructed electric phonograph, it is essential to use the new electrically cut records and a good loud speaker of the cone type. Of course the pick-up and amplifier must be good, but generally, after devoting much attention to them, the final results are spoiled by failure to use a good loud speaker.

In the June RADIO BROADCAST, details of a console phonograph cabinet in which a two-tube R. B. "Lab" receiver, baffleboard loud speaker, and lamp-socket powered amplifier with record pick-up, will be described. Data on the construction of a special amplifier, entirely lamp-socket operated and designed primarily for use with a pick-up device, will also be given.

RADIO BROADCAST Photograph

A VIEW OF THE TURNTABLE COMPARTMENT OF THE BRUNSWICK "PANATROPE"

This picture shows the magnetic pick-up arm to the right, the "start-stop" switch at the left, and the volume control above the switch. An induction type of motor turns the turntable, making the operation of the "Panatrope" completely electrical

A Balanced Short-Wave Receiver

A Description, by the Designer of the Best Receiver Submitted in Radio Broadcast's *Recent Contest, of a Short-Wave Receiver That Won't Radiate*

By FRANK C. JONES

Amateur Station 6 AJF

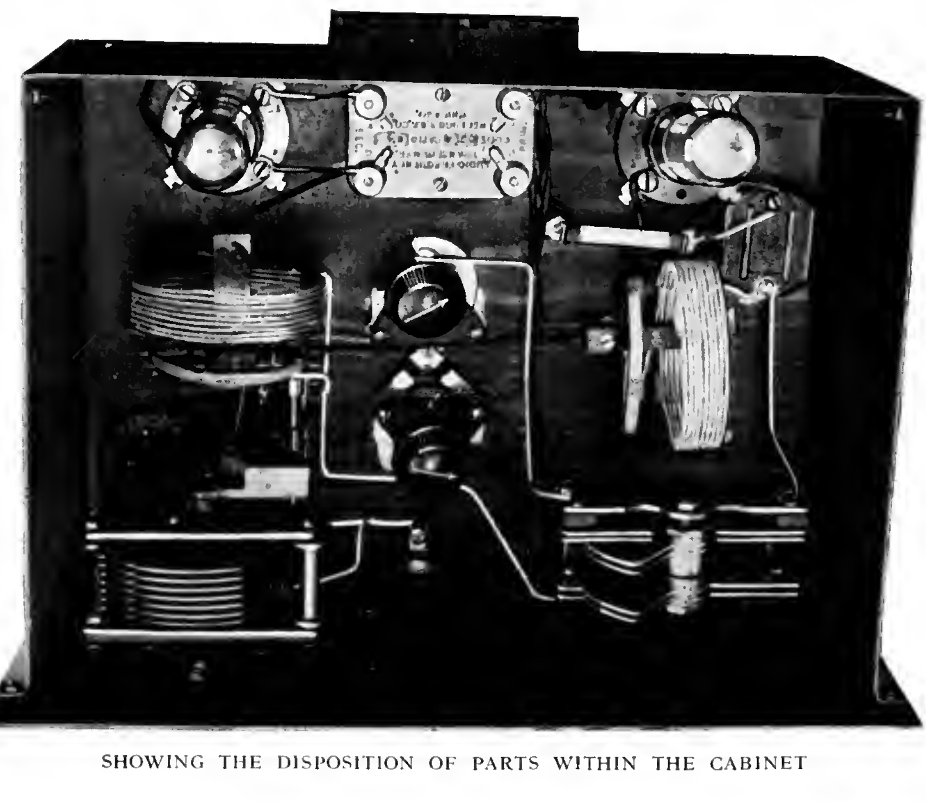
THE short-wave receiver described by the author in the September, 1926, issue of RADIO BROADCAST was an effort toward the design of a short-wave receiver which would not radiate and interfere with other near-by receivers. Although it had many desirable features, it was not as sensitive as a standard short-wave receiver. The receiver described in this article is the result of further experiments and calculations carried along the same lines. If made carefully, it does not radiate at all and is, in the author's opinion, just as sensitive as the ordinary carefully built short-wave receiver. The improvement over the first receiver described is considerable; in fact, there is no comparison between the two, both as to non-radiating qualities and sensitivity.

The receiver, as shown in the accompanying pictures, was a model built up after the circuit was conceived and not in its final form, since a thorough job of shielding had not been done when the photographs were taken. Imperfect though the photographed receiver was, it was possible to copy New Zealand amateurs on a second receiver while this incompleted one was connected to the same antenna and ground system and permitted to oscillate on the same frequency as the distant station. No interference whatsoever was apparent from the oscillating set during the reception of the New Zealand stations. The writer has never seen any other short-wave receiver which could approach that mark for non-radiating qualities. When listening to the same New Zealand station on the balanced receiver described here, the standard receiver could not be tuned to the same frequency without absolutely swamping everything with its whistling. In fact, it would ruin any attempt to receive anything except a local station when it was oscillating on the same frequency as the received station. Capacity coupling to the same antenna was used by both receivers, one being the balanced and the other a standard Reinartz receiver.

The circuit of the balanced receiver is shown in Fig. 1, and, as can be readily seen, is a form of Wheatstone bridge. It is absolutely necessary to use some form of a bridge with the antenna and ground across zero potential points of the oscillating circuit or circuits. In Fig. 1, the midget coupling condensers, C_1 and C_2, form the two capacitive arms of the bridge and L_1,C_3,C_8 and $L_3C_4C_7$ form the essential arms on the other side of the bridge. Both of these latter arms are tuned simultaneously to the same frequency, *i.e.*, that of the incoming frequency and plus or minus say 1000 cycles for heterodyning purposes, and C_1 and C_2 are left set in a certain relation to each other. C_8 is a resultant capacity from the combination of C_5 and the grid-filament capacity, C_g. The condensers C_3 and C_4 are on the same shaft and should be exactly similar so that the two circuits will be tuned to the same frequency or wavelength at any point of the tuning scale. The tickler coils, L_2 and L_4, are coupled inductively to their respective coils, L_1 and L_3, in the proper phase relation to cause the oscillatory currents in the bridge to just neutralize each other, or balance out. L_2 is coupled to L_1 so that the detector will oscillate, and L_4 is reversed with respect to direction of winding to L_3. C_7 is a very small neutralizing type condenser which is set to the same capacity as C_8. This latter setting is easy to determine in practice. C_6 is simply a "throttle" condenser to control the amount of regeneration or oscillation in the detector circuit, such as is used in practically all modern short-wave receivers. Thus the balanced receiver has one tuning control and one feed-back control, the latter being adjusted only once or twice throughout the whole tuning range of the receiver. Simplicity and ease of tuning have been accomplished in this receiver.

Now for some simple theory as to why the receiver does not radiate when properly balanced. The energy of the incoming signal at any one instant can be represented by the dotted arrows. This energy splits and part of it goes through each coupling condenser, C_1 and C_2. The tuning circuits associated with L_1 and L_3, are tuned to the frequency of the desired incoming signal energy and so offer an extremely high impedance to this energy. This means that most of the signal energy is impressed equally across the grid-filament capacity of the detector tube and the small capacitance C_7. The action thus far is the same as for any receiver. The energy component in the plate circuit of the detector through the tickler coils L_2 and L_4 induce energy in the coils L_1 and L_3 respectively, that in L_1 in a direction as indicated by the single-headed solid arrow, and in L_3 in a direction as shown by the double-headed solid arrow. This is obtained by having the direction of the windings of the coils in reverse directions. The energy induced in L_1 adds to the incoming signal energy of the same frequency and this continuous feed-back causes the detector to oscillate. Unfortunately, part of this feed-back energy, as shown by the single solid arrows, splits at the top of the bridge, part of it going across the grid and the rest through C_1 to the antenna, which can, for our purposes, be represented as an inductance, resistance, and capacitance across the points A and G, as shown in Fig. 1. The energy induced in L_3, however, is in such a direction as to be opposite to that induced in L_1 in its effect across the points A and G. The net effect in the antenna circuit is zero output from the receiver. Thus we have a one way circuit, the antenna gives energy to the detector but does not take any away.

Since the circuit $C_1L_3C_7$ is tuned to the desired frequency, as is also $L_1C_3C_8$, these two arms of the bridge offer high impedance to the feed-back energy from the opposite tickler coils respectively, and most of the energy finds its way across the points A and G. The reactance or impedance of the antenna circuit is comparatively low so that the main components of energy are as shown by the arrows. The minute quantities, in comparison with those shown by the arrows, can be automatically eliminated or compensated



SHOWING THE DISPOSITION OF PARTS WITHIN THE CABINET

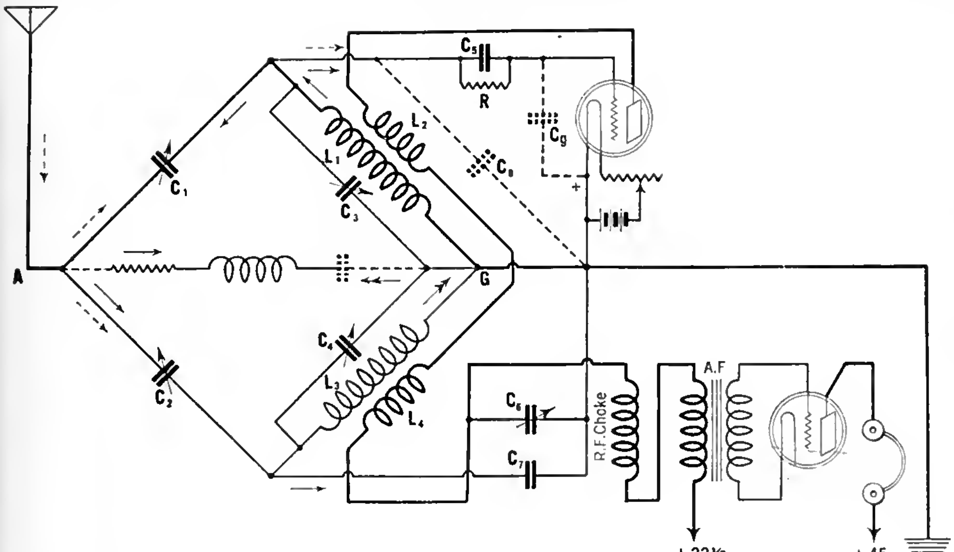


FIG. 1

The Facts About this Receiver

Name of Receiver	Balanced Short-Wave Receiver (Non-Radiating).
Type of Circuit	The circuit is of the autodyne type in which the detector acts as an oscillator. The local oscillations are prevented from going out on the antenna by a special Wheatstone Bridge arrangement.
Number and Kind of Tubes	Two tubes are used, one as an oscillator and detector, and the other in a stage of audio frequency. Either 199 or 201-A type tubes can be used, a slight change in the number of turns in the tuning coils being required for the different tubes, as explained in the text.
Wavelength Range	30 to 50 meters (9994 to 5996 kc).

This receiver is the result of further work on the part of Mr. Jones in his efforts to develop a truly non-radiating short-wave receiver which may be used by the average amateur. His first attempt was described in RADIO BROADCAST in September, 1926. The present receiver is more sensitive and radiates far less than the first because of refinements in the bridge circuit.

in adjusting the values of C_1 and C_2 and the relative positions of the tickler coils L_2 and L_4 with respect to their associated coils, L_1 and L_3.

In order to simplify as much as possible the explanation of this receiver circuit, values of energy were spoken of instead of induced currents and effective voltages. In speaking of induced energy, it was meant that portion of energy which was available at the points of the tuned circuits which would cause a radiation in the antenna system. In tracing through the circuit using currents and voltages, all of the phase differences must be taken into account, which would make it a very complicated explanation of the functioning of this circuit.

CONSTANTS OF THE CIRCUIT

A DIAGRAM which may be somewhat easier to follow in wiring up such a receiver is shown in Fig. 2. The coils L_1 and L_3 should be exactly similar, with preferably spaced winding on a form about 2½ inches in diameter. For covering the 40-meter (7500-kc.) band, 9 turns for use with the 199 type of tubes and 8 turns if 201-A type tubes are used, is about right. In the original receiver, an old 17-plate condenser was rebuilt so that there were two separate condensers in the one unit, each with four plates. This set tunes from about 30 up to 50 meters (about 10,000 to 6000 kc.) when using UX-199 type tubes. The tickler coils, L_2 and L_4, are similar and are wound with about No. 26 wire on a 2-inch form with 7 turns apiece. Celluloid dissolved in acetone was used in holding these coils in shape and makes a minimum amount of dielectric in the field of the coils, L_1 and L_3, where the losses should be kept as low as possible. The coils L_1 and L_3 were space wound with No. 18 wire on a 2½-inch cardboard tube. Four narrow strips of celluloid were laid at equal distances around the cardboard tube and the wire wound over them. Where the wire touches the strips, it was painted with the acetone celluloid solution and allowed to dry, after which the cardboard could be torn out leaving the four strips of cemented celluloid to support the coil turns. The two coil mountings for the four coils were made from strips of hard rubber acting as clamps over the coils, and the whole unit was screwed down to the baseboard of the receiver. This arrangement makes it possible to mount the tickler coils about an inch from the filament ends of the coils L_1 and L_3, and to vary the coupling to L_1 and L_3, which is necessary in balancing the receiver. Incidentally, plug-in coils could be used in order to cover the other amateur bands, providing exactly similar coils with their associated ticklers were obtainable with plug-in mountings.

The feedback control condenser, C_6, can be of any type of some value near 0.00025 mfd. maximum, and could as well be controlled by a small knob as a large dial since it has practically no effect at all on the tuning of this receiver. The radio-frequency choke, in series with the primary of the audio-frequency transformer, is in this case a midget honeycomb coil of about 400 or 500 turns of fine wire. Any kind of a small r.f. choke coil can be used here, though one with a very small external field should be used. There is nothing new or different in the audio amplifier, though a peaked transformer could be used to advantage here, say with a resonant peak somewhere between 600 and 1000 cycles. The coupling condensers, C_1 and C_2 are midget variable condensers of very low capacity, of which there are numerous types on the market. The grid condenser, C_5, should be about 0.0001 mfd., and the grid leak, R, of about 8 or 10 megohms in value. The detector socket should be well cushioned, a piece of sponge rubber being used in the receiver described.

In balancing the receiver, a separate short-wave receiver should be set up, preferably using separate batteries, but coupled to the same antenna and ground. By listening-in on the regular short-wave receiver, a loud squeal will probably be heard when the two sets are tuned to the same wavelengths. It is a good plan to use about 45 volts on the plate of the detector in the balanced receiver in order to make sure that the oscillations will be quite strong. C_1 and C_2, together with C_7, are then varied until the bridge is balanced, which condition will be indicated by there being no interference in the regular receiver when the two are tuned to the same frequency. If the same relative setting of C_1 and C_2 holds true for the whole tuning range of the receivers, then the receiver is nicely balanced and the tickler coils are coupled to coils L_1 and L_3 correctly, and the small capacity C_7 is correctly adjusted. If the condensers C_1 and C_2 have to be changed, then try readjusting C_7, and also the tickler coil couplings, until a correct balance is obtained.

In order to improve the receiver shown, the coupling condensers C_1 and C_2 should be shielded from the rest of the set so that there is no capacitive coupling to the antenna on the antenna side of the condensers. In this set, the antenna lead was brought into the set in a bunch of battery leads, which actually shield it to some extent until it reaches the condensers C_1 and C_2. A good arrangement would be to have the common connection point to the antenna as near as possible to the place where the down lead comes through the shielded box. Another better arrangement would be to have the twin condenser placed in the center of the front panel and the two circuits placed symmetrically on each side of it instead of in the arrangement as shown in the photograph. The set should of course be completely shielded, in order that no radiation will take place from the coils, etc., of the set itself.

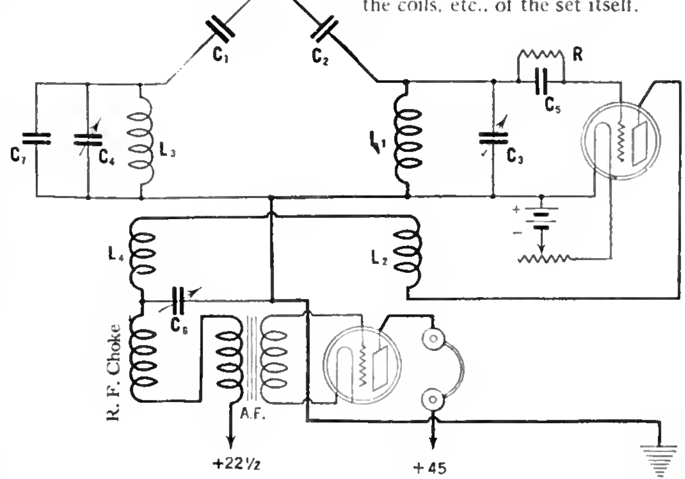


FIG. 2

What About the A Battery?

The Importance of Balance in Trickle Charging—Those Misleading Statements About A Battery "Elimination"—Comparing the Methods of Charging and Their Costs—The Best Rate and When to Charge

By EDGAR H. FELIX

SOCKET Power is a term used to describe devices which enable a receiving set to draw its power directly from the electric light mains. To the uninformed enthusiast, it usually implies a complete elimination of all the elements of the power supply system which require care and attention.

Socket power devices now on the market fall slightly short of accomplishing this desirable result. They do, however, reduce to the very minimum the care and attention required to keep the receiver's power supply at full efficiency. The storage battery and rectifier, which these devices invariably combine in a single unit, do nevertheless require a little intelligent care, and, given that care, are both reliable and convenient.

The most advanced types of socket power equipment comprise a charging device and storage battery so designed that the battery is left on charge at a slow or trickle rate during the entire time the set is not in use. Therefore the storage battery is either discharging through the tubes of the receiver or being charged by the trickle charger. Theoretically, the only attention which must be given such socket power devices is the occasional addition of distilled water to the storage battery and the trickle charger. Even when turning on and off the set, it is not necessary to think about the trickle charger connections because, by the use of an automatic device, the receiver's "on-off" switch disconnects the charger when the switch is turned on, and connects it when in the "off" position. With most devices provision is also made for connecting the power line to a B supply device when the control switch is in the "on" position.

A minimum of attention is indeed attained, *provided* that the trickle charge is of the correct rate to offset the current drawn when the set is used. But, alas, this condition of perfect balance of input to output is not always happily secured. Therefore the filament current requirements of the receiver and the number of hours a day it is used must be determined fairly accurately, and the charging rate by the trickle charger adjusted to meet them. For this reason, A power combinations are equipped with means of adjusting the trickle charge rate to suit the power requirements of different receiving sets.

The importance of balancing charge and discharge becomes apparent when we consider the effects of undercharge and overcharge upon the life and condition of the storage battery. If the trickle charge rate is too low, the battery voltage will fall gradually until the set at last fails to function because of a discharged A battery. In this case, unless the trickle charger has a high charging adjustment which permits bringing back the battery from its discharged state to full charge quickly, it is difficult to restore it to good working order without the assistance of a high-rate charger. When a user experiences a run-down A battery, he naturally increases the trickle charging rate to the maximum, which should bring the battery back to full efficiency in several days. But often, he considers such an experience as evidence that the charging rate should permanently be kept at maximum. For a long time, perhaps even two or three months, this rate gives satisfaction because the battery is always kept fully charged, but, sooner or later, the battery breaks down completely from prolonged and continued overcharging. Active material starts to fall out of the plates and, also, the specific gravity of the electrolyte may rise to a high value and the distilled water of the solution requires renewal every few days. Usually the manufacturer is condemned for these misfortunes, while the cause is simply incorrect setting of the trickle charging rate.

Different socket power devices use different combinations of charging rate. Philco, for example, has three adjustments, low, medium, and high, giving 0.2, 0.33, and 0.6-ampere charging rates respectively. Willard uses a low and a high adjustment, giving 0.5 and 2.0 amperes, while Gould offers no less than five adjustments, 0.2 to 0.25 ampere, 0.275 to 0.320 ampere, 0.350 to 0.425 ampere, 0.450 to 0.750 ampere, and 0.9 to 1.5 amperes, according to line voltage.

With charging rates as high as two amperes available, the danger of grave overcharge, resulting in quick destruction of the battery, is constantly present. On the other hand, a few hours a week with a high charging rate, and a low trickle charge for the balance of the time, will keep the battery in the best of condition.

There are always occasions when a set is used a great deal for a few days for special reasons, and in this case a higher charging rate is temporarily necessary to bring the battery back to full charge. The table on page 27 shows the charging adjustments recommended by Philco. This table gives the average number of hours a day a set may be used at various current drains and charging rates. For example, with a five-tube set used 3.02 hours a day, each tube drawing a quarter of an ampere, the trickle charger at the 0.2 ampere adjustment will keep the battery up to full charge. If the set is used but two hours a day, the trickle charger should be shut off by removing the attachment plug occasionally so that constant overcharging is avoided.

On the other hand, such a five-tube receiver may be used for twelve hours within two days because of some special broadcasting event, and this would draw a total of fifteen ampere hours from the battery. For example, the set may be in use from eight o'clock until one a. m. on one evening and from six o'clock to one a. m. on the next, drawing a total of fifteen ampere hours from the storage battery. Between these two periods of listening, and between the second period and a third period which we shall suppose commences at eight o'clock on the third evening, the battery is recharged for thirty-six hours at the low rate, which gives it back 7.2 ampere hours. Now, if the current drain, after this experience of twelve hours' use in two days, is continued at its normal average for about three hours daily, and the normal charging rate of 0.2 ampere is maintained, the battery may never be restored to full charge.

Understanding these conditions, it is not difficult to understand the correct charging rate. Estimate the average needs of your set in ampere drain and hours of use and adjust the trickle charging rate recommended by the manufacturer for that load. If you depart from this average use by extended use on special occasions, use a higher charging rate for a few days to counterbalance it. On the other hand, if the receiver is subject to long periods of disuse, disconnect the attachment plug for a few days when you estimate the battery to be in a fully charged condition. These are operations of the utmost simplicity and, by observing

Radio Broadcast Photograph

A THREE-IN-ONE SOCKET POWER DEVICE

Combining trickle charger, storage battery, and B power supply in one unit. Although there are many manufacturers combining the first two in one unit, there are comparatively few who manufacture such a device supplying B current also them, you get the true convenience of socket power.

The only other attention required to keep a socket power device in working order is to keep it constantly filled with fresh distilled water. The Gould "Unipower" has an ingenious method of reminding you of this water matter because the rectifier cell is so designed that the rectifier cuts off just before the storage battery needs renewal of water. Hence the battery will go dead before its plates have been unduly exposed because of lack of water. Philco supplies a convenient hydrometer with certain of its larger storage batteries, fastened in the top of the cell case. If the water is at the proper level, squeezing the hydrometer bulb draws electrolyte into the charge indicator. If it fails to do so, you are plainly warned that the water must be renewed. Philco and others also use built-in charge indicators which permit one to see the electrolyte level through the glass walls of the cell, simple markings indicating the danger point.

MISLEADING STATEMENTS

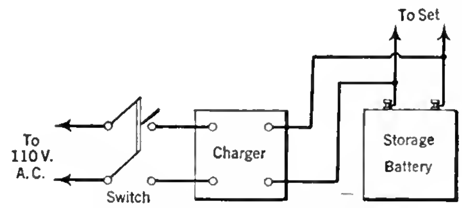
WE HAVE observed the advertising and literature of several concerns purporting to describe A-battery eliminators or insinuating that their devices eliminate A-battery troubles, storage battery attention, etc. A number of these devices which we have examined, are simply storage batteries with trickle chargers. To imply "elimination of storage battery troubles" with such devices is plain deception. If manufacturers are not above using such deception in their advertising, dealers can hardly be blamed for extending this misrepresentation to the consumer. Readers are therefore warned to examine so-called A-battery eliminators carefully before purchase, lest they prove to be only the conventional trickle charger–storage battery combination. They then require the simple attentions herein recommended and will fail in service if they are not given it.

The condition of a storage battery, whether used in connection with a trickle charging device or otherwise, is not difficult to check so long as it receives fairly normal treatment. Voltmeter readings, however, should not be relied upon unless a very accurate, high-grade instrument is used.

A hydrometer is very useful for the purpose, because it is inexpensive and somewhat more accurate in its indications than a voltmeter. However, it too is subject to certain slight discrepancies which, when understood, are not difficult to account for.

When a battery is fully charged, the specific gravity is at its maximum. Constant overcharge produces boiling, reducing the water in the solution and accordingly increasing the specific gravity. Extended and continued overcharging (such as that resulting from an excessive trickle charging rate) tends to force the sulphuric acid to the top of the cell so that we sometimes get a high specific gravity reading although the battery goes mysteriously dead after a few minutes of use.

Another misleading state is manifest when an unusually strong sulphuric acid solution is used. This subterfuge is sometimes employed to make a storage battery appear better than it really is. In automobile service, where extremely heavy current is drawn for a few seconds, it is of advantage to use a strong solution because an electric starter sometimes draws as much or more than ninety amperes from the battery but, with a radio battery, no such heavy loads are drawn. The only advantage gained by the use of a strong solution is a little higher terminal voltage and better specific gravity reading; on the other hand, it causes more rapid deterioration of the plates. The specific gravity reading for a radio storage battery at full charge should be between 1225 and 1300, depending upon the recommendations of the maker. The majority of radio



THE CHARGER ARRANGEMENT

The double-pole single-throw switch is for disconnecting the a. c. power source when the set is in use. The charger is left connected to the storage battery while the set is operating, but unless you are sure that the grounded side of the power line tallies in sign with that of the A battery, the latter should be disconnected from the set during charging hours, unless otherwise specified by the manufacturer of the charger

batteries use an electrolyte showing a reading between 1265 and 1285 at full charge. Recharging should be begun when the specific gravity falls to 1200. Complete discharge is between 1100 and 1150, according to the strength of the electrolyte.

The actual value of a storage battery to a user is determined by:

1. Its voltage output.
2. Its capacity, as determined by its service requirements.
3. Its life.

The voltage is simply a matter of having the correct number of cells and, for radio purposes, the six-volt standard is established by the requirements of storage battery tubes. Four-volt storage batteries are sometimes used for large dry cell sets employing the UX-199 type tubes.

DISCHARGE REQUIREMENTS

THE rated capacity of a storage battery is usually fixed at the maximum amperage which the battery will deliver in a complete discharge of 100 hours. Thus, a one-hundred ampere-hour battery will deliver twelve amperes for a little over eight hours. At higher discharge rates, it gives a lower output in ampere hours, while at a lower discharge rate, somewhat higher capacity.

The effect of drawing an exceedingly high amperage from a storage battery is to concentrate the chemical action of discharge upon the surface of the plates. One of the by-products of discharge is the gradual formation of a high resistance coating of lead sulphate on the plates, and this increases the internal resistance, thus causing battery voltage to fall. A slow discharge rate permits the withdrawal of energy from the very heart of the plate itself and, in so doing, causes the formation of lead sulphate to some depth in the plates. Consequently, the small drains and low charging rates of radio service are harder on storage batteries than the heavy periodical drains of the automobile storage battery.

For this reason, a much heavier and better built form of plate must be used to withstand the ravages of radio service. This is particularly the case in trickle chargers, which are constantly subjected to chemical action by charging or discharging electric potentials. The service life of a storage battery is largely determined by the thickness and quality of the plates. For example, a plate with active material a quarter of an inch thick is good for about 600 to 800 cycles of complete charge and discharge, while one of half that thickness is good for only about 300 cycles of complete charge and discharge. Hence thickness of plates is one of the hidden qualities which determine the value of a storage battery as an investment. The value of purchasing a battery made by a manufacturer of established reputation is apparent when we realize that the true value of a storage battery is completely concealed by its case.

Although a storage battery should not be subjected to continued and prolonged overcharge, it should, on the other hand, be given at least two to four hours overcharge about once a month. This tends to reduce the deleterious effect of sulphation and maintains the battery at its highest efficiency. By overcharging is meant continuation of the charging process after the battery has reached the full charge point. During this part of the charging process, gassing takes place freely and, for this reason, the vents of the battery should be removed.

Only distilled water should be used in replacing that lost by evaporation. It should be added before charging the battery and not afterward in order that it may be thoroughly mixed with the electrolyte during charging. The use of other than distilled water introduces traces of metals and other impurities into the cell, resulting in parasitical electro-chemical actions within the cell, which reduce its output. Rain water, collected in clean containers by direct precipitation, without first passing down roofs and through leader pipes, may be used, as well as clean snow, gathered in clean bottles immediately after a snowfall, if there is no dust or smoke in the air. Distilled water, however, is quite inexpensive and there is little reason for trying to save on this item, thus possibly risking the serviceability of a storage battery worth fifteen or twenty dollars.

The excessive evaporation of distilled water to below the level of the tops of the plates means that a part of the plates is not used in charge and discharge, reducing the capacity of the battery, also that the electrolyte is more highly concentrated, both of these being undesirable results.

Filament Current, Amperes	Rate and Hours Service		
	0.2 Amp.	0.33 Amp.	0.6 Amp.
0.25	10.0	13.1	16.4
0.50	6.35	9.00	12.4
0.75	4.65	6.86	10.0
1.00	3.66	5.54	8.40
1.25	3.02	4.64	7.24
1.50	2.57	4.00	6.35
1.75	2.24	3.50	5.56
2.00	2.00	3.13	5.10

A RATE-OF-CHARGE TABLE

Which shows at a glance how many hours a day you may use your set and keep the storage battery fully charged by leaving the trickle charger on for the other hours of the day. For example, suppose you had a five-tube receiver, using four 201-A type tubes and a UX-171 type power output tube. This combination would draw 1.5 ampere hours from the battery per hour. The set could then be used for four hours daily providing the trickle charger was left on for the remaining twenty hours at an 0.33-amp. charging rate

The cases of storage batteries are now so well designed that they are usually quite sanitary. Hydrometers are equipped with non-drip points so that keeping the battery clean is reduced to a small labor. Another convenient form of hydrometer, as stated previously is designed as part of the vent caps, to be screwed permanently into the top of the cell cases. This type eliminates the risk of dripping electrolyte, which damages carpets and furniture. If acid sometimes gets on the outside of the battery, it can be taken up with blotting paper or with a cloth which has first been soaked in ammonia. Local chemical action forms a coating on the terminals of the battery as a result of moisture or spray from overcharging. This should be carefully removed by means of soda water applied with an old tooth-brush, followed by final cleaning with a file or scraper. This precaution is apt to be slighted and is often the cause of receiving set noises. After cleaning the terminals and connecting clips, cover them with vaseline. It will keep them uncorroded for a period of several months.

When a trickle charger or A-battery socket power unit is not employed, other types of chargers are available. Those of the vibrator type are the least expensive. They have the disadvantage of causing noise and, if the vibrator contacts stick, feeding alternating current into the storage battery. New contacts are easily installed at low cost and a fine file can be used to keep the contacts smooth and fairly silent.

Electrolytic chargers of various kinds can be purchased separately or in combination with small storage batteries, forming a socket power unit. These require the addition of distilled water about as frequently as the storage battery itself needs it and, generally after a year or two of use, renewal of the active electrode. Occasionally new acid is needed for the rectifier and that is best renewed at a battery service station, usually at the cost of a dollar or two.

Bulb rectifiers are generally of the two-ampere or five-ampere type. A bulb is usually good for two thousand or three thousand hours of charging. For example, a set which requires a twenty-five ampere-hour storage battery supply a week can be recharged and maintained by five hours charging a week from a five-ampere charger. This is the average A power requirement of a four-tube storage battery set used about three hours a day. A charger bulb used in this modest service would last for many years. In trickle charger service, however, the bulb would be in use about 140 hours a week instead of but five and would therefore last only five or six months. The bulb depreciates as rapidly when furnishing half an ampere as when furnishing two amperes.

Some trickle charger outfits are fitted with bulb chargers. Only when the current drain from a storage battery is so large, by the use of a multi-tube set for many hours a day, is a trickle charger of such large capacity necessary. Otherwise the overcharge danger, to which we have already referred at length, occurs, and the life of the charger bulb is reduced to a matter of months, unless the trickle charger is disconnected from the line a good part of the time. For example, a half-ampere rate, supplied forty hours a week, instead of the entire time the set is not in use, may tenfold the life of the rectifier tube, cut the electric power required to one tenth, and greatly increase the life of the storage battery, by avoiding continued overcharging.

Since the crux of the whole matter of storage battery life and economy is a matter of correct charging rate so as to assure ample current in the battery when you need it but not at the cost of continued and damaging overcharging, it may be of advantage to suggest a simple charging policy which meets the requirements of the average individual.

With bulb type chargers (whether combined in trickle charger units or not) it is preferable to use the two-ampere rate on the required number of overnight charges per week necessary to keep the storage battery in condition. Experience will determine whether one night a week or two nights a week is sufficient to keep the battery in good condition, showing full charge at the end of the charging period and still giving reasonable service voltage before charging is begun again. Five-ampere chargers bring the battery back into condition quickly, but they offer a rate which is generally a little high for radio receiving requirements. A high charging rate means more intensive chemical action with consequently intensified deterioration of the plates.

With chemical types, low charging rates are generally available. Perhaps the easiest policy to pursue is to use a low charging rate during the week, which seems to keep the set going satisfactorily under ordinary conditions, without permitting the storage battery to reach a nearly discharged condition at any time. It may be below full charge a good part of the time without danger so long as it is not showing a specific gravity below 1150 at any time. Then, over the week-end, give it a high charging rate, if that is necessary to bring it to the full charge condition. If the set is used for prolonged periods, one or two nights during the week, so that the balanced condition is upset, restore the battery to its normal condition by a few hours at a high charging rate.

There may be occasions when a low trickle charge rate keeps the battery constantly at full charge and the renewal of distilled water is found necessary more frequently than once a month. This indicates continued overcharging and should be avoided by disconnecting the trickle charger from the set one or two days a week. When some such formula, which gives the balanced condition, is established, storage battery maintenance becomes a simple and easy matter.

CONCLUSION ABOUT CHARGING

IN THOSE few areas served by direct current, rectifiers are not suited to storage battery charging. The only thing required is some form of resistance so as to reduce the current supplied to the battery during charge to the value which it requires for the purpose. A convenient form of resistance is an electric light bulb connected in series with the battery, of a wattage determined by the battery's charging requirements. A fifty-watt lamp, connected with a six-volt storage battery, supplies about half an ampere; four such lamps in parallel will deliver two amperes. The circuit diagram on this page shows the correct circuit connections.

Two precautions should invariably be observed when charging storage batteries. First, be certain that the positive or plus, charger lead is connected with the red, plus, or positive A-battery terminal and that the negative charger lead is connected with the minus A-battery terminal. Second, disconnect the radio set from the A battery terminals, unless you are absolutely certain that the power line is not short-circuited through the charger.

To determine the polarity of the power line leads when charging through a bank of lamps plunge the terminals to be connected with the battery into a glass of salt water solution. Bubbles will rise from the negative terminal. Rectifiers of the electrolytic and bulb type have plain markings, usually employing a red wire for the positive lead.

Many misleading statements have been made as to the cost of battery maintenance.Service stations charge from fifty cents to one dollar for charging a radio battery and, if this service is required twice a month, the cost comes to one or two dollars a month, plus inconvenience and "time out" because the set is not in service.

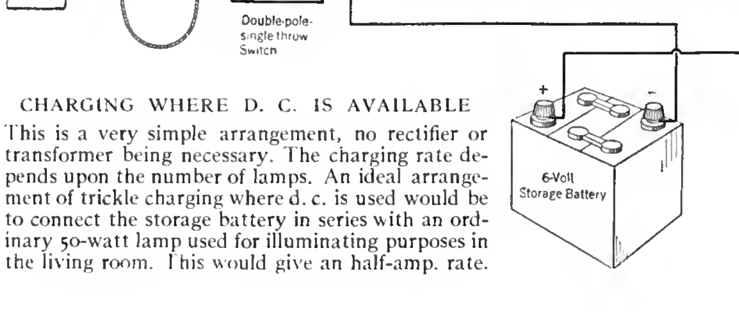
Chargers of various types are generally advertised as drawing negligible current from the line but this is not always true. The most efficient way to charge a battery is with a standard charger capable of supplying several amperes—say two. Such chargers draw 25 or 30 watts from the line so that, if used five hours a week, only about one seventh of a kilowatt, costing from two to three cents depending upon the locality, will be used. Trickle chargers draw from 5 to 20 watts from the line, the average being about 10 watts. Assuming you use a set three hours a day, this means about 630 hours of non-use a month which, at 10 watts, means 6.3 kilowatt hours The average rate is ten cents a kilowatt hour so that the upkeep cost for electric power is about sixty three cents a month. The chemical type of charger is somewhat more efficient than the bulb type when they are used for trickle charging and, for this reason, from the standpoint of economy, the electrolytic type is preferable although this advantage is offset by the fact that the chemical type requires more care in its upkeep than does the bulb type.

Since it is advantageous to disconnect the trickle charger if it subjects the battery to over charge, we find in power economy an added argument for disconnecting the trickle charger two or three days a week. In this way current cost, with practically any type of charger, may be reduced to less than a dollar a month.

We therefore find that A power satisfaction, with due consideration to convenience, economy, and reliability, is most readily attained by observing the following:

1. Use a charging system, whether trickle or high-rate, which balances the load from the battery.
2. Keep the electrolyte level of rectifier and storage batteries correct by the addition of distilled water.

The first rule may require occasional disconnection of the trickle charger or the use of a higher charging rate for limited periods. The reward for obeying these most simple precautions is unfailing and reliable A battery service at low cost.



CHARGING WHERE D. C. IS AVAILABLE

This is a very simple arrangement, no rectifier or transformer being necessary. The charging rate depends upon the number of lamps. An ideal arrangement of trickle charging where d. c. is used would be to connect the storage battery in series with an ordinary 50-watt lamp used for illuminating purposes in the living room. This would give an half-amp. rate.

THE LISTENERS' POINT OF VIEW

Conducted by John Wallace

How Long Will Radio Broadcasting Prosper?

DOPING out what is going to happen in the future is always a pleasurable, if hardly ever a profitable, pastime. Most dopesters of radio's future are extravagant in their prophecies of ever-widening influence and ever-increasing prosperity. We are inclined to agree with them, providing they do not attempt to push their claims too far into the future. For it is our conjecture that radio will arrive at its full maturity in a very few years. From then on its course will be no more sensational than is that of the talking machine at the present time. And in a decade or so will come some new contraption that will relegate radio to as exciting and varied career as that of a telephone operator.

But this inevitable cycle could, conceivably, be nipped in the bud (astounding mixed metaphor) by the failure of radio to keep up with the exactions of a public which has already become inured to its novelty. Concerning this possibility we have an interesting letter from a reader, J. R. Coolidge 3rd, of Brookline, Massachusetts, which presents a good analysis of the factors which will determine radio's longevity. Mr. Coolidge says in part:

"Answering your questionnaire has prompted me to go further into the fundamental questions which affect the future of radio in this country, questions which radio enthusiasts discuss eagerly whenever they meet and for some strange reason rarely put on paper.

"Without having any statistics at my disposal I will assume that there is one radio receiver in use for 50 per cent. of the families in America, and that B. C. L.'s may be divided into three important classes:

"1. Average normal healthy citizens who buy standard sets in good looking cabinets as an investment in entertainment and as a piece of furniture for the living room and because their neighbors have one. This class spends from $50.00 to $300.00 on an outfit once in about five years and then about $25.00 per year in upkeep.

"For them, this investment cannot be worth while in the long run if most of the 'entertainment' is dance music, jazz, cheap popular songs, etc., because the same amount of money would permit them to hear the original performances at frequent intervals and to go to the dance halls, etc., where this class of music is current. If this is to be the prevailing type of program, the majority will cease to use their receivers after the novelty wears off. To hold the interest of this large class permanently it will be necessary to provide music of very high quality indeed, not necessarily heavy classics only but any good music played by well trained orchestras, organ recitals by the most skilled players, good instrumental solos, etc., in the field of music. In other fields, such as politics, education, religion, athletics, and radio plays, the same standards must be maintained if broadcasting is to be permanent. Give the B. C. L. something at home which would be expensive or impossible to obtain outside, and his receiver will be in use every night.

"2. Invalids, shut-ins, convalescents, aged people, those who are hard of hearing, and those who have poor sight. This class is not nearly so large numerically as the first but it is very important because nearly every family has at least one member. To this class, the radio is more than mere entertainment; it is their constant companion. Instead of mere 'news flashes' a good reader could read them in detail extracts from the morning papers every morning, including the best editorial comment. The same could be pursued with regard to magazines and popular novels (a chapter a day). For this class a certain amount of popular music, etc., could be worked in at appropriate intervals before the healthy members of the family returned from their daily occupations. This class does not buy radio receivers, but uses the family receiver hard and constantly. Often it is because of them that the receiver is purchased.

"3. The smallest class, the enthusiasts and experimenters, who buy radio parts and build and rebuild their own receivers, constantly striving to improve the quality, the selectivity and sensitivity of reception, always spending more than they can afford, whether it be in tens, hundreds, or even thousands of dollars, on their equipment. Most of the readers of RADIO BROADCAST must belong to this group, because they alone, among B. C. L.'s, are interested in technical questions and details of construction.

"This group has special requirements—It wants high grade programs just as much as the first group, but in addition it must have DX because DX is a definite measure of comparison between receiving sets in the matter of sensitivity."

The writer's classification of radio listeners seems to us an accurate one, as does also his outline of their respective demands. The first group, he says, must be guaranteed first class entertainment or they will gradually lose interest and finally abandon radio altogether. There need be no grave fears on this score however, for this fact is realized by a sufficient number of radio station operators. Of course it is not realized by all. But that is their hard luck. The

AN INFANT PRODIGY AT WRVA
Conrad Rianhard, aged nine years, who is said to have mastered, to an incredible degree, many difficult piano compositions




NO STRANGERS TO THE MICROPHONE

The first is Eva Gruninger Atkinson, contralto, who sings from KPO; next is Keith McLeod, studio manager and pianist at WJZ; the third is Miss Honarine La Pee, a "syncopating pianist" at KMOX. Miss La Pee recently won a contest as the most popular artist on the staff of this St. Louis station. The fourth photograph shows Miss Josephine Holub, violinist on the "Pilgrim" program, heard from KGO on Tuesday nights

listeners, instead of abandoning their receiving sets, will abandon the inferior stations, whereupon the inferior stations will go out of business.

The service which radio can perform for Mr. Coolidge's second group is undeniable. However, it is a *service*. That is, it is a department which can bring the broadcaster no demonstrable financial return. Evidently, in this day of cut throat operation, no station manager can afford to devote much time and thought to a group which is numerically small. But when time and the operation of the 1927 Radio Law has winnowed the existing number of stations down to a comparative few, these stations will find it not only possible, but advisable, to provide features for minority groups.

Why a Good Program Was Good

THE inaugural program of the National Broadcasting Company, which took place last winter, has come in for quite a lot of praise. Perhaps the most authoritative testimonial to it was that of Samuel Chotzinoff, music critic of the New York *World* in his column: "Concert Pitch." Commenting on the arrangement of the program, Mr. Chotzinoff said.

If Mr. Aylesworth constructed this masterpiece of program making he proves himself a better psychologist than all the orchestra conductors we have ever listened to. Mr. Aylesworth knows that the untutored radio ear cannot be much different from the sophisticated concert ear. Four Beethoven sonatas on the same program are as boring to the trained musician as they are to the public at large, even more boring, in fact, because the musician knows what he is in for.

Mr. Aylesworth might have followed the ethereal "Lohengrin" prelude with the equally ethereal prelude to "Parsifal" and by doing so alienate the radio fans from Wagner forever. Instead, he isolates the "Lohengrin" piece by following its last pianissimo with the lustful, mundane chorus from "Tannhauser." Who but Mr. Aylesworth, ever thought of presenting only the first movement of Schumann's concerto? This movement contains the best of Schumann's inspiration—the other two are anti-climax. During the intermezzo of this concerto, people have a tendency to scan the ads. in the program. Mr. Aylesworth must have noticed this and decided not to take any chances. Even the first movement demands the listeners' closest attention, so Mr. Aylesworth gives his invisible audience a chance to relax by bringing on Mary Garden at once. Mary chooses her own songs, but her personality is intriguing, whether she decides to sing Bach or Irving Berlin. Bear in mind that it is Mr. Aylesworth's purpose to keep his twenty millions from straying out of earshot of the loud speaker.

Those who feel that the Chorale from "Die Meistersinger" is a little too steep will stay to hear the "Lost Chord," which follows it. Will Rogers follows the "Lost Chord." etc.

Compare this amazing program with, let us say, that of the Cleveland Orchestra, which paid us a visit last week. The Clevelanders played a Mozart symphony, the Stravinsky "Fire Bird," and three new American compositions. With the exception of the symphony, for which Mr. Aylesworth can match the Schumann concerto and the Wagner numbers, the highbrow orchestra gave us nothing near as good as any number on the radio program.

As I see it, it isn't the radio that needs encouragement. Mr. Aylesworth should be consoled. The so-called legitimate musical events get the great volume of critical comment because they need it. The radio seems to be getting along beautifully without it.

JAMES PEARSON

The "Newsboy" at KFNF, Shenandoah, Iowa. Mr. Pearson gives a digest of the news at 7:45 P. M. "The Newsboy" is also heard in a health talk at 7:50 A. M. On Sundays, Mr. Pearson gives religious talks



AT STATION CKNC, TORONTO

Frank Blachford, violinist of the Toronto Conservatory of Music Instrumental Trio; R. H. Combs, general manager of CKNC, which is owned by the Canadian National Carbon Company; Arthur Blight, baritone, frequently heard from this Toronto station

Thumb Nail Reviews

WEBH (and others)—The last act of "Il Trovatore" by the Chicago Civic Opera Company from the Auditorium stage. This was the second trial at broadcasting the Chicago Opera and it proved an incredible improvement on the first job. The voices, which in the first attempt were blurred and echo-y, came out clear and undistorted. The orchestra, as before, was well picked up. In fact the whole broadcast made us reconsider our statement that we had little faith in theater broadcasts. It was in every way a success, and to our taste vastly more pleasant than watching the same opera. An unforeseen delay brought this act on almost an hour late. The attempt of the broadcasters to fill in this wait without specially prepared "filler" was indeed a sorry one.

WMAQ—The Woman's Symphony Orchestra of Chicago playing the Caesar Franck symphony, which is heard all too infrequently by radio. The first movement of this symphony, full as it is of luscious tunes, could be made quite as popular as the hackneyed William Tell overture if radio orchestras would give it sufficient airings. And as real music goes, it would constitute a large improvement on the Tell piece.

WBAP—Jazz, pre-war jazz of a vintage we thought entirely exhausted. But evidently it is making a last stand in the hinterlands. Jiggly jazz with stops, panting jazz with a hurry-up tempo, noisy jazz with neither rhyme nor reason.

WHT—Al and Pat, the ultra-lowbrow Hello-folkers-ers of a super-lowbrow station, supplying us with one of the very few stomach laughs we have ever got out of radio. With Al at the organ, Pat commenced reeling off the weather reports in delightful burlesque of our old friend the Pianologue. While Pat improvised a melodramatic and quavering accompaniment on the organ, Al recited, in the manner of one depicting little 'Liza's flight across the ice: "For Iowa increasing cloudiness and rising temperature Saturday (sob). Rain Saturday night (tremolo). Sunday cloudy to p-p-p-partly c-c-c-cloudy (blubber), preceded by rain or snow (tears and a complete breakdown)."

WLS—Haymaker's Minstrels. Oh how sad! Minstrel Shows just naturally don't get over by radio. Even the best of minstrel jokes need the reinforcement of a clowning End Man and the coöperation of a lenient For-the-Benefit-of-Charity audience. As for the worst of minstrel jokes—well those were the type essayed by the Haymakers. F'rinstance: A long discussion between two End Men as to the definition of a new moon, capped after many minutes of futile introduction with the side splitting climax "If a man by the name of Moon had a son he'd be a new Moon!"

KOA—Monologue by a Mrs. (or was it Miss?) Harrison. First rate, and in excellent style for radio delivery. Mrs. (Miss?) Harrison is acquainted with one of the principal secrets of success in humorous broadcasting, to wit—that of not pausing after each wise crack for a laugh. Nobody laughs out loud at a radio joke anyway so such pauses are simply flat. This monologist rushed through with her lines at top speed and without underscoring her jokes by a changed inflection of the voice. The ludicrous laugh which punctuated her remarks lost nothing of its mirth in the broadcasting. The sketch was original and had to do with a club woman's busy day.

WJZ and Blue Network—A new radio team, Vernon Dahlhart, Carson Robinson, and Maruy Kellner, specializing in light popular selections, comedy numbers, and songs of the South. Dahlhart, the singer and spokesman, has a non-obnoxious Southern accent, striking a happy mean between the orthodox "number" and the Southern "numbah." The accompanying instruments are a guitar and a violin. Rather good.

WHT—Al Barnes and Pat Carney again; this time in the "Your Hour," presenting "A Trip Through the Dials." Highly comical in a boisterous, infectious way. Why, we ask ourself, have we been missing these perfectly elegant low-brows all these years? To those of you who become wearied at the lofty pomposity of Doctor Damrosch, we heartily recommend the artfully artless Al Barnes as an antidote.

WJZ and associates—The First National To-Be-Weds issuing propaganda for various picture shows in the guise of a controversy on the merits of a movie just witnessed. Terrible!

WEAF, WJZ, WEEI, WBZ, WTIC, WJAR, WTAG, WCSH, WGR, WGY, WLIT, WRC, WCAE, KDKA, WTAM, WSAI, WLW, WWJ, WGN, WMAQ, KYW, KSD, WOC, WCCO, WDAF, WFAA, WSM, WMC, WSB, KFKX, KVOO, KOA, KSL, KPO, KGO, KFI, KGW, KOMO, KFOA, KHQ, WJAX, WHAS—A speech by one Calvin Coolidge on the occasion of Washington's Birthday. But of course you heard it, so write your own review. This is simply for purposes of record.

WAIU—Celebrating the installation of a new 5000-watt transmitter by reading a lot of telegrams and sending the best regards of the chief engineer to some personal friend of his in Florida.

WAAT—Nut Club at 2 A. M. Oh well, it was our own fault for staying up that late.

KOIL—A radio play "The Scoop." Good in that it was easy to follow and had a quick moving plot. But the lines were amateurishly written and read in a none too convincing manner.

WFAK—(or WFAD or WFAJ or WPCX!?)—Clearwater, Florida. A garrulous announcer who took up at least as much time between numbers as the numbers themselves, and in spite of all his wordiness never succeeded in pronouncing his call letters so they could be deciphered by any one other than a magician. In striking contrast to—

KFI—whose announcers, realizing, no doubt, that they represent the most sought after DX station, call their letters with a pause between each one making the signal intelligible through even the worst static disturbances.

KMA—Henry Powell doing some excellent old time fiddling. Followed by a trio playing conventional, uninspired jazz.

Microphone Miscellany

WE ARE eternally deluged with printed matter telling us how this feature drew three thousand telegrams of commendation and how that artist receives 'em at the rate of three a minute while his concert is in progress. While we frequently scoff, there must be some truth in the matter. If so, it is only reasonable to surmise that the advent of radio has brought the telegraph companies an enormous increase in revenue. Then if this be so, we suggest, with no very valid argument to back up the suggestion, that the telegraph companies return some of this gold to the people by sponsoring a weekly program. If the reports of large telegraphic returns made by radio press agents are veritable, which the telegraph companies will probably now deny, we can see no reason why they shouldn't spend several grand a week dishing out a first rate program. And if their programs were good enough they might receive enough of telegrams to pay the entire cost of said programs —which is something like the worm devouring himself.

ON THE AIR AT WBBM, CHICAGO

Howard Osburn's International Radio Orchestra. Left to right: C. Mason, P. Beckler, H. Osburn (leader), G. Moorehead, and N. Sherr

THE KFI-KPO-KGO network has been broadcasting a series of concerts by the Los Angeles Philharmonic Orchestra. The final concert will be on April 23 from 9:10 to 10:45 P. M. Walter Henry Rothwell is conductor.

Communications

SIR:

The National broadcasts form 95 per cent. of what's worth while on the air to-day and they are making, or rather *saving*, radio, but unless one goes up and down the dials on the hour and the half-hour he's liable to miss much that is really good and worth while, for nowhere are these programs all listed—the chaff winnowed from the wheat. Many metropolitan newspapers own or are affiliated with some one broadcasting station, and labor under the short-sighted policy that they should make no mention in their daily radio programs of any big event that is going out through stations other than their own. On New Year's Day, for instance, the Chicago *Tribune* featured the fact that it would put on the air that afternoon, through its station, WGN, a telegraphic report of the Leland Stanford—Alabama football game in Pasadena, "with the WGN Quartet singing college songs and furnishing the local color." Thousands of fans in this part of the country listened to Quin Ryan's "kiss-proof-lip-stick" voice broadcast this big game from the ticker, not knowing that KYW and the WJZ Chain was putting it on the air direct from the Rose Bowl!

And one other thing in this connection: If I were a national advertiser, spending from $1000 to $10,000 a week in creating good-will by giving the radio public the splendid programs that such advertisers are giving, I'd see to it that I had real coöperation from certain participating stations and the newspapers which own them. Station WGN never misses an opportunity of cutting off the New York announcer; and the Chicago *Tribune* does all it can to create the impression that it, The World's Greatest, at great expense, out of pure love, is furnishing this wonderful program to its Dear Readers. It hides altogether, or keeps well hidden in the background, even the name of the advertiser.

These great, national broadcasts can't continue unless they bring their sponsers at least a fair return, and they are not going to bring such return unless they are tied up with a certain amount of definite publicity for the advertiser in question, both in the news and over the air.

R. H. J.
MILWAUKEE, Wisconsin.

SIR:

Your fourth question on the enclosed questionnaire has been answered in a general manner because I think American people tend to judge the quality of their cigars by the price. ("What are the six best broadcasts you have heard?" was the fourth question in the recent RADIO BROADCAST questionnaire). As a simple matter of fact I believe it can be demonstrated that there are hundreds of voices as good as the best advertised ones, dozens of comparatively unknown orchestras that should be ranked near the top, and so on.

What I desire in radio is entertainment. If I wish education it can be secured from books and magazines in a fresher, more interesting, and more permanent form than by radio. I should like to hear a few great men talk over the radio just to discover how human they are—but the others can't ride on my electrons. Neither can the flatted and fluttery vocalists, or the jazz-bos who keep time with a pick handle. I am interested in DX because if the set will bring in KDKA in daylight, or 4 QG at night, then I know that the machine is keeping step in a half-hearted manner, and will bring home entertainment if the weather will let it.

Even in this stationless part of the country nearly every wave carries two stations and a pack of coyotes. It is to weep.

ROBERT T. POUND.
LAVINA, Montana.

SIR:

Of all the "technical" journal's articles I like your facetious articles best of all. Your self-admitted ignorance is refreshing, as is your style of writing.

P. L.
SAN FRANCISCO.

SIR:

I think there is too much constructive criticism of the destructive type in your dept. "As the Broadcaster Sees It" is my preference.

F. H. S.
PITTSBURGH, Pennsylvania.

There seems to be some difference of opinion here!

WHAT THE LISTENER LIKES AND HOW HE LIKES IT

IN THE January and February RADIO BROADCAST a full page questionnaire appeared in this department which was answered in great detail by readers of the magazine. More than 1000 answers were received and the results are tabulated below.

It is difficult to interpret the results fairly, because we had answers from city dwellers in congested radio districts and from listeners in remote points, many miles from the nearest broadcasting station. Many answers were not definite but were interestingly qualified. It will be seen that the replies are classified according to the district from which they came. Metropolitan centers, such as New York, Chicago, and San Francisco, were separated from the others in the tabulation.

Among the many important conclusions to be drawn from this survey, perhaps the most important is that, under present radio conditions, the city listener, especially in the large city, relies on his local stations for the most part, while those living some distance from the so-called "key stations" rely on DX. The comparatively few listeners who answered our specific question: Is the DX listener disappearing? gave conclusive reply that the DX listener is here now and for evermore. Another interesting conclusion is that "instrumental music" is favored as above all other classifications by more than 60 per cent. Serious music, so called, was most popular, although not overwhelmingly so.

The fourth question about the six most popular broadcasts received a variety of answers, which fell into three classes, as the tabulation shows. Our purpose was to discover what six broadcasts had attained great popularity. The tabulation of this question shows that the regular feature or "hour" of greatest popularity was always the one which was broadcast over the largest number of stations. But the comparative popularity of broadcasts such as that of the Happiness Boys and Sam 'n' Henry is remarkable, for each feature is broadcast over but one station. In special events, sports broadcasts top the list. Among individual artists, the name of John McCormack appears most often, although that of Walter Damrosch is a close second.

After this tabulation was completed a large number of questionnaires were received which arrived too late to be tabulated and we regret that these could not be included. And to all those who sent in letters of comment and appreciation and the filled-out questionnaire, we offer our hearty thanks.—THE EDITOR.

The Results

1. Do you listen to your radio evenings as you would to a regular show, or do you simply turn it on and use it as a background to other activities?

	New York	*Chicago*	*San Francisco*	*National*
As a background	10	3	4	91
As a show	45	10	18	370
As a background except for features	80	17	40	448

2. Do you regularly tune-in on distant stations or do you regularly rely on your local stations?

Locals only	65	13	19	314
Regularly rely on distance	25	8	27	423
Distance occasionally	40	5	14	187

(They tell us that the DX hound is a fast-disappearing breed. Is he?)

Yes	1	0	6	36
No	3	3	3	92

3. If you had a hundred minutes to listen to all, or any part of the following broadcasts, how would you apportion your time?

Instrumental Music:				
Serious	26.3%	30.1%	28.5%	23.3%
Light	18.	18.2	14.3	18.4
Popular	16.6	14.8	16.1	17.4
	60.9	63.1	58.9	59.1
Vocal Music	12.	13.6	13.2	12.6
Radio Play	5.3	1.7	8.0	4.7
Speech	4.7	4.2	3.0	3.8
Educational Lecture	7.6	8.2	4.6	7.0
Miscellaneous Novelties	9.5	9.2	12.3	12.8

4. What are the six best broadcasts you have heard?

Hours or Regular Events

Atwater Kent	228
Victor Hour	128
N. Y. Symphony	93
Eveready	89
Boston Symphony	76
Maxwell Hour	53
A. & P. Gypsies	49
N. Y. Philharmonic	48
Whitall Anglo-Persians	47
Clicquot Club	44
Capitol Theatre	44
Ipana	40
Goldman's Band	38
San Francisco Symphony	33
Happiness Boys	31
Roxy	30
Royal Hour	28
George Olsen	28
Sam 'n' Henry	26
Zippers	26
KDKA Symphony	25
Balkite	22
Cook's Travelogue	19
Silvertown	19
Goldy and Dusty	18
Little Jack Little	18
Marine Band	18
Record Boys	16
Davis Saxophone Octette	15

Special Events

Dempsey-Tunney Fight	153
Inaugural N. B. C.	131
World's Series	124
Army-Navy Game	83
Coolidge's Inaugural	39
Radio Industries Banquet	39
Democratic Convention	38
Pershing's Farewell	31
Alabama-Stanford Game	28
Dempsey-Firpo Fight	20
Election 1924	13

Individuals

John McCormack	45
Walter Damrosch	39
Schumann-Heinck	33
Calvin Coolidge	30
Vincent Lopez	28
Joseph Hoffman	19
Will Rogers	18
Rev. Cadman	18
Reinald Warrenrath	17
Madame Homer	16
Marian Tailey	16
Godfrey Ludlow	14
Mary Lewis	12
Mary Garden	12
Rev. Fosdick	10
Wendell Hall	10

Filament Lighting from the A. C. Mains

A Discussion of a Practicable Method for Batteryless Receiver Design—The Advantages of Series Connection of Filaments

By ROLAND F. BEERS

A NATURAL query when discussing the subject of series filaments is to inquire why such an arrangement is either necessary or desirable. This inquiry ably illustrates that growth of tradition which radio is rapidly accumulating. With a few exceptions, modern radio receivers up to the present time have employed the parallel filament connection. The filaments of the radio tubes have been operated from a constant 6-volt source, and variations of individual tube filaments have been made by changing the applied voltage.

It is not difficult to trace the reason for the prevalence of the parallel filaments scheme. In the beginning, audion filaments often required one or two amperes for each tube. A multi-tube set would therefore require 3 to 6 amperes. What better source of power was there, then, than the familiar 6-volt storage battery—a low-voltage, high current capacity affair? Its availability through the regular channels of distribution was assured, and everyone was acquainted with its operation and maintenance. As the first uses of the vacuum tube were determined by the amateurs, so were its tendencies bound to follow along their pioneer activities. It did not take long, therefore, for the 6-volt parallel filament scheme to become firmly entrenched in the minds of those who were to become radio set designers and builders of later periods.

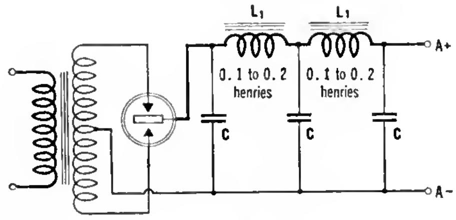
In answer to the query concerning the system wherein radio tube filaments are arranged consecutively in series, it is first necessary to show why A batteries have not yet been completely eliminated by the use of the parallel filament scheme. Let us first consider the general principles of power supply, illustrated by the modern B-power unit. Here we have the customary transformer, rectifier, and filter circuit, as shown in Fig. 2. The current and voltage capacity of such a device is of the order of 85 mA. and 200 volts d. c. The degree of filtering of high-grade units of this type is such that a variation or ripple of but 0.1 per cent. is attained in the current output.

If high-quality reproduction is desired, with freedom from hum and "motor-boating," it is absolutely necessary that the variation in current supply be of this order. In order to achieve this degree of smoothing in plate supply devices, a filter structure of such design as is shown in Fig. 2 is used. The retail cost of a structure of this type is approximately $20.00.

If we are to adhere to the same standard of quality with regard to the A power-supply source, it is also necessary that the current ripple shall not exceed 0.1 per cent. This statement has been theoretically demonstrated and experimentally verified, using an average radio receiver with no potentiometers which may be used to balance out any hum. With such a receiver the storage battery might be replaced with this theoretical A power-supply unit. Basing our judgment upon the design of the filter circuit shown in Fig 2, we may increase the values of the constants required until we obtain the same degree of filtering for $2\frac{1}{2}$ amperes at 6 volts. Our structure will then look like Fig 1. The weight of such a device would be approximately 300 pounds, and its cost, on the same basis as previously assumed, would average $1500.00! For the reason of its weight and cost, it is therefore not feasible to effect A-battery elimination at $2\frac{1}{2}$ amperes.

There are two main reasons why the series filament connection is so much more desirable from the power standpoint. The first reason is that the total current to be filtered is very much less than with the parallel system. With any number of tubes in series, the maximum current required is only that taken by one filament, and as the size and cost of filter chokes increases rapidly with the increase in the amount of current they are required to pass, we realize the economy possible by a reduction of current.

We are somewhat assisted by the fact that the filtering efficiency of a choke coil increases with the current through it; therefore, we should be able to design a more efficient filter system for A supply than for B supply, as far as the chokes are concerned. The amount of energy that can be stored in a given choke coil is equal to one half the inductance times the square of the current. In spite of this fact, however, there are other considerations which work to our disadvantage in the design of a high-current choke coil. For example, on account of the direct-current saturation of the steel core it is necessary to include large air gaps in high-current chokes. These air gaps reduce the effective permeability of the core to low values, making it necessary to increase the amount of copper and iron to large quantities, in order to attain sufficient inductance at high direct-current saturations. We are also limited in this consideration by the amount of copper that can be used in a choke coil, on account of the d. c. resistance. If the choke coils have high d. c. resistance, the voltage output of a power unit intended for parallel filament supply would be much too large on a 3-tube set, for example, if the unit were designed to supply sufficient voltage for a 6- or 8-tube set. A power unit having sufficiently low regulation for parallel filament operation would therefore require monstrous inductances.



C = 2000 to 8000 mfd. for 6 Volts, 2.5 Amps.

FIG. 1

A second reason why the series filament connection is desirable is that higher voltages are available for filtering. For example, a 5-tube receiver with 199 tubes in series requires 15 volts for the filament supply, and an additional 15 volts may be advantageously employed for grid bias. Therefore, the total voltage required is 30 volts instead of 3 volts (grid bias is obtained from external batteries) for the parallel filament connection. Additional voltage is also available at the filter circuit by virtue of the fact that the A current is obtained through a series rheostat, the voltage drop through which may range from 100 to 150 volts (Regulation in this circuit has not the same importance as in the parallel filament scheme, because it is a constant-current system and not a constant-voltage system). The total voltage applied to the filter circuit is equal to the sum of these values or approximately 200 volts.

Now it is a matter of common knowledge that condenser efficiency in a filter circuit is much greater at high voltages than at low voltages. The amount of energy stored in a condenser is equal to one-half the capacity times the square of the voltage applied. Therefore, from this standpoint alone, a great saving is gained. For example, if a total capacity of 12 mfd. is required for a given degree of smoothing at 200 volts, the capacity required for the same degree of smoothing at 3 volts would be in excess of 50,000 mfd. The saving in inductance and capacity affected by the use of the series filament scheme is therefore enormous.

Fig 3 shows a typical filter circuit for use in connection with 199 type tubes in series. This arrangement actually gives the same degree of filtering found in Figs. 1 and 2. Its cost is within reasonable limits, in comparison with other methods of power supply, while its size is not beyond the scope of average radio cabinets.

One obvious way in which to attack the problem of series filament connections is to place the vacuum tubes consecutively in sequence, in the same order in which they normally occur. That is, we may begin with the radio-frequency stages and run through the detector and audio stages. While this method may appear to be the most straightforward, it is open to several criticisms. In the first place, it has been demonstrated that less difficulty with hum will be experienced if the detector is placed nearest the B-minus or ground connection. Several different theories have been advanced to explain this situation, but the important fact to

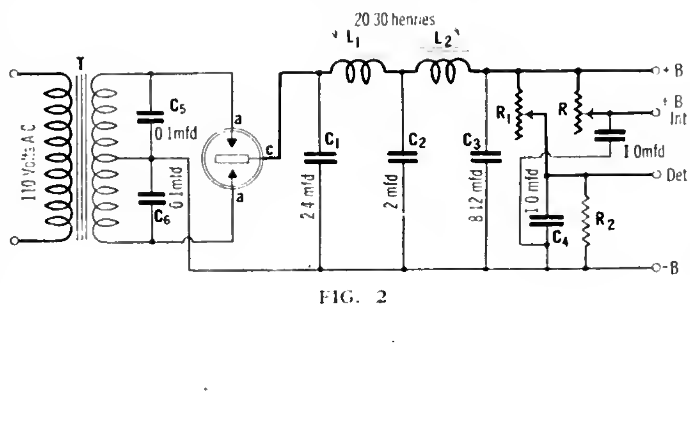


FIG. 2

the average set constructor is that a real advantage is gained by this position of the detector tube.

A second difficulty frequently encountered in this method of series connection is that the proper values of negative grid bias are not always available. In certain commercial receivers, notably the Western Electric 4-B super-heterodyne, it is common practice to connect the grid return lead of those tubes requiring negative grid bias to some preceding filament in the series. This connection takes advantage of the voltage drop

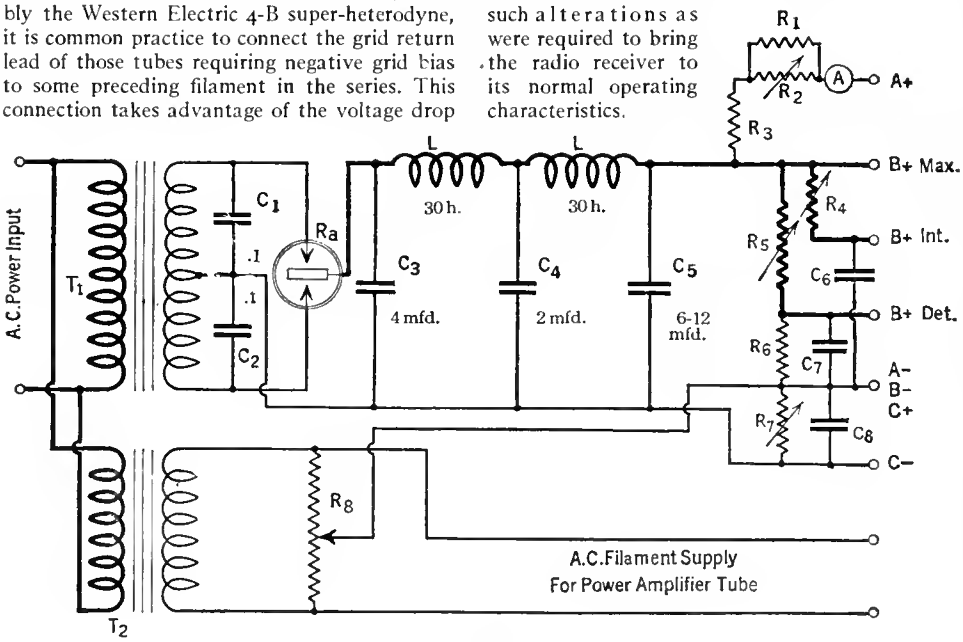


FIG. 3

in the filament circuit, and employs it as a grid bias. It can be readily demonstrated that while some of the tubes in the series will be benefited by such a connection, there will always be at least one of the tubes for which the required negative grid bias is not available. The third objection to the straight series connection is that all of the 199 tube filaments, with the exception of the first, must have some current overload in them, if the applied plate voltage exceeds 40 volts. For an analysis of this situation, see Fig. 4.

In this diagram, with no potential applied to any of the plates, the filament current ammeter, A, could be adjusted to read 60 mA., and the correct current would then be passing through each tube filament. However, when B voltage is applied to the plates, current flows in all the plate circuits, as indicated by the plate milliammeter, B. This current must return to the negative B. If we check the current in the filament for tube No. 3 at the point (b) we would find that it was carrying the regular filament current plus the plate current of tubes Nos. 1 and 2, because, as stated above, these plate currents must return to the negative B, and the most direct path is through the filaments. Consequently, the filament of tube No. 3 would be overloaded by an amount depending upon the plate current of tubes Nos. 1 and 2.

The data printed on the diagram, Fig. 4, give the amount of current in the filaments of each of the first five tubes. The amount of overload depends on the plate current of the preceding tubes. Thus, in the case of tube No. 3 (the 2nd audio stage), the overload is equal to the sum of the plate currents of tubes Nos. 1 and 2.

Examination of the other filament circuits would indicate similar overloading.

On account of these various difficulties involved, it was determined to make a study of the errors which existed in the straight series connection and to make such alterations as were required to bring the radio receiver to its normal operating characteristics.

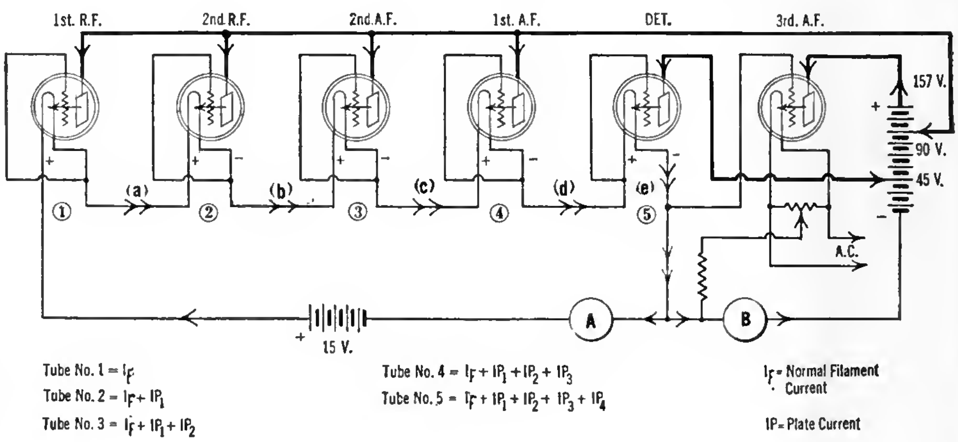


FIG. 4

The first step in this direction was to place the normal grid bias on each tube, with 90 volts on the plates of the amplifier tube and 45 volts on detector plates. It was frequently found that, if the various filament voltage drops were relied upon as the only source of grid bias, three difficulties arose. First, because of the need of a tube in the series ahead of each one requiring grid bias, the number of available biases was insufficient. A receiver wired in this manner very frequently blocked completely in one or more stages on account of improper grid bias. When C batteries were inserted in these troublesome stages, amplification was again at normal values, but as this receiver was intended to be a batteryless set, other means of grid biasing were sought.

The second difficulty was encountered in the r.f. stages, where regeneration often occurred. In this situation the operator is unable to control his receiver on account of the incessant squeals and whistles of heterodyned carrier waves. A similar situation may also exist in a.f. stages. In this case it may cause an audio howl that will completely prevent reception.

The means finally adopted in obtaining correct grid biases was to place a 60- to 75-ohm adjustable resistance in series with each filament, for 199 type tubes, as shown in Fig. 5. This method is entirely satisfactory and has been used to some extent in Western Electric receivers. If adjustable resistances are used, the plate current of each tube can be set at the right value when final tests are made on the receiver. Fixed resistances may be used, however, if the constructor does not want to make this refined adjustment. The plate current of each 199 type amplifier tube can be reduced to about 2.2 mA., with 90 volts on the plates.

When the 60-ohm resistances were placed in position in the filament circuit, it was found that there was no tendency to regenerate, as outlined above. From a study of Fig. 5 it may be seen that r.f. currents in tube No. 1 must traverse the filament of tube No. 2; likewise, those currents in tube No. 2 must pass through the filament of tube No. 5. The question might arise whether or not this would be a source of regeneration. It was found, however, that the inclusion of the 60-ohm resistances in the grid circuit of the respective tubes was of the proper value to eliminate the tendency to oscillation. This phenomenon is a well known fact, and in many modern radio receivers a resistance is deliberately included in the grid circuit for the purpose of stabilizing the tendency to oscillate. The principle involved here is that, if the resistance of an oscillatory circuit is of sufficiently large value, sustained oscillations

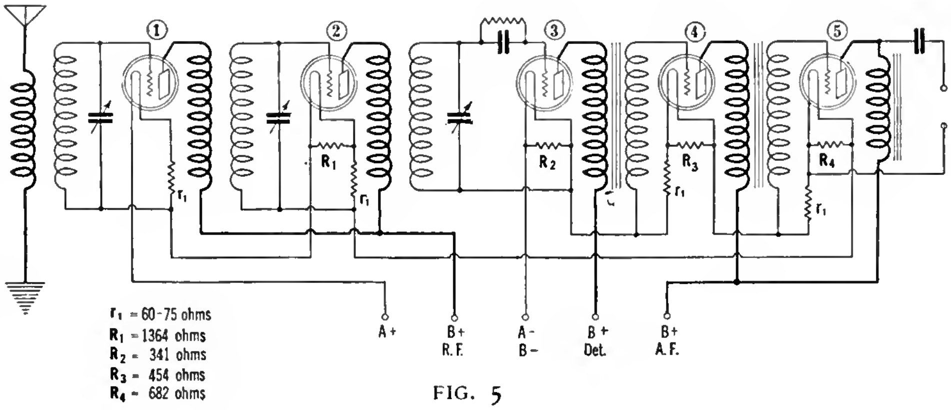


FIG. 5

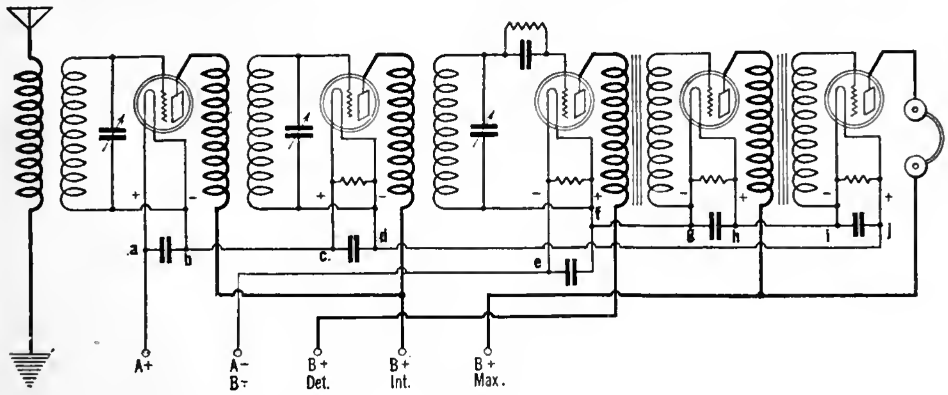


FIG. 6

cannot be produced therein. Such a circuit is said to have a high decrement.

When the series filament receiver had been provided with proper grid biasing, as described, it was found that its performance was at least equal to that of a similar set with parallel filaments. This particular receiver had two stages of tuned r.f., detector, and three stages of resistance-coupled a.f. amplification. Five UX-199 tubes and one UX-112 power tube were used. A filament battery of 36 volts was employed feeding 60 mA. to the set. A plate battery of 157 volts delivered a total current of 22 mA.

If the results of Fig. 4 are now applied to the set in consideration, it is readily seen that the filaments of all the 199 tubes in series, with the exception of tube No. 1, will carry a current which is in excess of 60 mA. The excessive current in the last tube in the series may rise to a value which is 30 per cent. above the normal value. The actual current overloads may be computed by reference to the table on this page. In this table, the overload figures are obtained by deducting 60 from the filament-current figures given in the second column of figures. These data are based on the assumption that all tubes have proper grid bias, that amplifier tubes are provided with 90 volts on the plates, and that detector tubes have 45 volts on the plates. This arrangement will give a plate current in each amplifier tube of approximately 2.2 mA., while that of the detector tubes will average 1.0 mA.

A very simple and satisfactory method of reducing the filament current overload is to shunt a bypass resistance across each filament, as shown in Fig. 5. These resistances do not all have the same values, and their proper size, for 199 tubes, is determined as follows:-

$$R = \frac{3}{\text{Excess Filament Current, Amperes.}}$$

For example, the last tube in a 6-tube series was measured, and its filament current was found to be 71 mA. The excess filament current is therefore 11 mA., or 0.011 amperes. The correct value of the bypass resistance is then equal to $\frac{3}{0.011}$, or 273 ohms.

The table shows the correct values of bypass resistance to be used in various combinations of 199 tubes.

When the receiver has been provided with the correct biasing resistances and filament shunts, it is now ready to be connected up for use. If the receiver is to be used in connection with an electric power supply device, it may be necessary to take additional precautions to prevent "motor-boating."

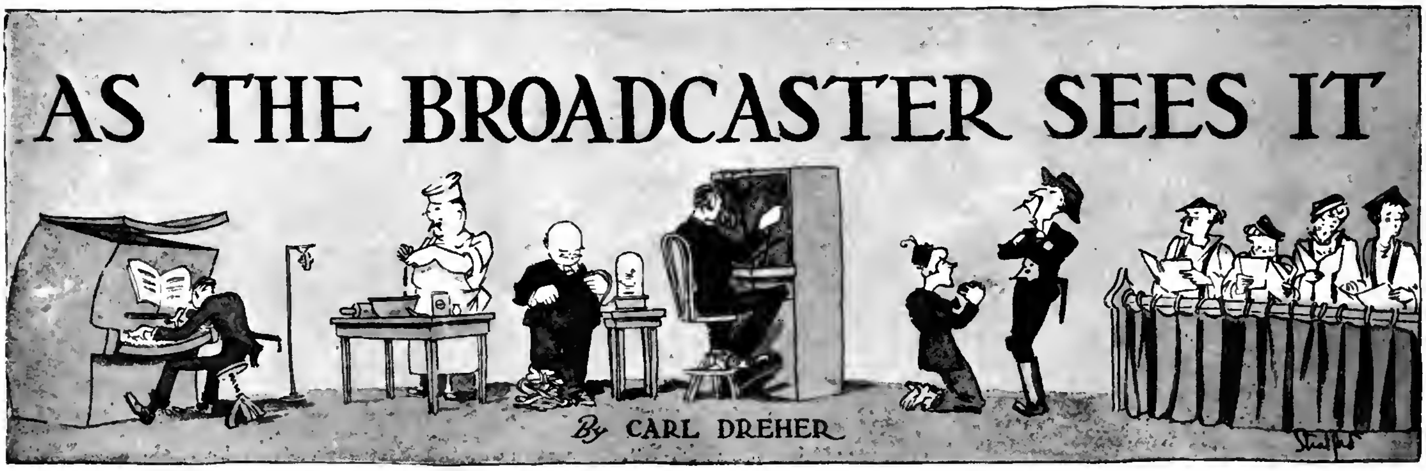
For the present discussion, the following rules summarize the procedure in laying out a series filament receiver using 199 tubes:

1. Wire all filaments in series, including a 60-ohm resistor ahead of each amplifier tube for grid bias. (see Fig. 5).
2. Choose the proper order of wiring the filaments, so that the detector is next to the B minus or ground connection.
3. Place shunt resistances across each filament, as shown in Fig. 5.

The foregoing discussion is based upon a plate voltage of 90 volts on all amplifier tubes, so that large signal voltages may be applied without distortion. Under this condition it is necessary that a negative grid bias be obtained in some manner for these tubes, such as by the use of the 60-ohm resistances in series with each amplifier filament. It is entirely possible, however, to build a satisfactory series filament radio receiver without the use of these 60-ohm resistances, for use on moderate volumes. In this case it is essential that the amplifier plate voltage shall not exceed 50 volts, so that the average plate current will lie between 2.0 and 2.5 mA. This situation frequently prevails in radio-frequency stages where the signal voltage is low enough not to warrant the use of a high negative grid bias, and also in resistance-coupled a.f. stages where the actual voltage on the plates is frequently of the order of 40 volts.

In such cases as these a very simple procedure may be followed—that of connecting the grid return leads to the negative leg of the respective filaments, as shown in Fig. 6. It is, of course, apparent that the use of shunt resistors across each filament is always necessary, in order to prevent current overload. It will also be advisable to provide some means of stabilizing the r.f. amplifier, thus preventing the tendency to oscillation. The inclusion of the 60-ohm biasing resistances reduces this tendency to a very low degree, but without their use, difficulties are at hand. A satisfactory means of overcoming this situation is to bypass these r.f. currents through a 0.1-1.0 mfd. condenser shunted across each filament, as shown in Fig. 6. The use of these bypass condensers insures complete control over the receiver at all times and affords a greater possibility of high-quality reproduction.

Type of Set	Order of Tubes	Plate Current, Ma.	Filament Current, No Shunt. Ma.	Shunt Resistance.
3-Tube Regenerative 3-199's	2nd a. f.	2.2	60.0	None
	1st a. f.	2.2	62.2	1364
	Det.	1.0	64.4	682
Browning-Drake 3-199's; 1 UX-112 on A. C.	1st r. f.	2.2	60.0	None
	1st a. f.	2.2	62.2	1364
	Det.	1.0	64.4	682
Browning-Drake 4-199's; UX-112 on A. C.	1st r. f.	2.2	60.0	None
	2nd a. f.	2.2	62.2	1364
	1st a. f.	2.2	64.4	682
	Det.	1.0	66.6	454
T. R. F. 4-199's; 1 UX-112 on A. C.	1st r. f.	2.2	60.0	None
	2nd r. f.	2.2	62.2	1364
	1st a. f.	2.2	64.4	682
	Det.	1.0	66.6	454
T. R. F. 5-199's	1st r. f.	2.2	60.0	None
	2nd r. f.	2.2	62.2	1364
	2nd a. f.	2.2	64.4	682
	1st a. f.	2.2	66.6	454
	Det.	1.0	68.8	341
T. R. F. 5-199's; 1 UX-112 on A. C.	1st r. f.	2.2	60.0	None
	2nd r. f.	2.2	62.2	1364
	3rd r. f.	2.2	64.4	682
	1st a. f.	2.2	66.6	454
	Det.	1.0	68.8	341
T. R. F. 6-199's	1st r. f.	2.2	60.0	None
	2nd r. f.	2.2	62.2	1364
	3rd r. f.	2.2	64.4	682
	2nd a. f.	2.2	66.6	454
	1st a. f.	2.2	68.8	341
	Det.	1.0	71.0	273
Super-Heterodyne 8-199's	1st i. f.	2.2	60.0	None
	2nd i. f.	2.2	62.2	1364
	3rd i. f.	2.2	64.4	682
	1st Det.	1.0	66.6	454
	Osc.	1.0	67.6	400
	2nd a. f.	2.2	68.6	348
	1st a. f.	2.2	70.8	277
	2nd Det.	1.0	73.0	231



Drawings by Franklyn F. Stratford

One Explanation for the Plethora of Broadcasting Stations

FOR some time, as the number of broadcasting stations in the United States mounts toward the thousand mark, I have been wondering where they all came from, and what process caused them to multiply. Did they reproduce by simple cell division, like the amoeba? Did they cast spores over the countryside, which, falling on fertile soil, took root and became new transmitters? Or was it necessary to mate a pair of them in order to produce a third? Whatever the mechanism, I have found one of the sources of their nourishment, which heretofore I had overlooked. In small towns, it may well be the principal urge leading to expression in kilocycles. It is the booster spirit, the "Bigger and Better Blattville" pressure which all but blows off the safety valve in the would-be metropoli of the inland states. Among other activities, it builds broadcasting stations.

The rivalry between country towns, while usually good-natured, is exceedingly intense. When it goes so far as to lead to the posting of signs about the town, urging the citizens to buy round-trip tickets at the local railroad station, in order that the total for the year may be higher than the ticket sales of some rival settlement down the line, it is apt to extend to all the other activities of community life. One of these is broadcast reception—and transmission. Some village of 2000 out on the plains possesses a broadcasting station, perhaps by accident. A manufacturer of babies' diapers, say, has erected it to advertise his product. Incidentally, he advertises the town. The next village, with 4000 population and a natural feeling of superiority, feels an irresistible impulse to have a broadcasting station bigger than the diaper broadcasting station. The local manufacturer of varnished pretzels thinks he might take a whack at it. His primary object is, of course, to advertise his varnished pretzels. But he also wants to shine at his luncheon club among his fellow business men. He wants to be slapped on the back by the President of the Chamber of Commerce. He wants to be pointed out as a benefactor of the town. These considerations weigh with him as much as his itch for gold. No doubt they are the determining factor in many cases where a station stays on the air although it is actually losing in dollars and cents. The boosters must broadcast. Some of them are even willing to hold the bag for a while, as a matter of civic pride.

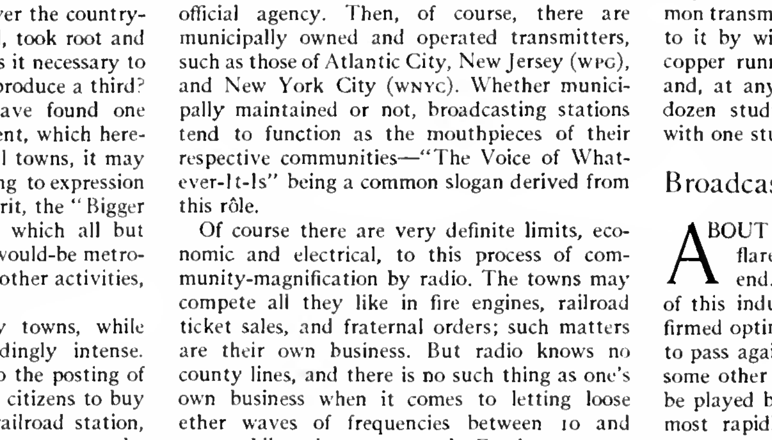
In some cases the stations actually receive community support through the local Chamber of Commerce or some other semi-official or official agency. Then, of course, there are municipally owned and operated transmitters, such as those of Atlantic City, New Jersey (WPG), and New York City (WNYC). Whether municipally maintained or not, broadcasting stations tend to function as the mouthpieces of their respective communities—"The Voice of Whatever-It-Is" being a common slogan derived from this rôle.

Of course there are very definite limits, economic and electrical, to this process of community-magnification by radio. The towns may compete all they like in fire engines, railroad ticket sales, and fraternal orders; such matters are their own business. But radio knows no county lines, and there is no such thing as one's own business when it comes to letting loose ether waves of frequencies between 10 and 50,000 kilocycles per second. Furthermore, to plant a broadcasting station in every township is about as rational a procedure, economically, as maintaining a dozen telephone systems. In wire telephone systems, for reasons too elementary to require statement, unity is the aim. And right there we have the answer to the broadcasting problem as it affects the civic ambitions of the smaller towns. Instead of Podunk having its own precious twenty-watt squeaker manipulated by one of the local apprentice electricians, and Peadunk, fifteen miles away, competing desperately with a twenty-five watter, let Podunk and Peadunk and a few others, if they *must* broadcast, contribute toward a common transmitter, and maintain studios connected to it by wire lines. There is plenty of No. 12 copper running on poles over the countryside, and, at any rate, one transmitter with a half-dozen studios is better than six transmitters with one studio apiece.

Broadcasting and Social Upheavals

ABOUT a year ago the British general strike flared up, ran its course, and came to an end. Maybe it was the last general strike of this industrialized world, but it takes a confirmed optimist to believe that. If it should come to pass again, whether in the British Isles or on some other portion of the globe, what part will be played by radio broadcasting, the latest and most rapidly developing of all the means of mass communication?

The British conflict afforded some indications of what may be expected to happen in the future. Once the battle was on, the regular newspapers either ceased publication or were reduced to little more than handbills. The government published a newspaper of its own, the *British Gazette*, in opposition to the *British Worker*, representing the Labor side. Judged by normal newspaper standards, neither paper was a shining star. But they were about all that remained of British journalism. Piling transportation difficulties on to the confusion in the newspaper plants themselves, the strike raised hurdles too high to surmount. Had it not been for the chain of the British Broadcasting Company, with its principal stations at Aberdeen, Belfast, Birmingham, Bournemouth, Cardiff, Glasgow, London, Manchester, Newcastle, and Daventry, the public would have been practically uninformed during the early days of the strike. At such times the tide toward panic runs swiftly. In the absence of reliable information, sensational rumors spring up and circulate rapidly, gaining horrors, by a well-known process of accretion, as they go



"HE ALSO WANTS TO SHINE AT HIS LUNCHEON CLUB" along. An agency which helps to keep people's feet on the ground, at such a time, is performing no small service. This is substantially what radio broadcasting did in England during the crisis of May, 1926.

Let it be emphasized that our discussion is concerned with the function of broadcasting during times of grave social disturbance in industrial communities. During normal periods, broadcasting occupies a field quite distinct from that of journalism. Since fairly normal periods, until the world gets a good deal worse, may be expected to cover 0.999 of the total time, the newspapers are in a secure position. Their facilities for news-gathering and catering to the interests of great masses of people are in a class by themselves. Broadcasting, in quiet times, interferes with the newspapers about as much as the theatres do; that is to say, not at all. If a man intends to go to a show in the evening, or to listen to his radio, he reads his morning and evening papers just the same.

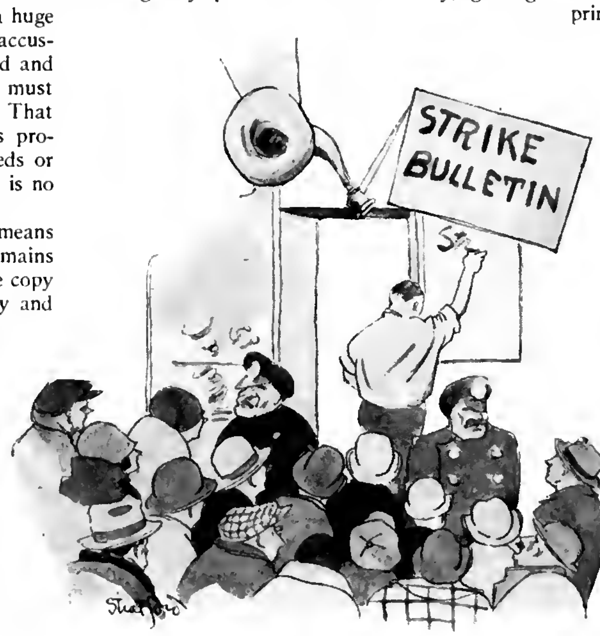
But when there is an acute industrial crisis, the tables may be turned temporarily, as the British strike showed. The reason lies in the contrasting conditions of news dissemination by radio telephony and by printing. Publishing a modern newspaper of large circulation is a formidable project. We do not realize what a huge undertaking it is merely because we are accustomed to it. The thing has been organized and built up on such a scale that we feel it must come around every morning, like the sun. That is a palpable mistake. The newspaper is produced by the concerted action of hundreds or thousands of men. If the men quit, there is no newspaper.

Even if the newspaper is produced, it means nothing unless the distribution system remains intact. Modern newspapers are bulky. One copy does not weigh much, but try lifting fifty and then visualize the motor trucks and mail cars required to transport fifty thousand. Reduce the size, and you have ameliorated the difficulty, but you cannot remove it. Paper is gross matter, subject to the physical limitations of physical things.

Contrast the radio telephone station. Instead of hundreds of workers, it requires only a handful of men. A station of 1000 watts output is considered fairly large; its night program coverage in an urban district is, in fact, comparable with that of a good sized newspaper's circulation—say 100,000 listeners. Plenty of 500- and 1000-watt stations with the studios, control room, and power plant in close proximity can be, and are, run by *one* technician. One of the largest broadcasting plants in the world, with forty or fifty field points, and the studios and radio power plant separated by thirty-five miles, is operated by a technical staff of sixteen men. In a pinch, with the field work tossed overboard, the two engineers in charge, whose functions in normal times are mainly administrative, could run the whole plant alone. They might need a wire chief for the lines connecting the studio and radio station, but a telephone engineer could substitute for the wire chiefs if the latter all went out on strike. In short, three or four professional men, who are likely to be on the "White" side in a serious industrial conflict, can operate the largest broadcasting stations, and one or two men each can take care of the rest. They might not turn out a one hundred per cent. transmission job, but that is beside the point. The station would radiate and say what the proprietors wanted it to say.

The second factor, that of transportation, presents an even more striking contrast. A broadcasting station generates its own "carrier," as the high frequency wave is aptly termed. Its content is not printed on a few ounces of paper or other tangible medium. It is of the nature of radiation—weightless, impalpable, invisible, and, once released, it penetrates to every point within range of the station without the aid of a single man or vehicle. In distribution, even more than in production, the radio is free where the newspaper is shackled, when the men walk out.

Not very many powerful radio stations are required to cover a country of moderate area. In Great Britain a single high-power station, Daventry, of twenty-five kilowatts rating, can cover the entire island kingdom. Countries like France and Germany are similarly protected. Even in the United States a single fifty-kilowatt station located in the North-East can provide usable service, in daylight, for South-Eastern Canada, New England, New York, Pennsylvania, New Jersey, Maryland, Delaware, the District of Columbia, and the Virginias, with a possibility of service to regions beyond. The daylight range of such a transmitter is about 400 miles. The population of the area of a circle of this radius, in this part of the United States, is of the order of thirty millions. Three or four such stations strategically placed over the country, getting news over telephone or telegraph lines remaining in service, or by airplane if the worst comes to the worst, could solve the problem even in the United States. Of course, not every family, even in such industrialized countries as the United States and Great Britain, owns a radio receiver. But millions of them do, and each set is potentially a focus of information when information is hard to get by other means.



"OUR LISTENING WILL BE DONE AT THE ORIFICES OF LOUD SPEAKERS"

The weaknesses of radio distribution of news fall under two heads: First, physical vulnerability analogous to, but less serious than that of the newspaper; second, the limitations of the spoken word, as such. The first division may in turn be considered under two subheads: Power supply and wire connections. A broadcasting station requires electric power, normally obtained from central stations. During a general strike this power might not be available. But the amount required is not excessive, being in the ratio of five or six times the energy output of the transmitter. Ten horsepower would be an ample supply for a 500-watt station. A gasolene driven alternator of two hundred and fifty kilowatts capacity would supply the largest broadcasting station in existence at the present time. Such a machine is readily obtainable, and might be included as an integral part of broadcasting plants whose continuance in operation is vital. As for the telephone lines connecting studio and power plant, the former being located in the city and the latter rurally, a detachment of infantry with a few motor cyclists, could safeguard twenty miles of aërial cable without special difficulty. And in many instances the stretch of wire is short. In New York City, for example, there are two five-kilowatt stations with studios practically adjacent to the power rooms. The assailability of radio stations, even if overt force is employed, is not greater than that of water works and similar utilities, and far less than that of newspapers. As for the telegraph circuits on which the radio stations would have to depend, in the main, for news—armies and navies usually maintain very effective radio telegraph systems. In the United States there would be no insurmountable difficulty on that score.

But, it may be objected, when the radio speaks, its words go in at one ear and out at the other; it lacks the relative permanency of the printed phrase. This defect is of only moderate consequence. For the general public the newspaper certainly contains no element of permanency; it lasts a morning or evening and goes into the fire. The readers remember principally the headlines of the articles which interest them. These salient points are impressed just as well by oral communication, and, by frequent repetition, or by some coördination of printing with radio, the defect may be overcome entirely. For example, in New York City, several hundred police booths and precinct station houses are being fitted out with receiving apparatus capable of responding selectively to the municipal radio broadcasting station. During periods of civil disturbance, these official receiving posts could be utilized as secondary distribution points for news, with no more additional equipment than simple lettering materials for printing bulletins. Such ideas have their ramifications, which we need not trace in this sketch; the developments will follow when the necessity for them arises.

Against the limitations of radio broadcasting, even admitting them to be more serious than they actually are, we must balance the directness and speed of this form of communication. When the radio audience receives blow-by-blow descriptions of prize fights, the impulse of pain has scarcely passed along the nerve paths of the man struck before the radio listeners know as much about it as he does. This quality of immediate contact, as opposed to the tedious mechanical interventions of printing, is of special importance at times when event follows event and conditions change from hour to hour.

The next general strike, wherever it bobs up, will provide food for further reflection. It is a plausible guess that we shall hear more than we shall see, and that our listening will be done at the orifices of loud speakers.

Glad Tidings from the West

A CLIPPING kindly contributed by Mr. Zeh Bouck to this department reveals astounding leaps forward in the progress of the radio art, as set down for posterity in the Santa Cruz *Morning Sentinel*. It is entitled: "Of

Interest to All DX Fans." Only one paragraph need be lifted:

The inventor's claims regarding the application of polarized harmonics was (sic) a little too deep for the writer but to demonstrate what he meant he tuned in KYW where Mr. Meehan was singing an Indian song and by manipulation of the loop he entirely eliminated the accompaniment, also reversing the situation by bringing the accompaniment up so loud that it interfered with the singer. Another demonstration on an orchestra was the elimination or making of the string instruments predominate at will. On a mixed duet the soprano could be almost completely tuned out leaving the tenor singer predominating and vice versa. Altogether, the demonstration was very remarkable.

The only comment I can think of is: "You bet!"

The Radio Club of America

FOR one evening each month, in the large lecture room of Havemeyer Hall, at Columbia University, the portrait of the venerable James Renwick, LL. D., Professor of Natural Philosophy and Chemistry, 1820–1854, looks down on a group of young men, and some older ones, gathered to discuss a subject which did not exist during his life. There are a hundred of these young men, more or less. They talk about power packs, loud speakers, short-wave transmitters, tendencies in modern radio receivers. The portrait of Professor Renwick, who lived while Clerk Maxwell was evolving the electro-magnetic theory, seems to bear a slightly puzzled frown. But the members of the Radio Club of America never look up at him. He is too far back for them. Their thoughts sometimes regress to the early days of radio, to the year 1909, say, when the Club was founded. In radio that is a long time. Radio men think mainly in the present; they find plenty there to occupy them.

The Club has two principal objects—one concerned with the engineering aspects of the radio art, the other with the perpetuation of the amateur tradition. The Year Book for 1926 states: "The Club now has among its members many prominent scientists, inventors, and engineers, as a glance at the membership list will show. However, it is always anxious to embrace amateurs of the present day, in order that its membership shall never lack the renewed life given by embryo scientists." It is primarily an amateur association, as the Institute of Radio Engineers is fundamentally a professional body. Amateurs and professionals belong to both organizations, but the Radio Club members never forget that they were or are radio amateurs, while the members of the I. R. E., carrying the burden of radio scholarship, seldom forget that they are professionals.

The Club now has some 400 members, of whom 108 are of Fellow grade. Fellows qualify by five years of membership in the Club or by contributions to the radio art, at the discretion of the Board of Directors, the governing body. It consists of a President, Vice-President, Treasurer, Corresponding Secretary, Recording Secretary, and thirteen Directors. The officers and seven Directors are elected annually by the membership; the remaining six Directors are elected by a majority vote of the newly constituted Board of Direction at its first meeting. This year, the President of the Club is Ernest V. Amy; C. R. Runyon, Jr. is Vice-President. Past Presidents are W. E. D. Stokes, Jr., Frank King, George J. Eltz, Jr., Edwin H. Armstrong (1916–1920), and George E. Burghard (1921–1925). Mr. Amy was re-elected in 1926 for the present year.

Among the authors who have presented papers before the Radio Club of America are included Armstrong, Farrand, Van Dyck, Weagant, Hazeltine, W. C. White, Godley, Conrad, Heising, Aceves, Clement, Morecroft, Grebe, John Stone Stone, Lowenstein, Dubilier, Goldsmith, Marriott, Logwood, Pacent, and Hogan. The complete list is a formidable one, and the names above represent it only partially. As early as 1912 the members of the Club were talking about square-law variable condensers and directional radio transmission. The value of the papers presented, to the radio art as a whole, has been inestimable. They form a contribution to the engineering literature second only to the collected *Proceedings of the Institute of Radio Engineers*. Incidentally, these papers are printed in RADIO BROADCAST.

AT A RADIO CLUB BANQUET

Seated at the table, from left to right: George H. Clark, E. E. Bucher, Gano Dunn, Edwin H. Armstrong, Michael I. Pupin, E. V. Amy, George J. Eltz, Jr., David Sarnoff, George Burghard, John L. Hogan, Paul F. Godley

The discussions following the presentation of papers are lively and informal. Nobody tries to display his knowledge and no one is afraid to show his ignorance. The attitude is simply that of a group of men vastly interested in radio, whether or not they are making any money out of it, who meet once a month to talk about the subject which happens to entertain them most.

And now, what course is to be charted for the future? Will the Club remain a sort of junior engineering society, or will it become a club literally? One plausible guess is that the organization will become a club in fact as well as in name, within the next few years, but without sacrificing its technical status. The two rôles are in no way incongruous. The formation of some sort of radio club in New York City, with permanent quarters, is obviously within reach. The Radio Club of America has the name. It is a going concern. It has a membership of 400 at this writing. An inspection of the 1926 Year Book reveals that 78 per cent. of the members therein listed reside in New York City or its suburbs. But it is not a club, as yet. It maintains an office at 55 West 42nd Street, New York City, but it has no lounging rooms where the members can guzzle bottles of cool ginger ale, boast about their distance records of fifteen years ago, recall fondly the days when Doc. Hudson called FNK with a service on 600 meters to remind John V. L. Hogan that he had left his pipe at the Doctor's house the night before, and consummate million dollar deals. If half the present membership wanted a club, it could be started on a modest scale, this year or next. Such a development, of course, would not interfere with the monthly technical sessions, and technical membership on the present order, with dues of $3 and $5 a year, could be retained for those not interested in the proposed aspect of the Club's activities. No one who has attended meetings of the Club, or been entertained at one of its annual banquets, can doubt that the organization has the vitality and energy necessary to take the lead in this enterprise. Steps have already been taken in this direction. It is interesting to note that the Club has recently appointed a special "House Committee" for the purpose of investigating the desirability of such an understanding and to submit recommendations for organization and financing. A modest Club House, with comfortable lounging room or rooms, is planned. The radio men in and around New York will await developments with much interest, now that the wheels have actually begun to turn.

Technical Operation of Broadcasting Stations

15. *Volume Indicators*

THE sight of a milliammeter in the plate circuit of an overloaded tube, its needle fluctuating violently, is familiar to every broadcast operator and engineer. When the tube is in the speech circuits of the transmitter the sight, for obvious reasons, is a deplorable one, but the principle, or something on its order, is valuable for preventing the very overloading which the fluctuating milliammeter shows. This is when it is embodied in the instrument called the "volume indicator," much used in broadcasting as a visual guide in setting energy levels.

Before going into the description of one type of volume indicator I should like to make it clear that it is an indicator, as the name implies, rather than a measuring instrument. Basically, the instrument is an alternating current voltmeter, and in certain forms it may be calibrated as an accurate low-reading instrument of this class, extremely useful in telephone and radio work for measuring audio potentials. Again, it may be designed and calibrated to measure telephone levels in TU's. The form shown in Fig. 1, however, is intended primarily as an indicator.

The input transformer shown may be an audio amplifying transformer, preferably with a high-step-up ratio (1:10 or 1:5). The primary impedance must be sufficiently high so that, even at low frequencies, the instrument will not affect circuits of about 500 ohms impedance, across which it is bridged. This means that at 100 cycles the primary of the transformer should have an impedance of 20,000 ohms, which requires 40 henrys inductance, approximately. The secondary of this step-up transformer feeds a vacuum tube, which may be of the UX201-A type, or its equivalent. The grid of this tube is biased negatively to about 10 volts, so that the plate current, measured on a milliammeter, MA., of 0-10 range, is only about 0.5 milliampere with 90 volts plate potential. A filament voltmeter is provided to keep the voltage across the filament constant.

The theory of operation is as follows: Through the negative biasing of the grid, the tube is being worked so far down on the curve that when the transformer secondary contributes a further negative potential to the grid the plate current is only insignificantly reduced. See the characteristic curve of Fig. 3. On the other hand, positive potentials carry the current up on to the steep portion of the curve once more, resulting in a flick upward of the milliammeter pointer. The amplitude of this movement indicates the magni-

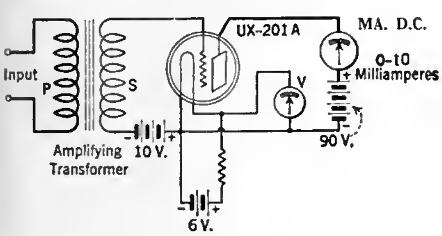


FIG. 2

tude of the alternating potential impressed on the grid, and hence, divided by the transformer voltage ratio, the audio potential on the line across which the volume indicator has been bridged. The device is merely a special form of rectifier. Fig. 4 is a table, in which columns 1 and 2 are taken from the characteristic curve of Fig. 3, showing the variation of plate current with grid potential. Column 3 shows the plus rise in voltage calculated from the base point, which is the negative grid bias potential, 10 volts in this case. Column 4 is this figure divided by the transformer ratio, assumed as 10; this gives us a rough measure of the audio voltage across the input of the instrument. By tapping various potentials along the grid bias battery one may calibrate a volume indicator, for comparative purposes, in this way. The results should not be taken as absolute values, because the response characteristic of the meter, the terminal conditions in the circuit being measured, and other factors, all affect the readings. However, these unknowns may be disregarded when only indications are required. For example, with a tube of normal emission in the volume indicator, and proper filament and plate voltages, it may have been ascertained that, when the volume indicator is bridged across the line leading to the radio station, with given settings there, the maximum allowable deflection of the meter, short of transmitter overloading, is 5.0. Then it is the control operator's business not to allow his peaks on the volume indicator meter to hit more than 5.0, and, even if he does not know the absolute value of the r. m. s. audio voltage he

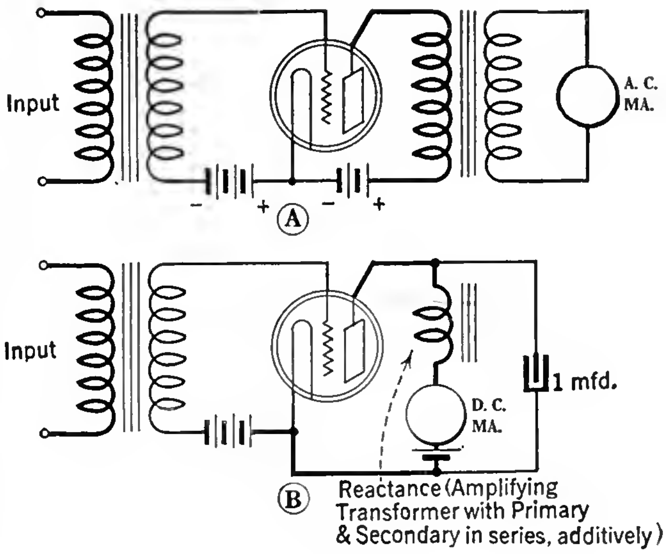


FIG. 1

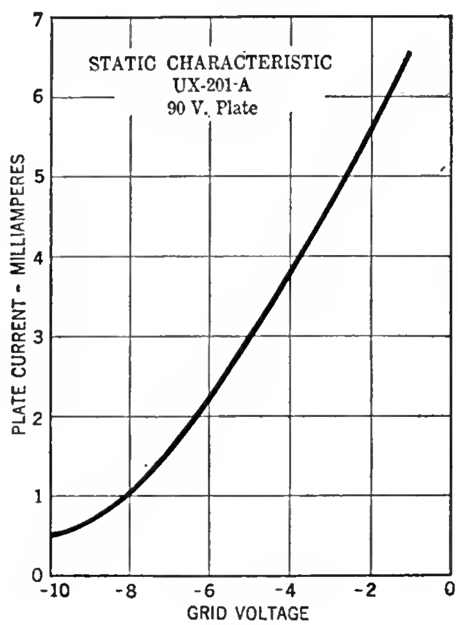


FIG. 3

is putting out on the line, the volume indicator gives him something to go by, and he is far better off than if he were trying to regulate his output only by ear.

Just as loud speakers may be coupled to the plate of the last tube through an output transformer, so an a.c. milliammeter or galvanometer in a volume indicator may be connected in the same way. The instrument then reads only the audio variations in the plate circuit of the tube, the pointer being at zero in the intervals, while when a d.c. millammeter is directly connected in the plate circuit there is always a residual reading of a fraction of a milliampere even when there is no modulation on the circuits. Fig. 1A shows the connection with an output transformer, 1B with a choke-condenser connection, which has proved effective in practice.

For increased range and sensitiveness, volume indicators are sometimes built with two tubes, the first stage being an audio amplifier to bring up low voltages to a point where they can register sufficiently on the second tube, which is the volume indicator proper. Both in the one- and two-tube outfits, various combinations of transformers, tubes, and indicating instruments may be utilized. An ordinary amplifying transformer of 1:3 or 1:5 ratio, a high-mu tube, and a galvanometer of about 1.5 milliamperes full scale reading, is a good single-tube combination. The voltages may be about the same as with the high ratio input transformer, UX-201-A tube, and 0-10 milliammeter described below. Mr. W. K. Aughenbaugh sends in a sketch of a volume indicator using two UX-112's, 45 volts plate, no grid bias, ordinary amplifying transformers, and a 0-10 d.c. voltmeter as an indicator. A swing from 2 to 6 on the meter gives him the proper modulation on the WFBG transmitter, which he runs. This is not really an orthodox volume indicator, and it would be improved with the negative bias feature, but it serves the purpose. Since the instrument is used only as a level indicator, the proper limits of operation having been established by listening checks on quality and overload observations in the amplifiers and transmitter, the operators at each

GRID VOLTS	PLATE MILLIAMPS.	POSITIVE GRID SWING VOLTS	INPUT VOLTS *
-12	0.3		
-10	0.5	0	0
-8	1.0	2	0.2
-6	2.25	4	0.4
-4	3.75	6	0.6
-2	5.6	8	0.8

* With 1:10 Input Transformer Ratio

FIG. 4

station may utilize whatever apparatus is handy and indulge their fancy for experimentation at the same time.

Something About Gain Control

FOR the edification of any members of the operating fraternity who may not have thought about the matter of proper gain regulation, I would point out a fundamental difference in methods. The wrong way is to cut down sharply on excessive peaks. The right way is to bring up the gain moderately on pianissimo passages, reducing it once more to a safe level before or at the beginning of the next crescendo. That is, a skilled gain operator works with a certain base level, set for the particular soloist or ensemble being broadcast as being within the overload limits of the amplifier and transmitter. He brings up the gain cautiously on low portions of the music. He does not have to cut down in a panicky fashion on peaks, because his base level is set to take care of peaks. This ideal procedure requires, in practice, familiarity with the artist's volume range and the score, which can generally be acquired only through a rehearsal.

It also requires a feeling for music. To entrust the gain control to a man without this feeling is like committing a $1200 Sèvres vase to a drunken chambermaid.

Some Facts About Coil Design

The Oscillating Circuit as a Form of Voltage Amplifier—The "Gain" in the Broadcast Spectrum of Some Typical Coils—The Essentials for a Well-Designed Coil

By ROSS GUNN

THE oscillating circuit, as applied to radio reception, has been so thoroughly discussed in the past that it might appear the matter has been completely exhausted. A certain point of view is always most fruitful in the consideration of oscillating circuits, especially in giving one a thorough understanding of the physical phenomena that take place. In the first part of the present paper an approach to the problem is made from a particular angle, and it will be shown that an oscillating circuit is not only a device to select a given frequency but may also be considered as a type of amplifier. In the second part of the paper, the radio-frequency inductance and its relation to selectivity and gain in a tuned amplifier, considering the oscillating circuit, is discussed. Finally, the prime factors that should be considered to make up the ideal coil are given.

The resistance or "loss" in an oscillating circuit is made up of several components, and it is convenient to divide the circuit resistance into two parts, namely, the part due to coil resistance, and the part due to condenser resistance. Modern condensers are relatively efficient since they have resistances of only a fraction of an ohm at broadcast frequencies, while the ordinary coils have resistances of from 5 to 50 ohms. It is then obvious that, even if a manufacturer of good condensers would succeed in cutting the resistance of his condenser in half, the total circuit resistance would be but slightly affected since the condenser resistance is, in general, but a small percentage of the total circuit resistance. On the other hand, if the coil resistance were cut in half, the circuit resistance would be cut almost in half, and the signal impressed on the grid of the amplifier will be double what it would be with the original poor coil. An improvement of this magnitude would be well worth while, and may be accomplished by giving sufficient attention to the design of the coil used in the oscillating circuit. Attention is directed to the coil particularly, because the good modern condensers are so much better than the best coils that there is no particular gain made by the use of the highest grade condensers. The coil, then, should be the object of considerable attention and study until its losses are reduced to a minimum.

In the following discussion it is shown that an oscillating circuit may be considered as a type of voltage amplifier, and a physical interpretation of the relation of the circuit constants to the gain or desirability of any given circuit will be given. The physical interpretation that this method leads to, simplifies to a great extent the perplexing questions that arise, when one tries to state definitely just what is desired in an oscillating circuit.

Every electrical oscillating circuit consists of an inductance, capacity, and a resistance (with usually an oversupply of the latter). The inductance serves to store the energy in the form of a magnetic field, the capacity serves to store the energy in the form of an electrostatic field, and the resistance serves to transform this stored energy into heat. The physical picture of what happens as the energy shifts from the condenser to the coil, and back again, is undoubtedly familiar to the reader, and will not be given at this time. In case the reader is unfamiliar with this process, he is referred to almost any good elementary textbook on physics or electricity.

ROSS GUNN, the author of this article, which is the first of two on the subject of receiving set inductors, was formerly a radio research engineer for the United States Air Service. Mr. Gunn is now attached to the Sloane Laboratory at Yale University and has devoted considerable attention to the problems involved in the design and use of coils in high-frequency oscillating circuits. The present article does not pretend to be revolutionary, for the basic theory involved is at least 50 years old. The author, instead of discussing power factor and decrement, which have little meaning to many readers, has chosen to use a factor which has a simple physical interpretation. The idea that there are two potentials in an oscillating circuit and that their ratio is the power factor, is of course well known, but the use of the factor "G" to explain the best ratio of inductance to capacity, has rarely been pointed out. The casual reader will find this story an excellent discussion of circuit problems which are by no means abstract, and those who are better informed should be interested in the work Mr. Gunn and his assistants have done, and in the way in which it is presented.—THE EDITOR.

When the theory of oscillating circuits is examined, it is found that, in any series resonant circuit, there may be considered to be two high-frequency potentials which are approximately 90 degrees out of phase with each other. That is, when one potential reaches its instantaneous maximum, the other potential is going through its instantaneous zero value. These two potentials have a certain interesting relation in terms of the circuit constants. One of these potentials will be referred to as the *applied* potential and the other as the *generated* potential. The applied potential is the potential introduced into the circuit from some outside influence, such as an oscillator or an antenna. This applied potential is in phase with the high-frequency current flowing in the oscillating circuit. The other potential, or the generated potential, is produced within the circuit, by the action of the oscillating current, and is 90 degrees out of phase with the current and the applied potential.

The current flowing in any alternating current circuit is determined by the applied potential and the circuit constants, in the manner given by the well known equation:

$$I = \frac{Ea}{\sqrt{R^2 + \left(2\pi fL - \frac{1}{2\pi fC}\right)^2}} \qquad (1)$$

where I is the current, Ea is the applied potential, L is the inductance, C the capacity, R the equivalent series resistance, f the frequency, and π is a numerical constant of value 3.1416. If the circuit is resonated to a definite frequency, the reactances are balanced and equation (1) reduces to:

$$I = \frac{Ea}{R} \qquad (2)$$

where I, Ea, and R are the same as previously mentioned. The greatest interest, however, is not in the current flowing, but in the signal produced by the applied potential. Considering now the application of the oscillating circuit to a radio set, it is assumed to be connected to a vacuum tube as shown in Fig. 1, and so neutralized that there is no appreciable regeneration. Since the vacuum tube is a device controlled solely by potential, the greater the potential we are able to apply to the grid, the greater will be the output signal from the tube.

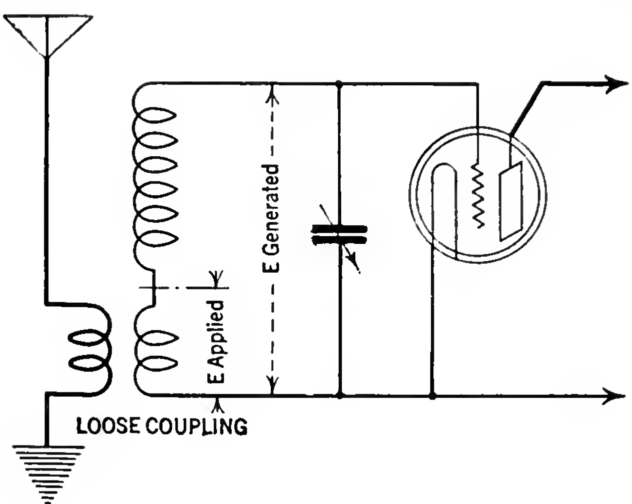


FIG. 1

THE "GAIN" OF A COIL

THE diagram of connections in Fig. 1 shows that the condenser and the inductance are in parallel across the grid and filament of the amplifying tube. Therefore, any potential that appears across the inductance or condenser will be impressed on the grid of the tube. It is well known that, when an alternating current flows through an inductance, there is generated a potential which is determined by the following equation:

$$Eg = 2\pi fLI \qquad (3)$$

where Eg is the potential generated across the coil, I is the current in the coil, L the inductance, and f the frequency. Similarly, the potential generated across the condenser is given by:

$$Eg = \frac{I}{2\pi fC} \qquad (4)$$

where the symbols are as before.

If we eliminate the unknown current from the equations (3) and (4) by substituting the relation expressed in (2), we obtain the following results:

$$\frac{Eg}{Ea} = \frac{2\pi fL}{R} = \frac{1}{2\pi fCR} = \frac{1}{R}\sqrt{\frac{L}{C}} = G \qquad (5)$$

or rewriting in the more convenient form, we have, due to inductance:

$$Eg = \frac{(2\pi fL)}{R} Ea \qquad (6)$$

or:

$$Eg = \left(\frac{1}{R}\sqrt{\frac{L}{C}}\right) Ea \qquad (7)$$

or simply:

$$Eg = G\ Ea \qquad (8)$$

where G is either of the factors given above and always has a value greater than unity. That is, the potential applied to the grid of the amplifier tube is always greater than the applied potential by a factor "G". The factor "G" is therefore of the nature of an amplifying factor, and the writer has usually referred to it as the "circuit voltage amplifying factor."

It has been suggested that this factor be called the "gain" and since this is a much more convenient term, we shall now call "G" the gain due to the oscillating circuit. Obviously then, the factor "G," or the gain, should be made as large as possible for any given circuit. To illustrate this idea, suppose we had two oscillating circuits, one with a value for "G" of 50 and the other a value of 200. Suppose further, that there was such an antenna current and such coupling in both cases that the applied potential was $\frac{1}{50}$ of a volt. Then since Eg = G x Ea, the potential applied to the grid of the tube (that is the generated potential) would be 50 x $\frac{1}{50}$ = 1 volt in the first case and 200 x $\frac{1}{50}$ (4 volts) in the second case. Obviously then, the coil with a high value of "G" would be the best. It may then be said, that in an oscillating circuit, the potential impressed on the grid of an associated tube depends on the potential *applied* to the oscillating circuit, and depends *equally* on a gain factor "G," which in turn is dependent for its value on the circuit constants only.

Before considering the application of the above results to the determination of the proper coil, it will be valuable to point out the intimate relation between this factor "G" and other characteristics of the oscillating circuit. Consider first, the relation between the factor "G" and the selectivity of the circuit. The selectivity, or the "sharpness of resonance," of an oscillating circuit is directly proportional to the factor "G," and if we define selectivity or sharpness of resonance as the ratio of the natural frequency of the tuned circuit at resonance to the difference of the natural frequencies of the circuit when on each side of resonance, such that the oscillating energy on each side or resonance is just one half the energy at resonance, then the selectivity so defined is exactly equal to the factor "G" or:

$$\text{Selectivity} = \frac{f_r}{f_2 - f_1} = G \qquad (9)$$

where f_r is the natural frequency of the oscillating circuit when in resonance with the incoming wave, f_2 the natural frequency of the tuned circuit at a point *above* resonance, such that the oscillating current is 70.7 per cent. of the current at resonance, and f_1 is the natural frequency of the tuned circuit at a point *below* resonance, such that the oscillating current is 70.7 per cent of the current at resonance.

This definition is equivalent in every way to the usual one. The fact that the selectivity of a circuit and the gain go hand in hand is indeed a very pleasant one since, if one increases, the other automatically increases also.

THE EFFICIENCY

THE expression for the efficiency of an oscillating circuit may be easily obtained by defining the efficiency in the following manner:

$$\text{Efficiency} = \frac{\text{ENERGY OBTAINED PER HALF CYCLE}}{\text{ENERGY SUPPLIED PER HALF CYCLE}}$$

This for convenience may be written as:

$$\text{Efficiency} = \frac{\text{ENERGY SUPPLIED}-\text{ENERGY LOST}}{\text{ENERGY SUPPLIED}}$$

Now, the energy supplied per half cycle is the maximum energy stored in the inductance which is given by the well known equation:

$$\text{Energy} = \frac{L\ I^2 max.}{2}$$

where L is the inductance and I max. is the maximum current. Moreover, the energy *lost per half cycle* is:

$$\frac{R\ I^2}{2\ f}$$

where R is the equivalent series resistance, I is the root mean square current, and f is the frequency. Making use of the relation between root mean square current and maximum current, namely:

$$I^2 = \frac{I^2 max.}{2}$$

the efficiency may be written as follows:

$$\text{Efficiency} = \frac{\frac{L\ I^2 max}{2} - \frac{R\ I^2 max}{4\ f}}{\frac{L\ I^2 max}{2}} = \frac{L - \frac{R}{2\ f}}{L}$$

and canceling out the common factors, the efficiency reduces to:

$$\text{Efficiency} = 1 - \frac{R}{2\ f\ L} = 1 - \frac{\pi}{G} \text{ since } G = \frac{2\ \pi\ f\ L}{R}$$

or

$$\text{Efficiency} = \frac{G - \pi}{G} = \frac{G - 3.1416}{G}$$

or for per cent. efficiency:

$$= \left(\frac{G - 3.1416}{G}\right) 100\%$$

Thus, if the gain is known for any given circuit, the efficiency may readily be computed.

This equation gives the efficiency of the circuit in the strict engineering sense and should not be construed loosely as a measure of the general performance of a coil. The poorest coils and condensers yield efficiencies of 90 per cent. and better while the best coils show efficiencies of 99 per cent., an apparent increase of but 9 per cent. The increase in performance would, however, amount to approximately 1300 per cent. for the good coil in comparison to the poor one.

Other things must be considered in radio telephony besides the intensity of the received signal. The quality of the received signal is of great importance and if we should increase "G" indefinitely we would soon have a circuit that would be so selective that the only frequency that would be amplified would be the carrier frequency, and the side bands, which give rise to the speech or music, would be cut off or, at the least, badly mutilated. There is an upper limit to the value of the "gain" if the quality of the speech is to be maintained. In the case of telegraphy, the upper limit is much higher than for telephony.

Calculations which would be tiresome and out of place in a discussion of this type, show that if all voice frequencies are to be faithfully reproduced up to 4000 cycles at a mean wavelength of 450 meters (666 kc.) the value of the factor "G" should not materially exceed a value of 250. This puts a definite upper limit to the gain or selectivity that can be used in the ordinary radio set.

Up to this point the discussion relates to the non-regenerative oscillating circuit as a whole. Now if the condenser used with the inductance is a good one, having a low resistance, then the losses of the condenser may, in comparison with the losses of the coil, be neglected. With this assumption, which is perfectly legitimate in the average case, we may then talk about the "gain" due to the coil, and understand by this, that this is the gain that would be obtained if the coil were used with any condenser of negligible resistance. These conditions have been met with in all experimental data given in this article since a precision condenser was used which was insulated with amber and which had a resistance of not over 0.2 ohm at 1000 cycles. Thus, at 300 meters (1000 kc.), the resistance would be entirely negligible.

Considering how the application of the principles just discussed are applied to an inductance, we may say that the inductance for any given circuit should be so chosen that the factor "G," which, as we have shown, is a measure of the selectivity and the gain, should be as large as possible, provided it does not greatly exceed the limiting value for good quality.

Returning now to the factors that determine how large the "gain" will be in any case, equation (5) shows how this factor varies with the inductance, associated capacity, resistance, and the frequency. It is impossible to examine the equation and say off hand that the ratio of the inductance to the capacity should be very large, as equation (7) would seem to indicate, because, as the inductance of the coil is increased, the resistance increases, perhaps very rapidly, depending on the physical structure of the coil. On the other hand, if the capacity of the condenser is increased the circuit resistance will decrease, but at a relatively slow rate. It would then appear that in order to determine just what combination of inductance and capacity to use or to determine what types of coils are the best, it will be necessary to make measurements of this factor "G" and determine experimentally its values under different circumstances.

The factor for the "gain" may be determined in several different ways. The ratio of the generated potential to the applied potential may be measured directly by means of a vacuum-tube voltmeter, and since by definition this ratio is the "gain," we have a simple method of getting its value for different coils. The factor may also be determined by use of the definition for selectivity as given in equation (9) which can be transformed so that known condenser settings may be used instead of frequencies. The values for "G" in this paper were computed from the known values of the resistance, inductance, and frequency, since these data were already available in some cases from previous work.

SOME COIL EXPERIMENTS

A GREAT many measurements on different types of coils have been made during the last year in an attempt to obtain sufficient information to point the way to the design of still better types of coils. Curves showing the "gain" of various representative coils are included in this paper. In every case but one, the coils were

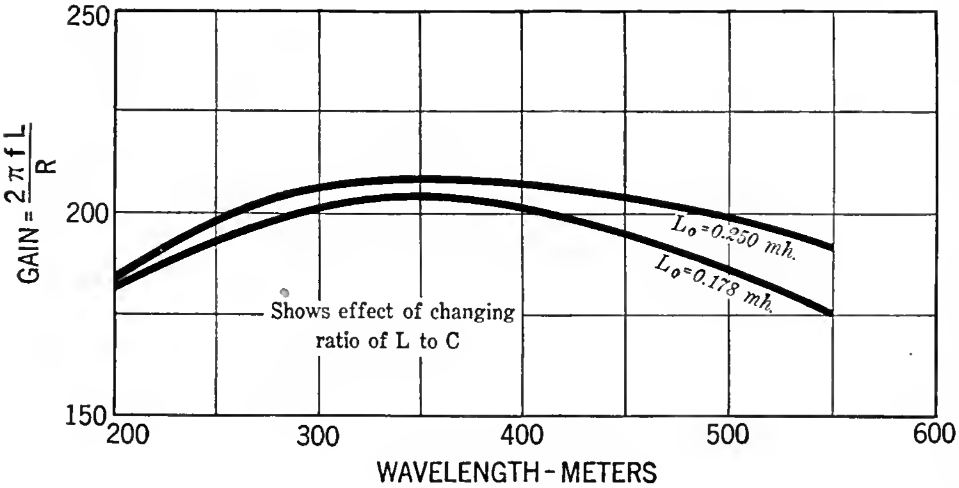


FIG. 2

purchased on the open market, and may be taken as reasonably representative of the commercial coils now available.

One of the first things investigated, in the light of the previous discussion, was the effect of changing the ratio of inductance to capacity in any circuit using coils of nearly identical construction. A single-layer solenoid, consisting of 45 turns of No. 24 s. c. c. wire was wound on a cardboard form of $3\frac{11}{16}$ inches in diameter. The values for the gain of this coil over the broadcast range, using a condenser with maximum capacity of 350 mmfd., were plotted as shown in Fig. 2, labeled $L_0 = 0.250$ mh. Wire was then taken off this coil until the coil resonated to 550 meters (545 kc.) with a maximum capacity of 485 mmfd. The values for the gain were again determined over the broadcast band and plotted as shown in the curve Fig. 2, labeled $L_0 = 0.178$ mh. These curves, with others, seem to show that the gain in any given oscillating circuit does not change greatly with moderate changes in the ratio of inductance to capacity. There does, however, seem to be some *slight* advantage in using the higher values of inductance.

Fig. 3 shows the value for the gain for a certain commercial "figure eight" coil. It was wound in the conventional manner, the winding beginning at one end and progressing in a series of "figure eights" to the other end. The coil was made up of 80 complete loops of No. 26 s. s. c. wire and had an inductance of 0.250 mh approximately. The coil was $1\frac{5}{8}$ inches long and $1\frac{1}{2}$ by 4 inches in the other directions. The gain for this type of coil was surprisingly low, as it varied from 100 to 130, as shown by the curve.

The curve for a typical commercial type coil is shown in Fig. 3 (b). This coil was a single-layer open solenoid of 0.245 mh. It was made up of 58 turns of No. 23 s. s. c. wire closely wound so it could be made self supporting with the aid of a binder. It was $3\frac{1}{8}''$ in diameter and $1\frac{5}{8}''$ long. The curve shows that the coil is not what one would call a bad coil.

Recent work of the Bureau of Standards has shown that in general the best type of solenoid construction is the type known as the "loose basketweave." The curve, Fig. 3 (c), shows the gain for such a coil. It was wound with 53 turns of No. 24 s. c. c. wire, and was $3\frac{1}{2}$ inches in diameter. This coil is a very good coil and would give the best of results if it is not placed too close to other apparatus.

Much better coils can, of course, be built by the use of litzendraht wire, but the writer has only considered the solid wire-wound coil so far. A graduate student getting his Master's degree at Yale in 1926 succeeded in building a solenoid out of "litz" with which he obtained an average value for the gain of over 450 for the entire broadcast band. Such coils are, of course, exceptional and are more or less laboratory curiosities because of their size and large external field. They cannot be used in the vicinity of other apparatus without increasing the losses and hence decreasing the value for the "gain." This is because their field sets up either eddy currents in the metal parts, or causes dielectric losses in insulators. These losses naturally decrease the value of the gain.

THE IDEAL COIL

THIS brings up consideration of the ideal coil or high-frequency inductance. Considerable thought has been given to this question and those points considered the most important, or necessary, are tabulated below. The requirements in their order of importance follow:

(a) The "gain" of the coil as previously defined, and hence also, its selectivity, should in general, be made as large as possible but should not exceed the limit of 250 for good quality.

This item in itself says a great deal, implicitly, since in order for the gain factor to be even as large as 200, say, all known methods to keep the coil losses down must be employed. This would mean, in general, that the coil would be self supporting, it would be wound with relatively small wire since small wire serves to keep the eddy current losses down, and it would be so wound that individual turns were reasonably well separated. It seems to have been pretty definitely established that the best coil is obtained when the wire is spaced by an amount about equal to the wire diameter. It would mean a great many other smaller things which can all be grouped under the statement given in the preceding paragraph.

(b) The exterior field of the coil should be zero or, certainly, very small. This is essential in order that there shall be as little stray energy exchange within the various circuits of the radio receiver as possible. Putting an ordinary coil having an exterior field in a metal can is to be discouraged, since it will greatly reduce the value for the "gain." For the same reason, the gain of an ordinary coil may be greatly reduced by mounting the coil in the vicinity of metal or poor dielectric.

(c) The distributed capacity of the coil should be very low, and the high- and low-potential ends of the coil should be well separated. The terminals of the coil should be well separated so that connecting wires to the coil will not introduce an excessive amount of distributed capacity into the circuit.

(d) Mechanically the coil should be strong and able to withstand a reasonable amount of abuse.

(e) Its physical structure should not be excessively large taking into account item (a).

(f) A commercial coil should have some marking which would give its "gain" over the broadcast band.

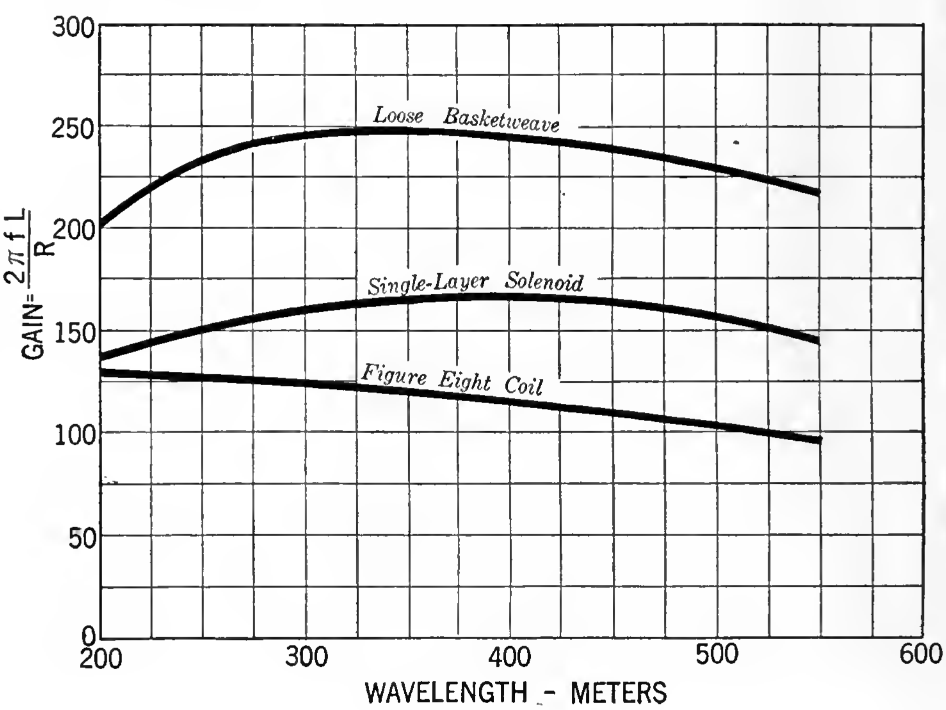


FIG. 3

Perfecting the B Socket Power Device

How the Oscillograph Is Utilized to Obtain Visual Indication of the Voltage Characteristics at Different Points of the Circuit—The Construction of a Better B Device with Uniform Output Properties

By HOWARD E. RHODES

B SOCKET power units are now in their second or third year of popularity, and during this time many excellent units have been designed. Some of the first models were described in this magazine as far back as September, 1924, but it was not until the present gaseous and thermionic type rectifiers became available that B power from the light socket became really practical for home use. It is surprising that since these rectifiers first became available there have been no important advances in design over the first models.

Power supply units are simple devices, employing principles that have been known many years, although their special application to radio is comparatively recent. Many construction articles have appeared in the various magazines but in these articles there has been little or no information as to how the devices function. It will be worth while to devote some space to a brief explanation of the fundamentals underlying the operation of any ordinary power unit.

For the purposes of our description we will use the power unit illustrated and described in this article. Sufficient information will be given to enable anyone to construct the unit and it is hoped that many will do so because this particular device gives very good results and has several design features, explained in this article, to particularly commend it.

B socket power units are devices intended to take power from an ordinary 110-volt 60-cycle a. c. house lighting system and convert it into high-voltage direct current suitable for the operation of a radio receiver. In order to accomplish this it is first of all necessary to transform the 110-volt a. c. power into energy of the same type but of higher voltage. This is accomplished by means of a transformer, a device which merely consists of two coils of wire wound on an iron core. If these two windings have a turn ratio of 1 to 2, placing 110 volts across the smaller, or primary winding, would give 220 volts across the other, or secondary winding; with a 1 to 3 ratio transformer the voltage across the secondary would be 330, and so on.

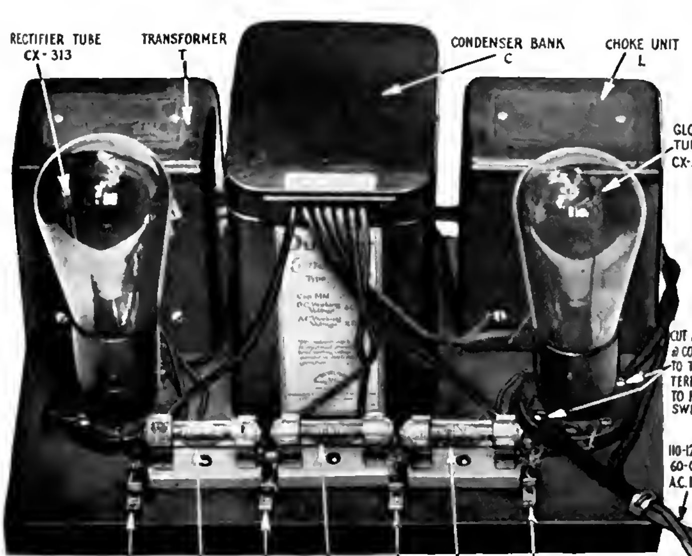
What does this voltage look like? We cannot see it directly, but with the aid of an instrument called the oscillograph, we are able to obtain a visual picture of it. The oscillograph consists of a thin wire, or vibrator, strung between two strong permanent magnets. A light is thrown on this wire and the shadow of the wire, by means of revolving mirrors, is thrown on a screen. If a current is passed through the wire, the magnetic lines of force set up by the magnets will react with the current variations through the wire, causing the latter to vibrate in accordance with these current variations, and the way in which it vibrates will therefore indicate the character of the current flowing through it. It is possible to connect an oscillograph at various points in a circuit and in this way determine the nature of the current—whether it is alternating or direct, or whether it is a combination of the two.

In analyzing the a. c. line voltage at the input of the power device, the oscillograph, indicated by the circle with an "X" in it in Fig. 1, was connected across the primary of the transformer of the B power unit, as shown at "A," and at "B" is a copy of the picture that was seen. The line marked "zero" indicates the position of the vibrator when there is no voltage applied. The voltage starts at zero, rises to a maximum in one direction, decreases to zero, and rises to a maximum in the opposite direction, decreases to zero, and then starts the same cycle over again. The voltage across the secondary of the transformer has the same form but it is larger.

Across the secondary of the transformer we have a high a. c. voltage and the next thing to do is to change it to d. c. In the particular unit we are working with, this is accomplished with a cx-313 double-wave rectifier tube. This rectifier has two plates and two paralleled filaments so that both the halves of the wave—above and below the zero line in "B"—can be utilized. The cx-313 tube was arranged as shown at "C" in Fig. 1, only one of the plates being connected, and the oscillograph was connected as indicated. We now get a wave as shown in Fig. 1 at "D." Notice that we get a current through the circuit for each positive half of the a. c. voltage but nothing during the negative half, because the rectifier will only conduct current when the plate is positive, while during the half cycle when the plate is negative, no conduction occurs. If we connect the other plate, as shown in "E," we will be able to take advantage of each half wave because, during the half cycle when terminal No. 5 of the transformer is negative, terminal No. 7 is positive, and thus, during the half cycle when no conduction is taking place from terminal No. 5, there will be current flowing at terminal No. 7. Consequently, we get a wave form in the oscillograph as shown in diagram "F" of Fig. 1. Now, for each half cycle of the original a. c. voltage shown in "B," we get a corresponding impulse in the oscillograph. But because of the rectifying action of the tube, which will conduct current only one way, all the impulses shown in "F" are in the same direction. We now have a circuit in which the current flows in only one direction, and this is the essential characteristic of a direct current. But, although the current is unidirectional, it is pulsating; that is, it goes from zero to its maximum value and then drops to zero again, and then repeats the same thing over again. Such direct current is not suitable for application to radio purposes for it must be perfectly constant for this use.

THE FILTER CIRCUIT

THIS brings us to the third part of a B power unit—the filter. In Fig. 1, at "G," we have added a filter to the output of the rectifier. The filter consists of choke coils L_1 and L_2 and condensers C_1, C_2, and C_3. The function of the choke coils is to block any sudden changes in current while the function of the condensers is to act as storage tanks or reservoirs. Energy is delivered to the filter in the form shown in "F" and the filter serves to smooth out these impulses and to allow non fluctuating direct current to be drawn from its output. The oscillograph was first connected at X_1, and the curve obtained is shown at "H." Here we notice a great change. The ripple is not nearly as great as in the preceding picture and it never goes down to the zero line. Through the ripple we show a dotted line indicating the average value of the ripple current. What the curve means is that we now have a direct current, I_{dc}, with a small a. c. ripple in it, I_{ac}. The ripple must be gotten rid of so we pass the output through another filter section. The oscillograph drawing "I" was obtained by connecting the instrument in the circuit at the point marked X_2 in "G". Notice how much smaller the ripple is. The filtration is almost complete. Connecting the oscillograph on the other side of the last filter condenser, C_3, at the point marked X_3, we obtain the drawing shown at "J," and the ripple is entirely absent. This means that the voltage at the end of the filter is satisfactory to apply to a receiver.



RADIO BROADCAST Photograph

THE B DEVICE DESCRIBED IN THE TEXT

The filter is one of the most important parts of a B socket power device, and it is essential that it be carefully designed if it is to give best operation. The best filter will, of course, be that one which gives the least hum in the output consistent with reasonable cost. It is preferable to accomplish the filtration with a filter as small as is feasible because, in this way, it is possible to keep the resistance of the filter circuit at a low value. In "F" the filter is supplied with energy at the rate of 120 cycles per second. It therefore seems logical to design the first section of the filter to eliminate this 120-cycle ripple and to then use one additional filter stage to eliminate any other harmonic frequencies or any residual ripple that gets through the first section. A selective filter of this type has been patented by Kendall Clough and is used in the Silver-Marshall 331 Unichoke and also is incorporated in this unit because, with such a circuit, excellent filtering action can be obtained and, at the same time, it is possible to keep the filter resistance down to a fairly low value.

At the output of the filter we obtain the maximum voltage delivered by the device. A receiver, however, requires several different potentials for its operation. In most cases a high-voltage tap, say about 180 for a 171 power tube, a 90-volt tap for the first audio amplifier and the r. f. stages, and a 45-volt tap for the detector, are required.

To obtain the various voltages it is necessary to equip the device with an output potentiometer, which merely consists of a resistance, or several resistances, connected in series across the output, as will be seen in drawing "G," Fig. 1. This circuit diagram is similar to many power units in use to-day. It has one important disadvantage, which is that the voltage obtained from the various terminals depends upon the load. If one tube is supplied from the tap marked 90-volts it might really receive 110 volts, two tubes 90 volts, and three tubes only 70 volts, and so on. This is one important respect in which a B power unit differs from a dry battery. From a battery we obtain the same voltage at all reasonable loads, but from an ordinary power unit we obtain voltages that depend on the milliampere drain.

"MOTOR BOATING" CAUSES

THAT the output of most B power units varies with load is important because it is very likely that one of the causes of "motor-boating" is to be found in this fact.

"Motor-boating" is seldom experienced (although it is not an impossibility) when an amplifier is operated from good new B batteries. Ordinary B batteries must be discarded as the voltage runs down, the actual reason for this being that the internal resistance of a battery goes up as the voltage goes down, with the result that the high resistance, being common to the circuits of all the tubes in a receiver, may cause oscillation, and most certainly distortion. Considering a B power supply from this angle, we find a comparatively high internal resistance unavoidable with standard rectifying devices, and we further find a comparatively high resistance is necessary for the mechanical construction of satisfactory filter chokes. The net result is poor voltage regulation; that is, as the current drawn from the B supply increases, the voltage does not remain constant as with a battery but, instead, falls off at a fairly rapid rate. Curve A, Fig. 3, indicates the regulation that may be expected from a standard B supply with an extremely low-resistance filter. The higher the filter choke resistance, the poorer the voltage regulation; and, likewise, the higher the internal resistance of the rectifier, the poorer the voltage regulation. In the case of batteries in good condition, the internal resistance being very low, the voltage remains substantially constant under normal current loads and a regulation curve for a battery is substantially a straight line. In itself, a falling characteristic may not, at first, appear to be a disadvantage so long as the curve indicates that the device is capable of supplying sufficient voltage at the particular load at which it is to be used, but, a poor regulation curve, indicating a high internal resistance, is doubtlessly an important contributory cause of "motor-boating" in a receiver.

"Motor-boating" can also be produced by overloading, which causes a change in the average plate current drawn by the receiver. If the average current drawn by the receiver varies, the B power unit will be called upon to supply a varying load. If its regulation curve is not flat, any variation in the milliampere load will cause a change in the voltage supplied to the receiver and this will produce another surge in the receiver again affecting the average plate current and repeating the process. "Motor-boating" due to this cause will be prevented if the regulation curve of the power unit be made substantially flat, and this has been accomplished in the particular unit illustrated on page 43 by connecting into the output circuit a glow tube, as shown in Fig. 2. The problem of eliminating "motorboating" is complicated and for this reason Radio Broadcast Laboratory expects to make a series of tests in an endeavor to determine the exact causes of the trouble. These data will be published in a later article.

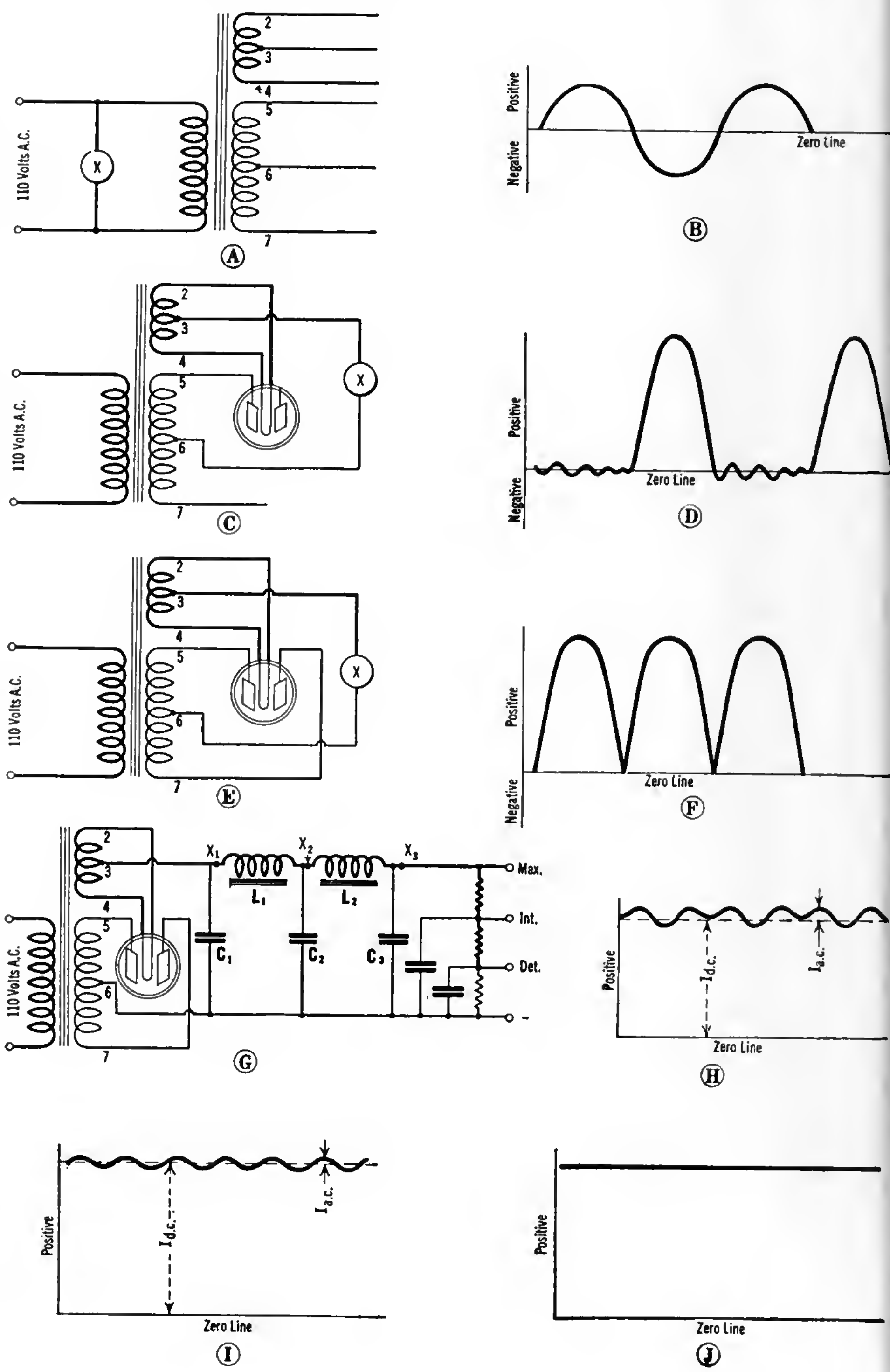


FIG. 1

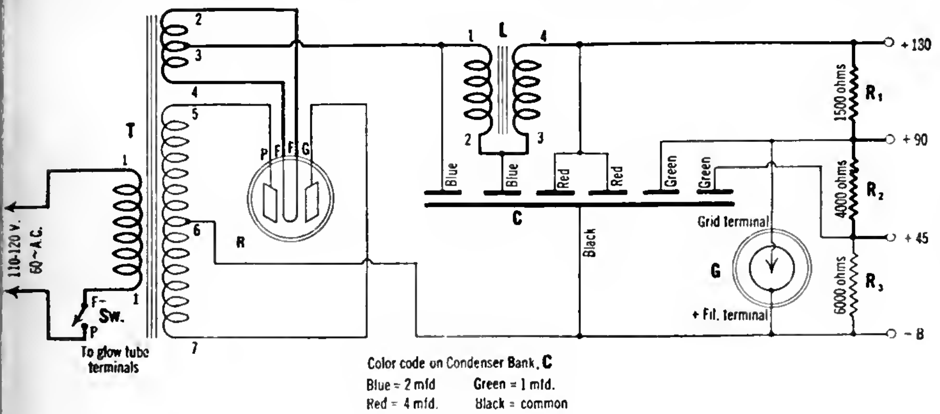


FIG. 2

The use of a glow tube to improve the regulation of a socket power device is a comparatively recent development. The effectiveness of this tube can be readily seen by referring to the curves B, C, and D in Fig. 3, and noticing that the voltage at the 90-volt tap varies only 5 volts between a load of 0 milliamperes to 45 milliamperes. The tube also affects the regulation of the other voltage taps on the device so that all of the taps show a comparatively small variation voltage with change in load. The voltage regulation at the 90-volt tap is most important since this tap generally supplies a majority of the tubes in a receiver. The use of a glow tube with the concomitant improvement in the regulation curve will eliminate a factor (poor regulation) which certainly has a very definite tendency to cause "motor-boating," and it is suggested that, where possible, the tube be used in conjunction with any B power unit that is causing a great deal of trouble.

As was mentioned at a previous point in this article, an important feature of the socket power unit illustrated herein is that it may be connected to any standard receiver drawing normal current with the certainty that the voltages will fall within the practically required operating limits, by virtue of the fact that a glow tube is employed. In an ordinary B unit, variable high resistances are used to control the output voltage, and it is seldom that the user has any definite idea what voltages are being applied to his receiver.

The parts necessary to build a B socket power employing the principles outlined in this article, are listed below:

LIST OF PARTS

R— Cunningham CX-313 Rectifier Tube	$ 5.00
G— Cunningham CX-374 Glow Tube	5.50
T— S-M 329 Power Transformer, with 5-volt balanced filament winding, two 200-volt secondaries, and electrostatic shield . . .	9.00
L— S-M 331 Unichoke	8.00
C— Dubilier Type PL 381 Condenser Bank	14.00
Two S-M 511 Tube Sockets . .	1.00
R1—Amsco 1500-Ohm Resistor with Mounts—50MA. Type 125 . .	2.00
R2—Amsco 4000-Ohm Resistor—10MA. Capacity	.90
R3—Amsco 6000-Ohm Resistor—10MA. Capacity	.90
Two Amsco Resistor Mounts .	.30
Four Fahnestock Clips . . .	.08
7" x 10" Wood Base with 17 No. 6, ½", R. H., wood screws, and 15 feet of Kellogg fabric insulated hook-up wire	.50
TOTAL	$47.18

The parts mentioned in the above list were used in the model constructed in the Laboratory and are known to give good results. There is no reason why the parts of other manufacturers might not be substituted provided care is taken to make certain that the electrical characteristics of the substituted parts are equivalent.

The Amsco type 125 resistance was not used in the model made up and illustrated in the photograph on page 43. It will be found that the type 125 unit is one inch longer than the resistance shown in the photograph.

Satisfactory block condensers are also made by Silver-Marshall, Tobe Deutschmann, Aerovox, Sangamo, Muter, Faradon, and the resistors that are used may be the products of any reputable manufacturer provided they are capable of carrying the currents that are specified. The S-M 653 resistor (Ward Leonard S 11500), costing $2.50, can be used in place of the Amsco resistors and mounts.

The construction of the unit is very simple. Upon the 7" by 10" wood base, beginning at the left-hand rear, the power transformer is screwed down with the Dubilier condenser bank along side of it, and the Unichoke at the right-hand end. The socket for the type 313 tube is placed directly in front of the transformer, while that for the 374 glow tube is placed directly in front of the Unichoke. The three resistance mounts are lined up in front of the sockets, and then, in front of the resistance mounts, are placed four Fahnestock clips. The left-hand clip is negative, and progressing to the right, we have the plus 45-, plus 90-, and plus 180-volt taps. Wiring to most of the units can be done without soldering, if desired, by simply fastening the scraped ends of the connecting wire under the terminal screws of those units which are so equipped. The circuit diagram given in Fig. 2 is marked with terminal numbers which correspond to those on the parts that were used in this particular model, and this will aid in making it a simple matter to correctly wire the entire unit. No particular care is necessary in the way in which the wires are run since there is little danger of feed-back. Just run the wires in the most convenient way to the various terminals. By reference to the circuit diagram it will be noted that a switch, marked Sw., is indicated in the primary of the power transformer. This switch is part of the glow tube base. The terminals in the glow tube corresponding to the plate and minus A (minus A as indicated on the Silver-Marshall socket) are short-circuited inside of the tube base wiring. Therefore, the lead from the unit that connects to the 110 volts a. c. is cut and one end connected to the plate terminal of the glow tube socket (right-hand socket) and the other end connected to the negative filament terminal of this same socket. With this connection, the power is thereby automatically cut off if the glow tube is pulled out of its socket. This is necessary because, with the glow tube removed, there will be practically 180 volts at the 90-volt tap.

In operation, there are practically no precautions to be observed; the unit is foolproof. The four B-battery leads from the receiver are simply connected to the similarly marked posts on the B unit, the receiver and B unit turned on, and reception obtained by tuning the receiver in the usual fashion. The 175 volts at 20 milliamperes, obtainable from the 180-volt tap, will operate a UX-171 type tube to perfection. The 90-volt tap will supply up to 45 mils. at this voltage; the 45-volt tap up to 10 mils., as shown by Fig. 3. There is no danger of damaging tubes and condensers in the receiver due to high-voltage surges from the B unit, since the voltage of the high tap can never rise above 190 volts.

In use, the two lighted filaments of the CX-313 rectifier tube will cause the tube to get rather warm; at no time should the plates ever become red due to heating. The glow tube will glow with a bluish or pinkish light, and this may possibly flicker when a very strong signal is being received, due to the reciprocating action of the tube. If too great current—more than 45 milliamperes—is drawn from the 90-volt tap of the unit, the glow tube may cease to glow. Turning off the receiver will immediately result in this tube re-lighting, after which the set may again be turned on. If more than 45 milliamperes is drawn by the 90-volt receiver circuit, it should be examined for trouble. The brilliancy of the glow in the CX-374 regulator tube will vary with different loads.

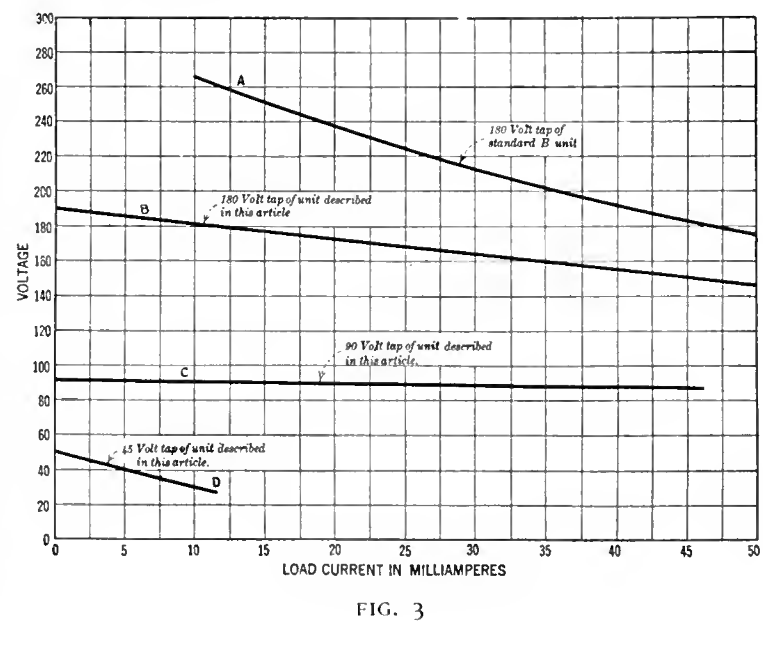


FIG. 3

Methods of Measuring Tube Characteristics

A Paper Delivered Before the Radio Club of America Discussing the Several Bridge and D. C. Systems for Use in Obtaining Tube Characteristics

By KEITH HENNEY

Director, Radio Broadcast Laboratory

IT IS neither the desire nor purpose of the writer to burden this article with an eulogy on the vacuum tube. Nearly every article that has appeared on the tube in the popular radio press has done that, pointing out that it is a most wonderful device, the modern Aladdin's Lamp, and a number of other superlatives that fill up space. There can be no doubt that the tube is important. Witness our present broadcasting structure, our long-distance telephone service, our communication by telephone across the Atlantic, and by high frequencies and exceedingly low powers to all parts of the world. All of these things depend upon the tube.

No study of the tube can be complete without a knowledge of its varied services. For example, it is possible with a tube to convert direct current from a set of batteries to alternating current of all frequencies from as near zero as one likes up to 60,000 or more kilocycles. It is then possible, with another tube exactly similar to the first, to convert these extremely high frequencies back to direct current. It is also possible to amplify both direct and alternating currents, and hence amplify power. It is also possible to separate what is placed on the input of the tube into direct and alternating currents of practically any ratio desired. All of these varied functions are carried out without any moving parts, without noise, with practically no loss of power, and with so little fuss that tubes now exist that are capable of giving service for 20,000 hours, a life greater than that of the circuit in which they are used. There can be no doubt about the importance of the tube in the field of electrical engineering. In addition, tubes and their associated circuits are now being used to measure the rate of growth of plants, to measure extremely small differences of thickness, the strength and rapidity of a man's pulse, and from this latter, to determine whether he is a lover, a thief, a liar. The tube has been harnessed and trained to do a vast number of interesting tricks.

Now this little assembly of glass and metal performs its multitudinous functions with the aid of three elements. The first and most important of these elements is the filament. This filament has undergone rather remarkable changes since tubes first came into existence. The first ones were made of tungsten which operated with a high temperature, then going to low temperature oxide-coated filaments manufactured by a complicated and difficult process, thence to our most recent filament, the thoriated wire. The measure of efficiency of the filament is its emission per watt expended in heating it, and the newest thoriated wire is exceedingly efficient. Pure tungsten filaments operate at a very high temperature. Oxide filaments consume considerable current at low voltage and at a much lower temperature. Thoriated filaments are somewhere between.

The other two elements are the grid and plate, and because these elements can be changed in size and relative position, tubes differ in characteristics. There must, then, be some means by which engineers can compare tubes just as they rate generators and motors or other electrical apparatus.

TUBE CONSTANTS

IN TUBE engineering, there are two very important factors which, when known, define the tube in exactly the same manner that we used to say in school that the United States is bounded on the north by Canada, on the east by the Atlantic Ocean, etc. The two constants—which really are not constants at all—are the amplification factor and the plate impedance,

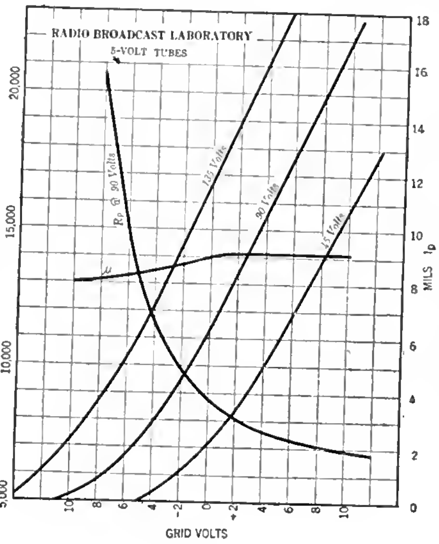


FIG. 1

and every function that the tube performs and its efficiency in doing so may be discovered by a knowledge of these factors and the constants of the circuits into which the tube works.

Another factor is the mutual conductance which, contrary to popular opinion, is not so important as it may seem. The term is somewhat difficult to picture physically. It has the dimensions of a conductance, *i.e.*, a current divided by a voltage, but the current exists in one circuit and the voltage in another, with the tube as the connecting link. It is due to Professor Hazeltine.

These constants, or factors, are variable within rather wide limits. For example, the amplification factor may range from 3 to 30, while the impedance varies, as someone has said, from Hell to Peru. The amplification factor is pretty well determined when the tube is sealed and pumped; that is, it depends to within very narrow limits upon the geometry of the tube. The mesh of the grid and its spacing with respect to the other elements are the governing factors. At low grid voltages the amplification factor falls off somewhat, rising to a maximum at zero grid voltage, and remaining constant thereafter, or falling gently in some tubes.

The plate impedance depends upon a lot of things, the filament efficiency, the amplification constant, and the grid and plate voltages. No one curve or graph can show how it varies. To properly represent it would require a three-dimensional model, such as has been constructed by Doctor Chaffee and others. Some photographs of very beautiful models of this nature may be seen in the *Proceedings of the I. R. E.*

After the tube is sealed and placed in operation the impedance changes with each change in instantaneous plate or grid voltage—all of which makes the theory of the tube more or less complicated.

These three elements, the filament, the grid, and the plate, cause any current flowing in the plate circuit to change, making it go through very wide fluctuations. The plate current is defined by the equation:

$$I_p = f(E_p + \mu E_g)$$

By maintaining constant any one of the three variables in this equation and varying the other two, we arrive at the relation between the plate current and the voltage on the grid or plate that we usually know as characteristic curves, and it is by means of these curves that the important tube factors are defined. For example, both grid and plate potential have some effect on the grid voltage, but the grid is relatively more important than the plate. In Fig. 1 it may be seen that at zero grid bias, changing the plate voltage from 90 to 135 changes the plate current by 5.2 milliamperes, while changing the grid bias by 5 volts will do the same thing.

The amplification factor is then defined as the ratio of the change in plate potential to the change in grid potential which produces the same effect in plate current. In this case the amplification factor is 9:

$$\mu = \frac{\Delta E_p}{\Delta E_g} = \frac{135-90}{5-0} = \frac{45}{5} = 9$$

The other factor of importance, the plate impedance, is the ratio between the change in plate voltage to the resultant change in plate current. In this case it is 45 volts divided by 0.0052 amperes, or roughly 8700 ohms:

$$R_p = \frac{\Delta E_p}{\Delta I_p} = \frac{135-90}{0.0116-0.0064} = \frac{45}{0.0052} = 8700$$

Now, as has been indicated by the Greek letter Δ in the definitions, these factors are defined by changes, and for accuracy the changes must be small.

The mutual conductance, defined as the ratio between a change in plate current and the change in grid voltage that produced it, is also the ratio between the amplification factor and the plate impedance, as can be seen from the mathematics below. For comparing tubes under exactly the same conditions, this factor is somewhat import-

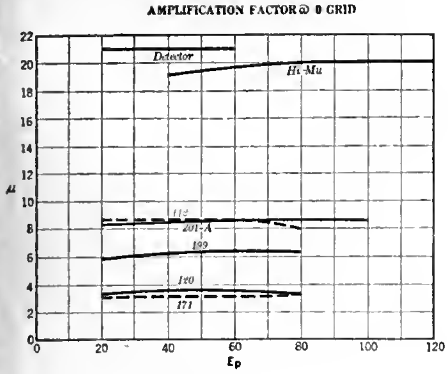


FIG. 2

ant, but as will be shown later, it serves little purpose in telling an engineer how well such a tube will function in the circuit:

$$G_m = \frac{\Delta I_p}{\Delta E_g} = \frac{\mu}{R_p} = \frac{\Delta E_p}{\Delta E_g} \div \frac{\Delta E_p}{\Delta I_p}$$

Figs. 2, 3, and 4 show how the tube factors change. The fact that the plate impedance is the reciprocal of the slope of the E_p–I_p curve is shown in Fig. 4. When the plate-current curve straightens out, the R_p curve is parallel to the E_p axis, but finally rises again as the saturation point is reached. These data were taken on a rather poor 199 tube.

It is a simple matter to get the tube factors from a set of characteristic curves which may show the effect upon the plate current of the grid or plate voltage. It is somewhat tedious, however, to take a mass of data and to plot it and then to pick off points on the resulting curves to determine the tube's factors. In actual practice it is simpler to go through a little routine, say of measuring the plate current under certain conditions of plate and grid voltage and then to get a new current by changing the grid voltage. This gives the mutual conductance. Then the plate voltage can be changed to get the plate impedance, and to multiply these factors together to get the amplification factor. At the risk of too much repetition the writer wishes to emphasize here that changes in grid and plate voltage must be small if the resultant determinations of amplification factor and plate impedance are to be representative of the tube's characteristics.

MEASURING THE TUBE CONSTANTS

THE various bridge methods of measuring tubes were developed to provide quick and simple means of measuring tubes.

One of the first methods of making quick measurements was due to J. M. Miller, and is shown in Fig. 5. In practice, the resistances, r_1 and r_2, are varied until closing the switch causes no change in plate current. Under these conditions the amplification factor is given by the ratio of r_2 and r_1. This follows from a consideration of the law governing the plate current as a function of grid and plate voltages given above.

If, with the switch closed, the voltage across plate and filament is increased, the corresponding grid-filament voltage is decreased. If no change in plate current takes place, however, the following relation holds:

$$(\Delta E_p + \mu \Delta E_g) = 0$$

whence $Ir_2 + \mu I r_1 = 0$

and $\mu = \frac{r_2}{r_1}$

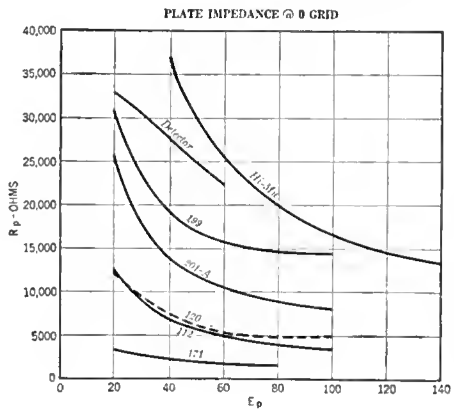


FIG. 3

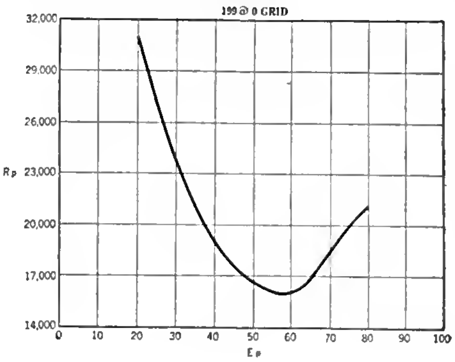


FIG. 4

the amplification factor is a constant over the ordinary ranges of grid and plate voltages, one determination will suffice for a given tube. It must be remembered, however, that any error in measuring mu will cause an error in Rp.

In the RADIO BROADCAST Laboratory a bridge has been in use for several years which will measure either the mu or plate impedance, independently of each other, and has the additional advantage that the desired factors may be read directly. This bridge in its two forms, which are easily convertible to each other, is shown in Fig. 7. The method of obtaining the amplification factor is exactly that of the Miller bridge while the other constant is measured in another arrangement of the same parts used by Miller.

In all of these bridges it is necessary to use some amplification to indicate a balance unless the work is done in a quiet room. The amplifier should preferably use batteries separate from those used for the bridge. The source of tone may be a buzzer a hummer, or an oscillator. As a matter of fact, a radio receiver might easily be used, since there is practically no change in tube characteristics at audio frequencies. The inclusion of a small variometer in the plate circuit to balance out the quadrature of plate voltage due to the grid-plate capacity, is also useful. Care must be taken with regard to the way it is connected into the circuit so that it will not be necessary to take into account its reactance in the final calculation of tube factors. When connected correctly the reactance, which is never greater than 10 or 15 ohms, is in series with the plate impedance. In the other connection this reactance is in series with the balancing resistance and will give absurd results.

LABORATORY BRIDGE

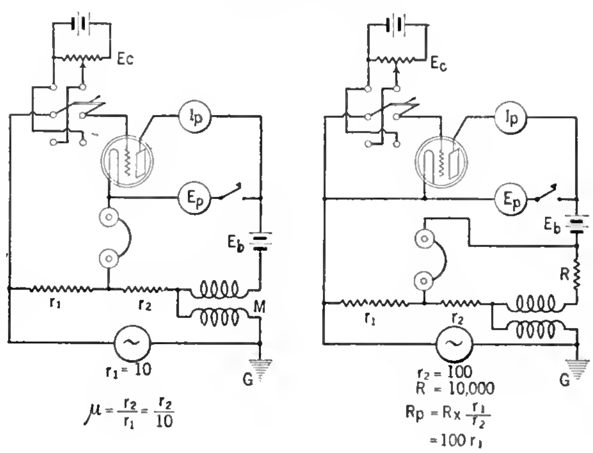


FIG. 7

MILLER D.C. BRIDGE

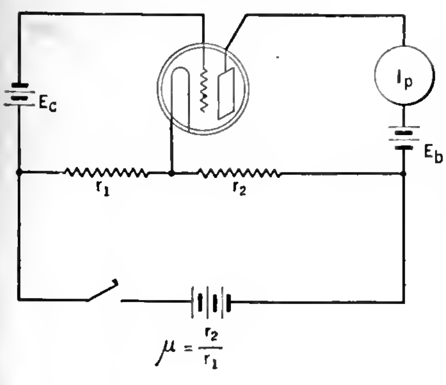


FIG. 5

The first improvement on this simple bridge was to substitute a.c. voltages and to use a pair of telephones in place of the plate ammeter. Under these conditions the amplification factor is found in exactly the same manner. When the bridge is balanced, indicated by silence in the receivers, the amplification factor is the ratio indicated above.

Miller described also the simple addition to this scheme which permits measurements of the plate impedance to be made as shown in Fig. 6. It is not difficult to prove that the bridge balance indicates that the following relation holds:

$$R_p = R\left(\mu \frac{r_1}{r_2} - 1\right)$$

There is one disadvantage in this system. It is necessary to measure the amplification factor before the other factor may be obtained. Since

MILLER BRIDGE

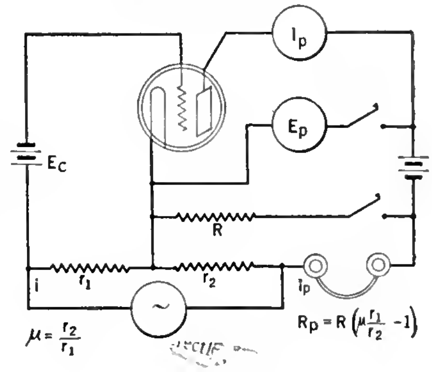


FIG. 6

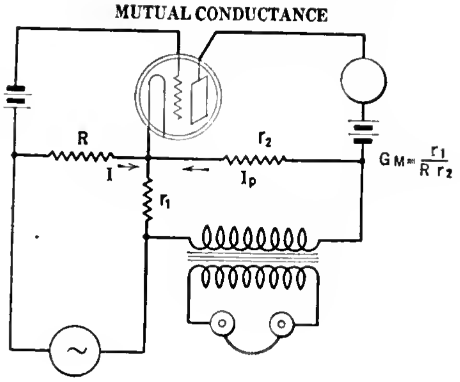


FIG. 8

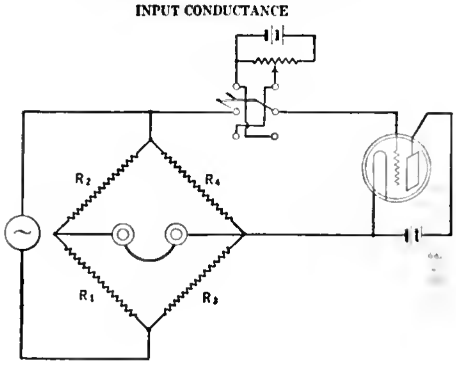


FIG. 9

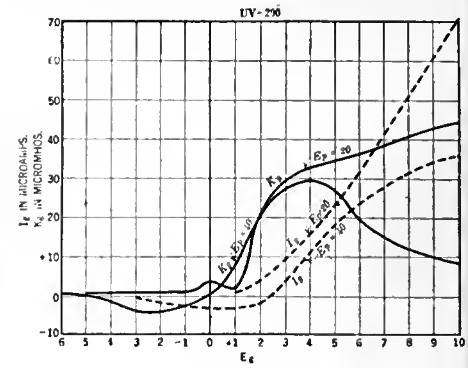


FIG. 10

There are two sources of error in the bridges shown so far. One is in the drop in plate voltage due to the plate current flowing through the balancing resistance. The other is the resistance drop of the indicating device, whether this be a pair of receivers or the primary of a transformer. Trouble from this source may be avoided by making certain that the actual plate-filament voltage is of the value desired after the balance is obtained, and by the use of a low-resistance transformer, such as a modulation transformer, to connect the bridge with the associated audio amplifier. On the Laboratory bridge, a push button connects the plate voltmeter when its reading is desired. Otherwise it is out of the circuit.

In practice, the normal filament, grid, and plate potentials are applied to the tube, and a 1000-cycle current of about one to two milliamperes flows through the bridge arms. To obtain a balance in measuring mu, the resistance in the grid circuit is set at 10 ohms and the plate resistance and variometer varied for balance. Thus, a tube whose mu is 8 requires 80 ohms in the plate side. In a quiet room, and with leads from the oscillator well separated from the amplifier mu can be read to the second decimal place. When tubes of high amplification factor, say 20 to 30, are measured, it is well to reduce the input grid resistance so that a smaller resistance is placed in the plate circuit.

To measure plate impedance with the Miller bridge, the switch is closed and a new balance obtained, when the factor desired is obtained as a function of mu. In both this bridge and in the Laboratory bridge, the resistance, R, against which the tube impedance is compared, may be fixed exactly at 10,000 ohms, although the value is not important as long as it is definitely known. On the Laboratory bridge the plate resistance is set at 100 ohms and the grid resistance varied for balance. If the impedance is 12,000 ohms, R_g will be 120.

MUTUAL CONDUCTANCE BRIDGE

THERE are a number of other bridge schemes for measuring the various factors in which engineers are interested. Ballantine has described several in the *Proceedings of the I. R. E.* One of these is a method of measuring the mutual conductance directly, and for comparing a great many tubes of the same sort under the same conditions, it provides a useful instrument for the laboratory or tube manufacturer, or even dealer. This is shown in Fig. 8. It will be seen that it differs but little from the other arrangements.

Another set-up of apparatus will measure the input characteristics of the tube at low frequencies. It is shown in Fig. 9. At balance, the grid conductance (the inverse of the input impedance) is given by:

$$K_g = \frac{R_1}{R_2 R_3}$$

and in practice, with normal tubes, all balancing is done with R_1, since R_2 is held constant at 100 ohms, and R_3 at 10,000 ohms. With soft tubes the conductance may change sign at high plate potentials, and it is then necessary to give the input a positive conductance by actually connecting across the grid and filament a high resistance, say of 50,000 ohms. The tube conductance may be obtained by subtracting from this known value, that determined by the bridge. Data given in Fig. 10 on a soft tube show the effect of ionization in giving the input circuit a negative conductance.

TABLE NO. 1

Type	Ep	Eg	A.C. Rp	D.C. Res.	Factor	Where d.c. = a.c.
201–A	90	—4.5	11000	30000	2.7	Ep 90, Eg—2
199	90	—4.5	18500	37500	2.0	Ep 90, Eg—3
112	135	—9.0	5500	21400	3.9	Ep 135, Eg—0.6

200-A TUBES

TUBE	NO. TESTED	AMPLIFICATION CONSTANT	PLATE IMPEDANCE
Perryman	2	37.5	31,750
Cunningham	3	22.5	24,000
Sylvania	2	20.8	25,000
Cleartron	3	24.5	38,000
Marathon	3	21.6	38,000
Q R.S.	3	21.0	31,000
Cable Supply Co.	3	26.3	37,200
Marathon	3	16.5	22,000
Q.R.S.	3	22.5	25,000
R.C.A.	2	21.0	26,000
Total	27	Average 23.4	29795

Conditions

February 8th, 1927 — Plate Volts 45 — Grid Volts 0

FIG. 11

COMMERCIAL TUBE TESTERS

THERE are a number of tube testers on the market some of which are very expensive. As far as the writer knows, there is but one which measures tubes according to the bridge schemes outlined above. This is made by the General Radio Company and uses the Miller connections. Others are made by the Hickok Company of Cleveland, by Jewell, Hoyt, and others. The Hickok uses a 60-cycle voltage obtained from a step-down transformer. The others vary the grid and plate voltages by fixed—and it is to be hoped, small—amounts, and obtain the various factors either directly or by simple calculations. They are quite reliable and valuable instruments although not capable of the precision that a true bridge circuit can attain.

It is also possible to obtain tube constants from a knowledge of the d.c. resistance. For a given type of tube, the plate impedance at certain conditions of plate and grid voltage may be obtained by multiplying the d.c. resistance under those conditions by a constant factor; at some other value of plate and grid voltage it will be exactly equal to the d.c. resistance. For example, dividing the d.c. resistance of a 201–A type tube at 90 volts on the plate and a negative 4.5 bias on the grid by 2.7 will give an approximate idea of the a.c. impedance.

Table No. 1 is representative of what may be expected from such methods of estimating tube impedance.

A tube tester with a d.c. plate current meter calibrated with several scales will read the plate impedance with an accuracy that may be all that is desired by dealers and others who do not need to use the values in circuit calculations.

The factors of tubes commonly used to-day are shown in the accompanying tables, Figs. 11, 12, 13, and 14. It is a fact to be thankful for that tubes are now so uniform, since a tube with odd constants placed into a well-engineered receiver is often enough to change conditions from good to very bad. A year ago such standardization had not been reached, as data on file in the Laboratory show.

Now, having shown how various tube factors may be calculated from curves, or measured with bridges or d.c. instruments, it remains to be shown how useful such factors are, and in some measure to justify the statement that mutual conductance is not the determining factor in a tube's goodness or unfitness for particular tasks.

In receivers, as we have them to-day, the first tube generally acts as a radio-frequency amplifier with inductance in both plate and grid circuits. It is necessary that the plate-grid capacity be small and that a given make and type of tube will be uniform. It is also necessary that the input impedance be high and the output impedance be low, for maximum gain. For example, the maximum possible gain from an amplifier is given by the well known expression:

$$K = \frac{\mu}{\sqrt{R_p}} \times \frac{\sqrt{R_g}}{2}$$

and a little mathematics will show that when the proper load is inserted into the plate circuit of a high-frequency amplifier that the maximum amplification will be given by the formula:

$$K_m = \frac{\frac{1}{2}\mu}{\sqrt{R_p}} \cdot \frac{L\omega}{\sqrt{R}}$$

where L is the inductance of the secondary coil and R the effective resistance of the circuit. Tube

CeCo Type K				
No.	μ	Rp	Gm	μ²/Rp
1	11.1	11,700	950	10.5
2	12.1	13,000	930	11.3
3	12.5	15,700	795	10.0
4	11.0	12,200	900	9.9
5	13.1	14,900	880	11.5
6	11.2	13,100	855	9.6
	Ep=90		Eg= −3	

TABLE NO. 2

were measured. These data should be on the carton of every tube sold.

Table No. 2 is illustrative of the fact that the mutual conductance of a tube may be lower than another and still have a higher "gain" factor; *e.g.*, compare No. 3 and No. 6 of this table.

DETECTOR IMPEDANCE

THERE has been much speculation about the output impedance of a detector tube. This is important in order that amplifier engineers know exactly under what conditions their products will work. For example, it is well known that a transformer-coupled amplifier will have one characteristic working with a tube of 10,000 ohms and another out of 30,000 ohms. Just what is the average impedance of a detector?

It is somewhat difficult to picture what happens when we measure this impedance in one of our bridges. The detector is a distorting device and a pure thousand-cycle note used for balancing the bridge will no longer be a pure note in the output. Furthermore, a detector tube has both high- and low-frequency voltages in both input and output. What effect has this combination of frequencies upon its impedance, if any? Is the impedance of a C-battery detector the same as that of a grid leak and condenser with grid slightly positive? It seems reasonable that the C battery demodulator will have a much higher impedance which may cause us to sit and think when such a device is recommended because of the superior quality of reproduction possible by its use.

There are other problems. For example, shall we place the voltage directly on the grid; shall the plate circuit have a load other than the resistance; shall there be radio-frequency voltages in the circuit?

112 TUBES

TUBE	NO. TESTED	AMPLIFICATION CONSTANT	PLATE IMPEDANCE	MUTUAL CONDUCTANCE
Cunningham	3	8.3	4660	1785
Daven Mu 6	1	5.3	5150	1060
Diatron	1	6.5	4670	1400
Hercultron	1	9.0	8700	1035
Q.R.S.	1	6.5	5700	1140
Regal	1	9.0	7400	1215
Zetka	4	8.1	7550	1114
Total	12	Average 7.5	6260	1250

Conditions

Plate Volts 135 Grid Volts -9

February 8th, 1927

FIG. 12

171 TUBES

TUBE	NO. TESTED	AMPLIFICATION CONSTANT	PLATE IMPEDANCE	MUTUAL CONDUCTANCE
Cunningham	2	2.9	2100	1380
Cleartron	3	2.6	2610	1000
Perryman	2	3.15	2650	1190
DeForest	2	2.5	2500	1000
Ureco Special	1	2.5	2000	1250
R.C.A.	5	2.85	2200	1300
Hercultron	1	3.25	2800	1160
Sylvania	2	2.7	2100	1290
Marathon	7	3.1	2600	1190
Total	25	Average 2.84	2395	1195

February 8th, 1927

Conditions

Filament Volts 5 Plate Volts 135 Grid Volts 27

FIG. 13

constants enter into other circuit calculations as shown below:

$$\text{Voltage Amplification} = \tfrac{1}{2}\sqrt{R_i} \times \frac{\mu}{\sqrt{R_p}}$$

$$\text{Power Amplification} = \frac{R_i}{2} \times \frac{\mu^2}{R_p}$$

$$\text{Power Output} = \frac{E_g^2}{8} \times \frac{\mu^2}{R_p}$$

where R_i is the input resistance and E_g is the input volts, peak.

In every case it will be seen that the tube enters in some ratio of its amplification constant squared, divided by its plate impedance. Knowing this factor, it is only necessary to insert it into circuit equations and calculate the result at once.

There has been much talk among tube manufacturers regarding standardization, and a universal desire is evidenced for a single term by which tubes could be rated. Unfortunately, no such term has been provided simply because no mathematics has been invented that will make such a thing possible. The important factors are the plate impedance, the amplification factor, and the figures for grid and plate voltage under which the values

201-A TUBES

TUBE	NO. TESTED	AMPLIFICATION CONSTANT	PLATE IMPEDANCE	MUTUAL CONDUCTANCE
Apco	5	6.3	8850	755
Armor	5	7.25	8360	850
Boehm	9	6.95	9030	780
Cable Supply Co.	8	7.4	9810	754
Ceco	6	8.15	11150	736
Champion	5	8.54	13320	643
Cleartron	17	7.1	10420	680
Cunningham	8	8.30	10825	750
DeForest D L 5	4	9.65	11100	885
DeForest D L 2	4	7.15	8625	830
DeForest D L 4	1	8.3	11200	740
Empiretron	3	7.1	10230	694
Fultone	6	8.85	11800	750
Gormac	5	7.15	12400	578
Hytron	3	9.43	14833	635
Ken-Rad	20	8.55	12450	695
Magnatron	2	8.0	12250	652
Marathon	9	8.2	11540	713
Perryman	14	7.6	10350	740
Q.R.S	24	8.2	11440	715
Schickerling RS 10	3	7.93	10167	790
Sky Sweeper	8	7.84	13100	600
Sonatron	4	8.43	13350	632
Strongson	6	8.2	9300	885
Supertron	3	9.5	14600	680
Sylvania	11	8.36	11100	757
Televocal	5	7.1	8000	860
Ureco	15	7.2	9820	800
Van Horne	12	8.63	12800	677
Voltron	19	5.64	7000	845
Zetka	8	8.1	13100	620
Total	225	Average 7.9	10000	735

Conditions

February 8th, 1927 Plate Volts 90 Grid Volts −4.5

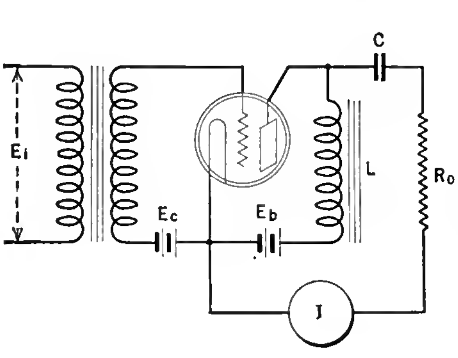
FIG. 14

Several schemes have been suggested to determine whether bridge measurements on distorting tubes mean anything. The one described here is due to Mr. Howard Rhodes of the staff of RADIO BROADCAST Laboratory. It follows from the succeeding consideration. In Fig. 15 is the symbolic representation of a simple circuit in which R_p is the usual tube impedance, and R_o is some other resistance inserted into the circuit and whose value is variable and known. It is simple enough to measure the voltage across this resistance.

Let us suppose the tube impedance, R_p, is 5000 ohms and that we measure and plot the voltage across R_o as the latter is varied. When the two resistances are equal, E_o will be $\frac{1}{2}$ μ E_g and when R_o is $3R_p$, E_o will be $\frac{3}{4}$ μ E_g, or 1.5 times as much as when R_o and R_p are equal. We shall then get a curve similar to that of Fig. 15. From these data a triangle may be formed whose base is fixed at three units and whose vertical leg is, when $R_p = R_o$, equal to 1.5. It is then only necessary to plot the voltages developed across known resistances in the plate circuit of the detector tube and to form the above triangle on this curve. Some data on detector impedance measured by several methods will be available later. Table No. 3 is the result of bridge methods.

POWER OUTPUT

THE final measurement in which we shall be interested at present is that of undistorted power output. With the advent of tubes of the 112, the 171, and the 210 class, honest-to-goodness amplifiers have been possible, and many strange misconceptions have arisen from a none too clear understanding of their nature. Some people think that a great increase in volume will result from the substitution of a 171 for a 201-A. Of course such a result is impossible. As a matter of fact the 201-A, with its larger mu, will produce twice as much voltage amplification as a 171, provided the proper impedances are used, but it is certain that more power, with less



$W_o = I^2 R_o$

FIG. 16

distortion, will be delivered to the loud speaker when a true power tube is used.

In the first place it may be said that measurement of undistorted power output from present-day tubes seems impossible, for the simple fact that there is no such thing. The question is one of allowable distortion, which involves not only matters of opinion but the particular amplifier and loud speaker used.

It is simple enough to measure the power from a tube. It is only necessary to measure the current through a known resistance, and if the tube constants are known to within ten per cent., and if the grid does not take over 10 microamperes in 350,000 ohms, approximately, the measured power will check the mathematical value to within 10 per cent.

The power developed in the load resistance in Fig. 16 is:

$$\frac{\mu^2 E_g^2 R_o}{(R_o + R_p)^2}$$

And when $R_o = R_p$ this simplifies to:

$$\frac{\mu^2 E_g^2}{8 R_p}$$

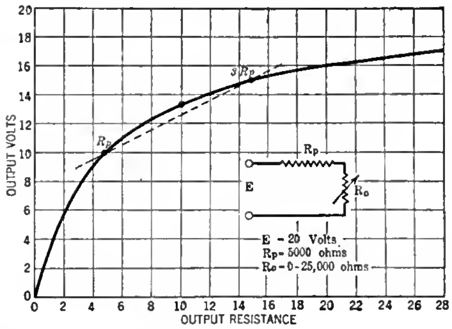


FIG. 15

Tube	Eg	Ep	Rp	R, megs.	C
201-A	—4.5	45	30,000		
201-A	G.L.	45	9500	1.5	0.00025
112	—4.5	45	14,000		
112	G.L.	45	6800	1.5	0.00025

TABLE NO. 3

where E_g is a peak voltage. If $R_o = 2R_p$ this value becomes:

$$\frac{2\mu^2 E_g^2}{9 R_p}$$

It is well known that the maximum power will be delivered to the loud speaker when the latter's impedance equals that of the tube, and recent data published in this country and in England indicate that the greatest amount of undistorted power will be delivered when the loud speaker impedance is twice that of the output tube. Fig. 17 shows how the power and the voltage gain of a tube vary with input voltage. When the lower bend of the characteristic curve is traversed, considerable rectification takes place, with corresponding change in d.c. plate current. When the plate current has changed roughly

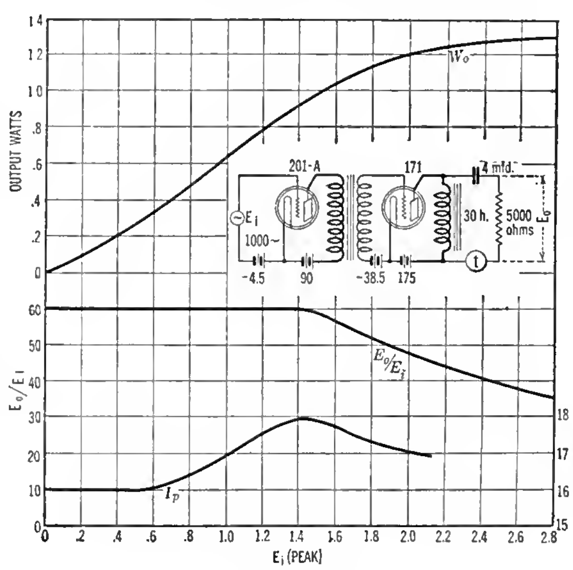


FIG. 18

10 per cent. the voltage amplification falls off, and the power output-voltage input curve flattens out.

Fig. 18 differs from Fig. 17 in several respects. Here the grid circuit is fed through a transformer. When the grid goes positive, the characteristic curve flattens out, duplicating roughly the curve at the lower bend. This results in smaller change in average d.c. plate current but a greater loss in amplification. In either case the change in plate current is a fair means of indicating distortion due to positive grid or to rectification at the lower bend.

NEW TUBES

TWO new tubes have been announced recently. One is a 300-milliampere rectifier which will make it possible to run 201-A type tubes in series from rectified a.c., while the other follows a suggestion of Mr. B. F. Meissner, whose paper, delivered before the Radio Club of America paper, on lighting filaments from a.c., was printed in the February and March issues of RADIO BROADCAST. This new tube requires two amperes at

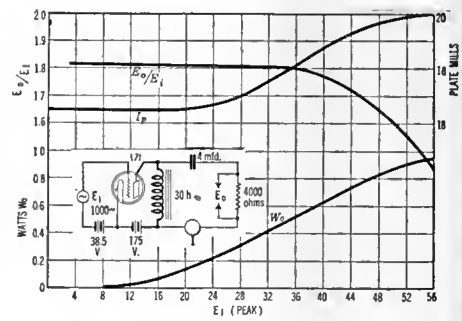


FIG. 17

0.6 volts. Naturally the voltage drop across such tubes to r.f. currents is remarkably low. Its thermal inertia is increased vastly over that of even 112 type tubes. The problem seems to be one of making a filament that will have a life comparable to that of other tubes now procurable.

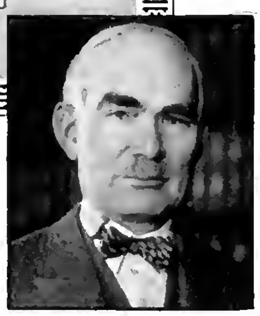
It must be admitted that there are a great many tube measurements that have not been discussed in this brief paper. For example, there is much to be done with detectors; with the possibility of using amplifiers in which the grid takes considerable current; on the effect of the amplitude of input a.c. voltages upon tube factors; and a host of other interesting and important measurements. There is, at the present time, too much taking the tube for granted, not only by the hundreds of thousands of users, but by manufacturers and engineers as well. A tube is not merely a thing to shove into a radio receiver socket; it is a sensitive and delicate device with a patient and willing nature.

¶ RADIO BROADCAST *is the official publication of the Radio Club of America, through whose courtesy, the foregoing paper has been printed here.* RADIO BROADCAST *does not, of course, assume responsibility for controversial statements made by authors of these papers. Other Radio Club papers will appear in subsequent numbers of this magazine*

FUTURE PERFECTION OF RADIO RECEPTION DEMANDS RADIO TUBES DESIGNED FOR EACH RADIO FUNCTION.

deForest

Like the Benvenuto Cellini cup from the Altman collection of the Metropolitan Museum in New York, the De Forest Audions are fine examples of craftsmanship and painstaking skill.



DE FOREST engineers have recognized certain characteristics in the functioning of tubes in all radio units. Our laboratories have labored long to advance these characteristics that so improve radio reception, and now, these highly desirable elements have been developed in De Forest Audions for specific operations in the various radio reception departments.

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These new De Forest Specialist Audions are now available for detector work, radio frequency amplification and use in all audio stages in types taking up to 500 volts on the plate.

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De Forest Audions have been standard since 1906. The same genius who has made the broadcasting of voice and music possible is still hard at work for greater perfection and greater achievement in radio reception.

Of course, De Forest has designed a general purpose Audion. It is a good one and where price is a consideration the DOI-A Audion is an unequalled value at $1.65. This tube is built to the same high standards of quality that mark all De Forest Audions.

De Forest dealers are pretty much everywhere. Look for displays of the brilliant black and orange Audion containers in shop windows. (Metal boxes in which De Forest Specialist Audions are packed insure their safety and dependability.)

If dealer is not available write for booklet which describes characteristics of each Audion and for chart indicating proper replacements for all standard makes of radio.

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Powell Crosley, Jr. *President*

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(A new booklet "17 Ways to Improve your Set" will be mailed on receipt of ten cents. Tells how to use fixed condensers and gives circuit details. Be sure to get your copy.)

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The *Radio Broadcast* LABORATORY INFORMATION SHEETS

INQUIRIES sent to the Questions and Answers department of RADIO BROADCAST *were at one time answered either by letter or in "The Grid." The latter department has been discontinued, and all questions addressed to our technical service department are now answered by mail. In place of "The Grid," appears this series of Laboratory Information Sheets. These sheets contain much the same type of information as formerly appeared in "The Grid," but we believe that the change in the method of presentation and the wider scope of the information in the sheets, will make this section of* RADIO BROADCAST *of much greater interest to our readers.*

The Laboratory Information Sheets cover a wide range of information of value to the experimenter, and they are so arranged that they may be cut from the magazine and preserved for constant reference. We suggest that the series of Sheets appearing in each issue be cut out with a razor blade and pasted on 4" by 6" filing cards, or in a notebook. The cards should be arranged in numerical order. Several times during the year an index to all sheets previously printed will appear in this department. The first index appeared in November.

Those who wish to avail themselves of the service formerly supplied by "The Grid," are requested to send their questions to the Technical Information Service of the Laboratory, using the coupon which appears on page 60 of this issue. Some of the former issues of RADIO BROADCAST, *in which appeared the first sets of Laboratory Sheets, may still be obtained from the Subscription Department of Doubleday, Page & Company at Garden City, New York.*

No. 89 RADIO BROADCAST Laboratory Information Sheet May, 1927

Short-Wave Coils

SOME DATA ON THEIR RESISTANCE

THERE are, at present, a great many excellent coils on the market for use in short-wave receivers. They are generally of the "plug-in" type so that different coils are used to obtain the various ranges required.

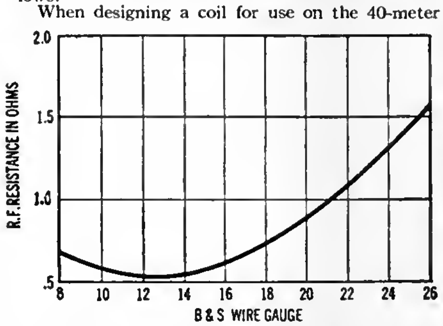
These coils should have as low a radio-frequency resistance as is possible, consistent with a construction sufficiently rugged to prevent their being damaged if they are handled somewhat roughly. It would be preferable if the coils could be wound on some solid form but the question then arises whether or not a form can be used without increasing the resistance of the coil to a considerable extent.

The General Radio Company has conducted some experiments along this line to determine just how much the form used affects the coil's resistance and also to determine what size wire is best to use. Tests were made using a standard bakelite form having a diameter of 2¾". The curve given on this Sheet indicates how the radio-frequency resistance of the coil varies with the size of the wire used. Evidently, from the curve, the wire size is not especially critical but best results are obtained with a wire size of about No. 12 or 14 gauge.

It was found that the use of good binders to hold the turns in place has no appreciable effect upon the resistance. A coil was wound in such a manner that a form could be slipped in and out of it without disturbing the wire. Measurements on the coil with and without the form indicated that the difference in efficiency was negligible.

Tests were also made with regard to shielding and it was found that the shielding could be placed very near the coil and have no appreciable effect. The result of the tests may be summed up as follows:

When designing a coil for use on the 40-meter



(7500-kc.) short-wave band (all these tests were made at this frequency), it is well to (1.) use about No. 12 to 14 wire; (2.) use a coil form if desired; (3.) use any good dope as a binder; (4.) use any reasonable amount of shielding where advantageous; (5.) keep the form factor (diameter divided by length) around 1 to 2.5.

These data are taken from the February, 1927, issue of the General Radio *Experimenter*.

No. 90 RADIO BROADCAST Laboratory Information Sheet May, 1927

Loop Antennas

SOME OF THEIR ADVANTAGES

THE operation of a transformer is usually explained by saying that the current flowing in the primary sets up an alternating magnetic field which in turn causes a current to flow in the secondary. This is also the simplest way to explain the operation of a loop antenna, the only difference being that the alternating magnetic field that causes the current to flow in the loop is in the form of radio waves.

The number of volts induced in a loop by the passage of radio waves is:

$$2 \pi f n A H \times 10^{-8}$$

where H is the amplitude of the wave, f the frequency, n the number of turns in the loop, and A the area of the loop. The voltage calculated from this formula is only correct when the plane of the loop is vertical and perpendicular to the direction of the magnetic field. That is, the loop must be pointing toward the transmitting station. If rotated about a vertical axis only a quarter of a turn, no voltage will be induced.

This feature is the most important advantage of a loop, for two stations using exactly the same wavelength may often satisfactorily be separated (provided they do not lie in the same or exactly opposite directions) by simply turning the loop at right angles to the interfering station. Loops are coming into greater use as transmitting stations become more powerful, and they will probably ultimately be used almost exclusively on account of the small space required, ease of installation, portability, lack of necessity to safeguard against lightning, and the improvement of the ratio of signal strength to interfering noises, due to their directional properties.

If a loop is compared in size to an antenna of the ordinary type it would appear that the amount of energy intercepted by the loop would be exceedingly small indeed. The fact is, however, that a good loop antenna, tuned with a condenser having low insulation losses, will pick up signals much better than might be expected from a comparison of its size to that of an outdoor antenna. This is due to the fact that the loop has a very much lower resistance than an elevated antenna.

The loop type antenna has been used most frequently in conjunction with super-heterodynes because, with this type of receiver, it is easy to obtain a large amount of radio-frequency amplification. During the last year, however, several receivers of the neutrodyne type have been placed on the market designed for use with a loop. These receivers are generally completely shielded so as to prevent interaction between the loop and the coils in the receiver.

Model AC-9

7-Tube, 2-Dial, Batteryless

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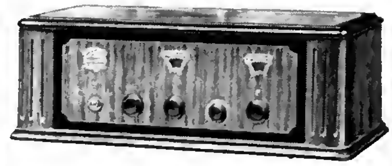
Console Model $192

$192.



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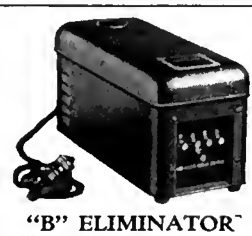

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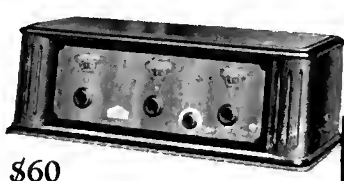

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Model S-522

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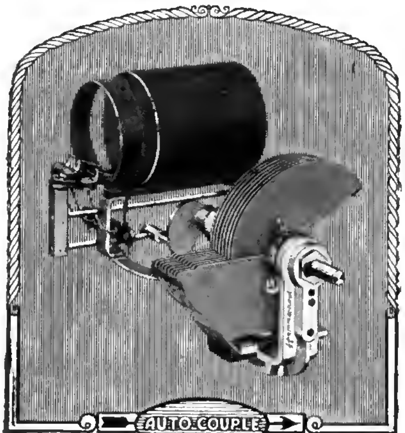

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The "Midline" condenser has a full-floating rotor, with removable shaft. A longer shaft permits coupling together any number of condensers for single control.

The Hammarlund "Auto-Couple" Unit (*condensers and coils may be purchased separately*) is readily adapted to any radio-frequency circuit and when combined with Hammarlund Shields, Equalizers, and Balancing Condensers, will make your receiver the last word in modern radio reception.

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For Better Radio
Hammarlund
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No. 91 RADIO BROADCAST Laboratory Information Sheet May, 1927

A Simple Tube Tester

HOW TO GET CHARACTERISTICS OF TUBES

CONTRARY to the opinion of many experimenters, a set-up of instruments to measure the characteristics of vacuum tubes is not excessively costly nor is it complicated. The diagram of connections of a tester is shown on Laboratory Sheet No. 92; this Laboratory Sheet will explain how to measure tube characteristics using the tester. The procedure can be explained most easily by taking an actual example.

Suppose we desire to measure the characteristics of a 201-A tube. We would first place the tube in the socket and then, with switch No. 2 in position B and switch No. 3 in position A, the rheostat would be adjusted until the filament voltage, as read on the voltmeter, is correct. In this case the correct voltage would be 5. Then, with switch No. 3 in position B the plate voltage is adjusted to 90 volts. The grid bias is next adjusted to 4.5 volts by throwing switches Nos. 1 and 2 to the A positions and adjusting the potentiometer P. The milliammeter will now read about 0.002 amperes (2 m A.). Note down the plate voltage, the grid voltage, and the resulting plate current.

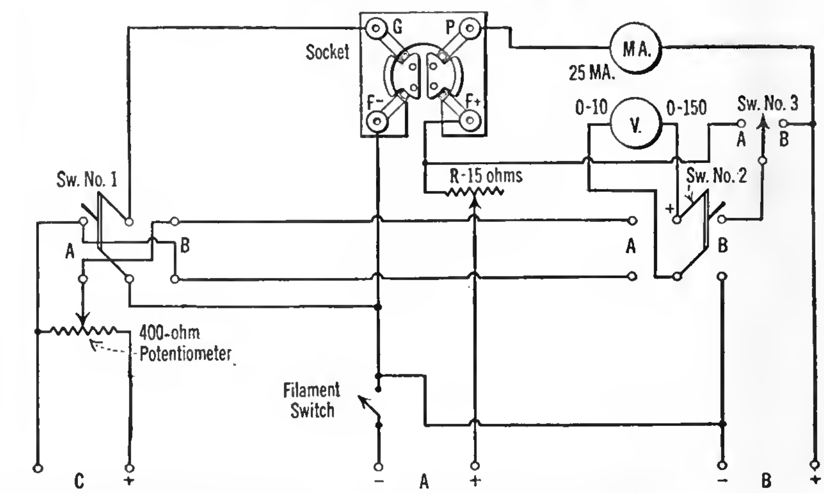
Now adjust the potentiometer until the grid bias is, say 3.5., and read the plate current. It should read about 0.003 amperes (3 mA.). Leaving the grid bias at 3.5, next adjust the switches to read the plate voltage. Reduce the plate voltage so as to make the milliammeter read exactly the same as before (2 mA.). The new reading of plate voltage may be 82. We now have all the necessary data to calculate the constants of the tube.

The amplification constant will be equal to the difference of the two plate voltages, 90-82, or 8, divided by the difference of the two grid voltages, 4.5—3.5 = 1. The amplification constant is therefore 8. The plate impedance is equal to the difference of the plate voltages divided by the difference in the plate currents, or 8 divided by 0.001. The quotient is 8000, which is the plate impedance. The mutual conductance is the plate current difference divided by the grid voltage difference, or 0.001 divided by 1 = 0.001 mhos or 1000 micromhos.

In measuring tube factors with this apparatus, care must be taken that the actual changes in voltages—and the corresponding current changes—are small. If the plate-current meter, and the grid-voltage meter, can be read with sufficient accuracy, very small changes should be made—say a plate voltage change of 5 volts. This, however, would make it necessary to read grid bias changes of less than a volt. The investigator, then, is between two fires in his endeavor to measure his tubes accurately. If he takes plate current readings resulting from large voltage changes, he gets a factor which represents working the tube over a large part of its characteristic curve. On the other hand, if he uses small voltage changes, the accuracy depends upon the accuracy ot his meters and his ability to read them.

No. 92 RADIO BROADCAST Laboratory Information Sheet May, 1927

Circuit Diagram of Tube Tester



No. 93 RADIO BROADCAST Laboratory Information Sheet May, 1927

Audio Amplifying Systems

DUAL-IMPEDANCE COUPLED AMPLIFIERS

ON THIS Sheet we give some facts regarding dual-impedance coupled amplifiers. A circuit diagram of such an amplifier will be found on Laboratory Sheet No. 87 (April, 1927).

Double-impedance amplifiers are capable of giving excellent results if care is taken in the selection of the apparatus and in the layout of the parts. The plate impedances should have an inductance around 100 henries; if the inductance is much less, the low frequencies will be lost. Well-made 0.1-mfd. blocking condensers are essential to prevent leakage.

The amplification of each stage is generally equal to about nine tenths of the amplification constant of the tube. If we lose one tenth on each stage, then the total amplification in three stages will be equal to 0.9 x 0.9 x 0.9 = 0.73 times the product of the amplification constants of the three tubes concerned. Suppose two 201-A's, each with an amplification of eight, and one 171 with an amplification of three, are used. Then the total amplification will be equal to 8 x 8 x 3 x 0.73 = 140.16. This value is rather too low for best results, and for this reason high-mu tubes, having an amplification constant of anything up to about thirty, are generally used in this type of amplifier.

From some tests made in the Laboratory, it appears possible to overload the power stage of an impedance amplifier to a considerable extent, without introducing very objectionable distortion. This comes about in the following way.

In a transformer-coupled amplifier the maximum signal that can be placed on the grid is limited by the fact that, if the signal voltage is too large, grid current will flow in the grid circuit of the power tube. This current flowing through the secondary of the transformer saturates the core and prevents the transformer from properly amplifying the signal. In an impedance amplifier there are no transformers, and the grid current only has the effect of slightly lowering the inductance of the impedance unit in the power tubes's grid circuit. Slight overloading is therefore less noticeable in an impedance amplifier than in a transformer-coupled one.

As stated above, the amplification obtained at low frequencies depends upon the use of high-inductance impedances in the plate and grid circuits. There has however been a recent development in the design of double-impedance amplifiers by which it is possible to obtain very good low-note amplification without using very large coils. This design feature consists in so determining the inductance of the plate and grid coils and the capacity of the coupling condenser, that the entire combination tunes or resonates at about 30 cycles, with the result that the amplification of these low frequencies is unusually good.

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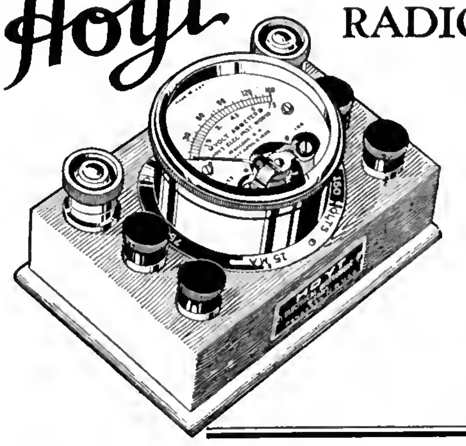
Hoyt RADIO ROTARY METER



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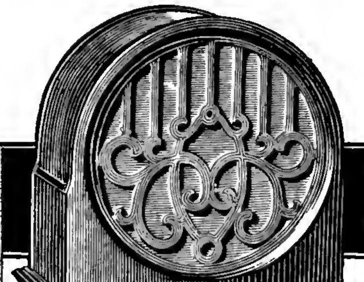

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AMPLION

No. 94 Radio Broadcast Laboratory Information Sheet May, 1927

The Principle of Reflexing

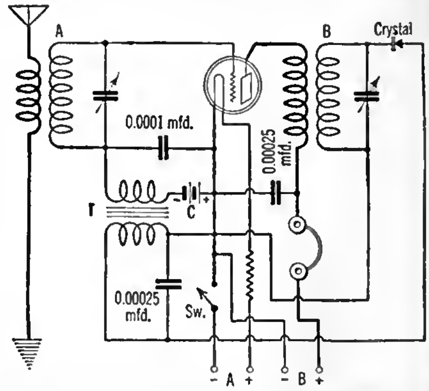
AN EXPLANATION OF THE ACTION

When a tube capable of amplifying a fairly strong signal is used to amplify a very weak one, it is evident that its power amplifying ability is not being made use of to the fullest possible extent.

"Reflexing" is a system for getting more out of a tube by making it amplify two things—the incoming signal, which is a radio-frequency current, and the detected signal, which is an audio-frequency current. The accompanying diagram indicates a simple receiver using one stage of reflexed amplification.

In this receiver, the radio-frequency current enters the receiver via the antenna and is impressed on the tube by the tuned circuit, A. It then passes through the tubes and into the tuned transformer, B, the output of which is impressed on a crystal detector. The audio-frequency currents resulting from the detecting action of the crystal pass through the primary of the audio transformer, T. The voltage induced in the secondary of this transformer is impressed on the grid of the tube and is amplified. A pair of phones is used in the plate circuit of the tube for receiving the signal.

So long as the variations of potential due to these two different signals do not cause the tube to overload, neither interferes with the other. Some circuits use a reflex principle consisting of several stages of radio-frequency amplification and several stages of audio-frequency amplification. In such sets it is advantageous to use the system due to David Grimes and known as the Inverse Duplex system. In this system, the tube handling the smallest amount of radio-frequency energy is made to handle the largest amount of audio-frequency energy and, vice versa, the tube handling the greatest



amount of radio energy handles the smallest amount of audio energy. In this way the point of overloading is not reached as quickly, and it is possible to obtain high efficiency from such a receiver.

No. 95 Radio Broadcast Laboratory Information Sheet May, 1927

Storage Batteries

NECESSARY CARE

The storage battery has been developed to a remarkable degree of perfection so that it will function over a long period of time with only a small amount of attention. Such attention consists more than anything else in keeping the battery properly filled with pure distilled water and correctly charged at all times. The efficiency and the life of the battery will decrease considerably if these two points are not carefully watched. The charging rate should be as close as possible to that recommended by the manufacturer, this information generally being given on the name plate of the battery. Although the state of charge of a battery can be measured with some accuracy by means of a voltmeter if the proper precautions are taken, the readings made in this way are not generally to be relied upon. A better method for use in testing a storage battery is to determine the state of charge by means of a hydrometer. The specific gravity, which is what the hydrometer measures, will be found to increase the reading of the hydrometer as the battery is charged, up to a certain point. The specific gravity reading for full charge is not the same for all batteries. For this reason, an endeavor should be made to obtain from the manufacturer of the battery information regarding the hydrometer reading which should be obtained using his battery when it is fully charged and when it is fully discharged. Frequently, but not always, these same data will be found on the name plate. In the event that this information cannot be obtained, it is a safe rule to charge the battery until the hydrometer reading does not change during a period of one hour. When this condition holds true, the battery has absorbed all the charge possible. It will generally be found also that, when this condition of constant specific gravity reading throughout an hour is reached, the electrolyte will also begin to gas or bubble.

Care should be taken in charging the battery to make certain that its positive terminal is connected to the positive terminal of the source being used for charging purposes. If the battery is charged in the opposite direction the plates will be reversed in chemical character, and if the charging is continued for any great length of time, the battery will be destroyed. If a battery has only been charged in the wrong direction for a short length of time it can generally be brought back to normal by charging in the right direction for a very long time at a low charging rate.

No. 96 Radio Broadcast Laboratory Information Sheet May, 1927

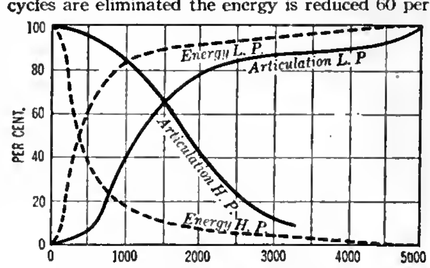
Analysis of Voice Frequencies

RELATIVE IMPORTANCE OF LOW AND HIGH FREQUENCIES

Many investigations have been made to determine the relative importance of the various frequencies that are found in the human voice. For these investigations a high-quality audio amplifying system must be employed over which it is possible to hear equally as well as by direct transmission through the air.

Tests have been made by the Western Electric Company using such an amplifying system to determine the relative importance of different frequencies in the voice frequency range, and the results of these tests are shown in the curves on this sheet. These curves were obtained by inserting in the circuit low-pass (L.P.) filters, which will only pass low frequencies, and high-pass (H. P.) filters designed to pass no frequencies below a certain point. First of all let us consider the curve marked "Articulation H. P." The curve shows that the articulation was 40 per cent. when a high-pass filter was used that eliminated all frequencies below 2000 cycles. The articulation rises to 70 per cent. when a high-pass filter was used to cut off all frequencies below 1400 cycles. The curve marked "Energy L.P." shows that 60 per cent. of the total energy in the voice remained when a low-pass filter was used to cut off frequencies above 500 cycles.

These curves indicate, then, that the lower frequencies furnish most of the energy in the voice and that the higher frequencies are most important for proper articulation. If frequencies below 500 cycles are eliminated the energy is reduced 60 per



cent., and the articulation is only reduced 2 per cent. Eliminating all frequencies above 400 cycles leaves remaining 60 per cent. of the total energy but the articulation is only about 5 per cent.

The curves on this sheet were traced from an excellent book by K. S. Johnson entitled: *Transmission Circuits for Telephone Communication.*

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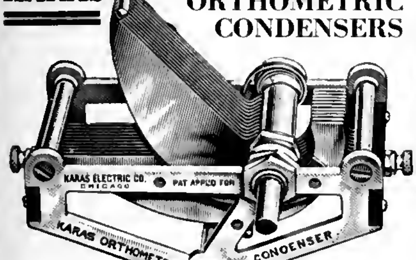

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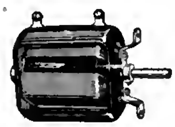

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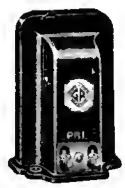

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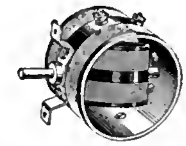

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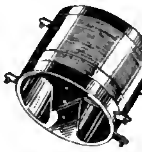

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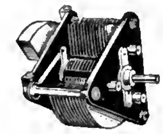

Type 247-F
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Equipment for the Home-Constructor

How to Use Some of the New Equipment Tested and Approved by the "Radio Broadcast" Laboratory

By THE LABORATORY STAFF

INTERFERENCE ELIMINATORS

MAN-MADE, as well as the natural sort of "static," will hinder the reception of radio signals. Fortunately, however, the former can be eliminated in almost all cases. Any kind of electrical spark will set up high-frequency oscillations similar to those used for broadcasting, the difference between the two being that the electrical spark from a motor or other household appliance is of an intermittent and varying intensity, which results only in noise in the receiver. There are many classes of electrical apparatus which can cause interference, such as oil burners, battery chargers, violet ray apparatus, etc. The commutator type of motor commonly used in connection with household appliances is one of the most common offenders. The spark takes place at the commutator, but the high-frequency oscillations may be carried along wires for a block or more and blanket reception over a large area.

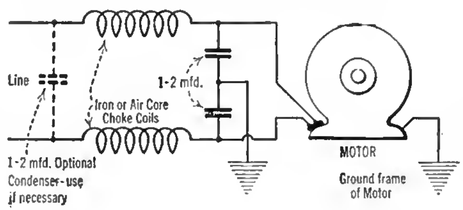


FIG. 1

A combination of fixed condensers and choke coils, placed in the electric line near the offending apparatus, will usually eliminate, or at least greatly reduce, the interference from this source. The common connections of such a filter apparatus are shown in Fig. 1. A choke coil is placed in each leg of the line supplying the motor or other apparatus. These coils have a high impedance to high-frequency oscillations, and are usually of approximately 200 millihenries inductance. They should be wound with wire heavy enough to carry the current required without undue heating. Chokes of this character may be constructed by winding 175 turns of No. 16 d.c.c. on a porcelain tube 1 inch in diameter and 12 inches long. The condensers act as a by-path to ground for the high-frequency current. The value of these condensers may be from 1 to 2 microfarads, depending upon the nature of the interference. Sometimes another condenser, shown by the dotted lines, is placed across the line side of the filter. These condensers should have a high enough working voltage to take care of any voltage which may be impressed on them.

There are several interference filters on the market, two of which are shown in the photograph. While the circuit diagram given may not be exactly that used in the commercial type of filter, these latter are all based on the same general principle. In each device there are five wires leading out of the case, two of which go to the electric line, two to the motor or other apparatus, and the fifth to the grounded frame of the motor. The Tobe Interference Filter No. 1 is made by the Tobe-Deutschmann Company, of Cambridge, Massachusetts, and sells for $15.00. This filter is designed for household appliances and will work effectively on motors up to ¼ horsepower, and may be used on d.c. or a.c. lines. It is understood that these filters may be obtained, by special order, for installations of as high as 500-kilowatts and 1000 volts potential. The Day-Fan Electric Company, of Dayton, Ohio, also make a filter, known as the "Quietus," which is obtainable in two models, one, the No. 6001, for general use in the home, which sells for $10.00, and another, the No. 6003, for use with a household lighting plant, such as the Delco-Light, which is priced at $8.00.

RESISTORS FOR SOCKET-POWER DEVICES

RESISTORS designed for use in socket-power devices may be of the wire-wound type or of the metallic filament type, but in every case, they must be designed to dissipate the heat generated fast enough so that they will not burn out. Some manufacturers rate their resistors according to how much current may be carried with safety, while others rate them in watts. To choose the correct resistance when the rating is given in current, the amount of current which is to flow in the circuit must be known. This may be measured or it may be calculated by Ohm's Law. For instance, if the resistance is 1000 ohms and the voltage 100, the voltage divided by resistance will give the amount of current which will flow, which in this case is 0.10 amperes (100 milliamperes). The current-carrying capacity of the resistor should therefore be rated at 100 or more mils. In the case of the resistor rated in watts, the procedure is slightly different. The wattage is found by multiplying the voltage by the current, or in the case of the above resistor, the voltage (100) times the current (0.10) gives us 10 watts. That is, a 1000-ohm resistor having a rating of 10 watts would carry the 100 milliamperes without overheating. Another way in which the carrying capacity may be figured is by the formula in which watts are equal to the current squared times the resistance. Transposing the formula we get:

$$I = \sqrt{W/R}$$

where I is the current, W is the watts rating, and R is the resistance. Substituting the actual values

Radio Broadcast Photograph

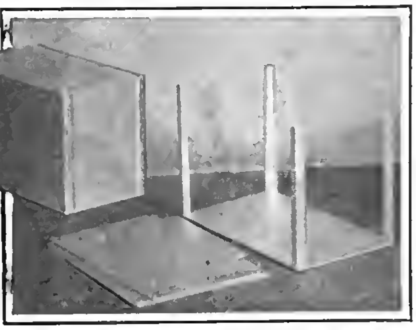
THE "QUIETUS" AND TOBE-DEUTSCHMANN INTERFERENCE FILTERS where R = 1000 ohms and W = 10, in the above formula, we have I equal to the square root of 10 ÷ 1000. Taking the square root, we obtain the safe carrying capacity in current as 0.1 amperes, or 100 milliamperes.

The resistances of various units as measured in the Laboratory by means of the Wheatstone bridge were found to differ by about 3 per cent. from the rated value, which is close enough for all ordinary purposes. Resistors of this type are made by Amsco Products, Incorporated, New York City; Ward-Leonard Electric Company, Mount Vernon, New York; the Tobe-Deutschmann Company (Veritas), Cambridge, Massachusetts; Arther H. Lynch, Inc., New York, and the C. E. Mountford Company (Kroblak), New York City.

SHIELDS

ARGUMENTS still continue among engineers, experimenters, and home-constructors, regarding the shielding of radio broadcast receivers. Some say that coils, condensers, etc., if properly designed and properly spaced in the receiver, will need no shielding, while others claim that shielding is an absolute necessity.

Until quite recently the home-constructor was hampered in the use of shielding, because he had no tools for working the material; besides, the latter was hard to get. Several types of aluminum box shields can now be had, and they may easily be incorporated in almost any receiver requiring a shield. These shields usually come in knock-



Radio Broadcast Photograph

INDIVIDUAL STAGE SHIELDS

down form, and may easily be assembled by means of ingeniously designed corner strips. Their size is sufficient to allow a tube, radio-frequency transformer, and variable condenser to be mounted within them without coming too close to the sides. If the size is not exactly right they may be cut down before assembly, as they are in flat pieces. An accompanying photograph shows one of these shield boxes, made by the Aluminum Company of America, both in knocked-down and assembled form. The Aluminum Company's box is 12 gauge, 6 inches high, 5 inches wide, and 9 inches deep, and is sold for $3.00. The Hammarlund Manufacturing Company's box shield is 22 gauge, 5¾ inches high, 6 inches wide, and 9 inches deep, and sells for $2.00. The Silver-Marshall Company makes a shield of this type which, however, is not knocked down. The box is 21 gauge, 5 inches high, 3¾ inches wide, and 7½ inches deep. The price is $2.00.

SOCKET-POWER UNITS

THE Balkite socket-power B units are all of the electrolytic type, having eight cells in series which rectify the a.c. current from the line.

Radio Broadcast Photograph

THE BALKITE "KX" UNIT

These cells are of the acid type having one electrode of lead and the other of a special material. As a rule, this type of rectifier, combined with the proper transformers, chokes, and condensers gives very quiet operation, and the only attention required is the addition of pure water at intervals of several months to take care of the evaporation which naturally takes place.

In the instructions accompanying the apparatus, it is stated that the formation of a brown or white sludge in the bottom of the cell is a normal condition and no attention should be paid to it. The solution sometimes turns pink, and this also may be regarded as natural. It should never be necessary to replace the electrolyte except in case of accident when the solution is spilled. A new solution should be obtained from the manufacturer or from the dealer who sold the unit. If the electrolyte gets spilled in the metal case, the whole unit should be shipped back to the factory immediately for a thorough cleaning, otherwise the acid may cause considerable damage to the electrical mechanism in the device and cause it to cease functioning.

Sometimes when the electrolytic type of rectifier is left for some time without being operated, a thin film of sulphate will form on the surface of the electrodes which will materially lower the output voltage. There are two methods of bringing the unit back to normal. For ordinary cases, the unit should be disconnected from the receiver and a short circuiting wire connected across the output terminals marked "High" and "Negative." The line current is then turned on for half an hour, after which the jumper wire is disconnected and the unit is again hooked up to the receiver, and normal operation should be obtained. Another method which may be used is to put a jumper across the output as before and then short out half of the rectifier cells at a time for a period of about thirty seconds. In the Laboratory the breaking down of the sulphate film was tried out, the voltage, in one case, being raised from 125 to 140 volts. On one of the smaller units, the voltage was raised from 105 to 120 volts. Both units had been standing for some time. One model, the type KX, which includes a trickle charger in the same case, is shown in the accompanying photograph on this page.

A table of the price list and capacities is appended at the bottom of this page. All of these Balkite units are for use with 110 to 120 volts a.c. Models are sold for either 50 or 60 cycles. They are manufactured by Fansteel Products, Incorporated, of North Chicago, Illinois.

Model	Watts Consumption	Terminals	No. of Tubes	Capacity	Price
B —W	7	Det., Amp., B neg.	5 or less	67–90 volts, 20 mils.	$27.50
B —X	12	Det., Low, Med., High, B neg.	5 to 8	135 volts, 30 mils.	42.00
B —Y	17	Det., Low, Med., High, Power, Gnd., B neg.	Any receiver	150 volts, 40 mils.	69.00
KX*	15	Det., Low, Med., High, A plus, A minus, B neg.	5 to 8	135 volts, 30 mils.	59.50

*Includes a trickle charger for the A battery.

PRICE LIST AND CAPACITIES OF BALKITE UNITS

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Ask any Radio Engineer

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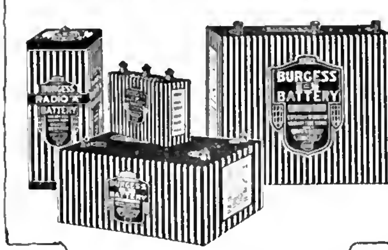

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A KEY TO RECENT RADIO ARTICLES

By E. G. SHALKHAUSER

THIS is the nineteenth installment of references to articles which have appeared recently in various radio periodicals. Each separate reference should be cut out and pasted on 4" x 6" cards for filing, or pasted in a scrap book either alphabetically or numerically. An outline of the Dewey Decimal System (employed here) appeared last in the January RADIO BROADCAST.

R550. BROADCASTING. BROADCASTING
Popular Radio. Jan., 1927. Pp. II-ff. *Who Pays for,*
"Who Pays the Broadcaster?" O. E. Dunlap, Jr.

The problem of supporting radio broadcast programs, either through actual contributions by the listening public, or through indirect channels, such as advertising, and thus creating good will and deriving publicity, is discussed. A list of sponsors of various program features, and the stations broadcasting, is tabulated, showing what is being done to-day in furnishing entertainment. A chart is also appended stating the toll charges of the various stations for given periods of time on the air.

R141.2. RESONANCE. RESONANCE,
Popular Radio. Jan., 1927, Pp. 31-ff. *Tuning.*
"What Happens When You Tune Your Set," Sir Oliver Lodge.

A simple treatise on the conversion of radio waves into electrical impulses in the tuning circuits of the radio set and its analogy to mechanical or sound resonance is given in this second of a series of articles. The function of the detector tube is clearly outlined.

R620.08. INSTALLATIONS. INSTALLATIONS,
Bureau of Standards Handbook No. 9. *Safety Rules.*
"Safety Rules for Radio Installations."

The material contained herein is a reprint of Part 5 of the National Electrical Safety Code, dealing with proper radio installations as approved by the American Engineering Standards Committee.

R090. HISTORY. HISTORY
Radio Service Bulletin. Dec. 31, 1926., Pp. 24-32.
"Important Events in Radio-Peaks in the Waves of Wireless Progress."

A brief outline of the important happenings in the history of radio, opposite the year in which these events occurred, is given. Starting with the year 1827, when the principle of magnetism was first discovered, and leading down through the year 1926, the progress made in radio is presented.

R550. BROADCASTING. BROADCASTING,
Radio Service Bulletin. Dec., 31, 1926.
Pp. 9-21. *List of Stations.*
"Broadcasting Stations, Alphabetically by Call Signals."

A list of broadcasting stations, giving call signals, location of station, owner of station, power, wavelength, and frequency, is presented. The list is complete up to December 31, 1926. This publication may be procured from the Superintendent of Documents, Government Printing Office, Washington, District of Columbia, at five cents per copy.

R330. ELECTRON TUBES. ELECTRON TUBES,
Radio. Jan., 1927, Pp. 20-ff. *4 Element.*
"The Shielded Grid Vacuum Tube," E. E. Turner, Jr.

By placing a second grid between the plate and the control grid of a vacuum tube, Doctor Hull, of the General Electric Company, has succeeded in reducing inter-electrode capacity between the elements of the tube. This second grid is said to act as an electrostatic shield when positively charged. It is composed of a number of flat circular discs, or rings, 3 mm. wide and spaced 3 mm. apart. The characteristics of the tube are discussed.

R344.5 ALTERNATING CURRENT SUPPLY. SOCKET-POWER
Radio. Jan., 1927. Pp. 23-24. DEVICE,
A Battery.
"A Home-Built A Battery Eliminator," G. M. Best.

Constructional data concerning a 2-ampere A battery eliminator employing a transformer, chokes, two tungar 2-ampere bulbs, and electrolytic condensers or rheostats, are presented.

R382. INDUCTORS. INDUCTORS,
Radio. Jan., 1927. Pp. 26-27. *Chart.*
"A Reversible Inductance Chart," A. C. Kulmann.

A very comprehensible and useful inductance chart for single-layer solenoids, giving either the inductance of a coil or the coil size required for a given inductance, is shown. The range in inductance is from 4 to 20,000 microhenries. The use of the chart is illustrated.

R134.8. REFLEX ACTION. REFLEX
Radio. Jan., 1927. Pp. 29ff. ACTION.
"More About the New Inverse Duplex," D. Grimes.

In this second of a series of articles on the new Inverse Duplex System, complete data on the construction of the separate coils, data on wiring and assembly, and elimination of trouble that might occur, are given.

R343. ELECTRON-TUBE RECEIVING SETS. RECEIVER,
Radio. Jan., 1927. Pp. 30ff. *Infradyne.*
"How and Why the Infradyne Works," R. B. Thorpe.

The writer discusses theoretically the operation of the new infradyne receiving circuit, analyzing the action taking place within the various parts of the circuit. Various diagrams and graphs are shown, in order to explain clearly the arrangement employed.

R344.3. TRANSMITTING SETS. TRANSMITTERS,
Proc. I. R. E. Jan., 1927. Pp. 9-36. *Crystal-Controlled.*
"Piezo-Electric Crystal-Controlled Transmitters," A. Crossley.

A discussion of piezo-electric crystals and the early history of the development of the art are given.

The development of crystal-controlled vacuum-tube oscillators by the Naval Research Laboratory is outlined, and various means of amplifying the output of a crystal-controlled oscillator are cited, the best method being described. This method consists of balancing or neutralizing the various stages of amplification and also observing proper precautions for reducing grid circuit losses by using high values of biasing voltage.

A complete high-power low-frequency crystal-controlled transmitter is described, and a schematic wiring diagram of the circuits employed in this transmitter is shown. A schematic wiring diagram, and illustrations of one type of low-power high-frequency transmitter, complete the subject matter covered in this paper.

R344. ELECTRON-TUBE GENERATORS. ELECTRON-TUBE
Proc. I. R. E. Jan., 1927. Pp. 37-39. GENERATOR.
"Simultaneous Production of a Fundamental and a Harmonic in a Tube Generator," H. J. Walls.

A method whereby a single generator tube may be used to transmit two frequencies simultaneously, thus eliminating the necessity of using two separate tubes, is described. In addition to the fundamental, some harmonic is amplified in a separate oscillating circuit. A broadcasting station may thus send out the same modulated energy on two frequencies using but one transmitter.

R113.1. FADING. FADING.
Proc. I. R. E. Jan., 1927. Pp. 41-47. *Recorder for.*
"An Automatic Fading Recorder," T. A. Smith and G. Rodwin.

A device for automatically recording signal intensities is described, with the method employed to amplify the signal sufficiently to operate a commercial type graphic meter. Sample fading records of various transmissions are also presented.

R331. CONSTRUCTION; EVACUATION OF TUBES. ELECTRON TUBES,
Proc. I. R. E. Jan., 1927. Pp. 49-55. *Alkali Vapor.*
"Behavior of Alkali Vapor Detector Tubes," H. A. Brown and C. T. Knipp.

The comparative efficiency of gas-filled tubes now on the market, and certain potassium sodium alloy tubes, is described. It is shown how the operation of gas-filled tubes depends on the temperature of the gas and the tube walls. It is also shown how these K Na tubes compare with the 201-A and the 200 type tubes, and that the K Na tubes are ideal for durability, true tone reproduction, and non-critical adjustment of plate and filament voltage.

International Short-Wave Test

FROM April 18th to 30th, short-wave tests on 7000-kc. (43 meters) will be conducted from WAQ-2 XAI, the Westinghouse experimental station at Newark, New Jersey. The schedule is: 8 to 8:30 P. M. (Eastern Standard Time) "ABC de 2 XAI" sent automatically on a crystal-controlled transmitter. From 8:30 to 9, amateurs will be worked and other tests made. The manager of the station, E. Gundrum, Westinghouse Electric & Manufacturing Company, Plane and Orange Streets, Newark, New Jersey, welcomes reports on audibility, fading, and keying, from listeners throughout the world. Reports should be forwarded either to RADIO BROADCAST or directly to the station.

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1. FILAMENT CONTROL—Problems of filament supply, voltage, regulation, and effect on various circuits. RADIALL COMPANY.
2. HARD RUBBER PANELS—Characteristics and properties of hard rubber as used in radio, with suggestions on how to "work" it. B. F. GOODRICH RUBBER COMPANY.
3. TRANSFORMERS—A booklet giving data on input and output transformers. PACENT ELECTRIC COMPANY.
4. RESISTANCE-COUPLED AMPLIFIERS—A general discussion of resistance coupling with curves and circuit diagrams. COLE RADIO MANUFACTURING COMPANY.
5. CARBORUNDUM IN RADIO—A book giving pertinent data on the crystal as used for detection, with hook-ups, and a section giving information on the use of resistors. THE CARBORUNDUM COMPANY.
6. B-ELIMINATOR CONSTRUCTION—Constructional data on how to build. AMERICAN ELECTRICAL COMPANY.
7. TRANSFORMER AND CHOKE-COUPLED AMPLIFICATION—Circuit diagrams and discussion. ALL-AMERICAN RADIO CORPORATION.
8. RESISTANCE UNITS—A data sheet of resistance units and their application. WARD-LEONARD ELECTRIC COMPANY.
9. VOLUME CONTROL—A leaflet showing circuits for distortionless control of volume. CENTRAL RADIO LABORATORIES.
10. VARIABLE RESISTANCE—As used in various circuits. CENTRAL RADIO LABORATORIES.
11. RESISTANCE COUPLING—Resistors and their application to audio amplification, with circuit diagrams. DEJUR PRODUCTS COMPANY.
12. DISTORTION AND WHAT CAUSES IT—Hook-ups of resistance-coupled amplifiers with standard circuits. ALLEN-BRADLEY COMPANY.
15. B-ELIMINATOR AND POWER AMPLIFIER—Instructions for assembly and operation using Raytheon tube. GENERAL RADIO COMPANY.
15a. B-ELIMINATOR AND POWER AMPLIFIER—Instructions for assembly and operation using an R. C. A. rectifier. GENERAL RADIO COMPANY.
16. VARIABLE CONDENSERS—A description of the functions and characteristics of variable condensers with curves and specifications for their application to complete receivers. ALLEN D. CARDWELL MANUFACTURING COMPANY.
17. BAKELITE—A description of various uses of bakelite in radio, its manufacture, and its properties. BAKELITE CORPORATION.
19. POWER SUPPLY—A discussion on power supply with particular reference to lamp-socket operation. Theory and constructional data for building power supply devices. ACME APPARATUS COMPANY.
20. AUDIO AMPLIFICATION—A booklet containing data on audio amplification together with hints for the constructor. ALL-AMERICAN RADIO CORPORATION.
21. HIGH-FREQUENCY DRIVER AND SHORT-WAVE WAVEMETER—Constructional data and application. BURGESS BATTERY COMPANY.
46. AUDIO-FREQUENCY CHOKES—A pamphlet showing positions in the circuit where audio-frequency chokes may be used. SAMSON ELECTRIC COMPANY.
47. RADIO-FREQUENCY CHOKES—Circuit diagrams illustrating the use of chokes to keep out radio-frequency currents from definite points. SAMSON ELECTRIC COMPANY.
48. TRANSFORMER AND IMPEDANCE DATA—Tables giving the mechanical and electrical characteristics of transformers and impedances, together with a short description of their use in the circuit. SAMSON ELECTRIC COMPANY.
49. BYPASS CONDENSERS—A description of the manufacture of bypass and filter condensers. LESLIE F. MUTER COMPANY.
50. AUDIO MANUAL—Fifty questions which are often asked regarding audio amplification, and their answers. AMERTRAN SALES COMPANY, INCORPORATED.
51. SHORT-WAVE RECEIVER—Constructional data on a receiver which, by the substitution of various coils, may be made to tune from a frequency of 16,660 kc. (18 meters) to 1999 kc. (150 meters). SILVER-MARSHALL, INCORPORATED.
52. AUDIO QUALITY—A booklet dealing with audio-frequency amplification of various kinds and the application to well-known circuits. SILVER-MARSHALL, INCORPORATED.
56. VARIABLE CONDENSERS—A bulletin giving an analysis of various condensers together with their characteristics. GENERAL RADIO COMPANY.
57. FILTER DATA—Facts about the filtering of direct current supplied by means of motor-generator outfits used with transmitters. ELECTRIC SPECIALTY COMPANY.
59. RESISTANCE COUPLING—A booklet giving some general information on the subject of radio and the application of resistors to a circuit. DAVEN RADIO CORPORATION.
60. RESISTORS—A pamphlet giving some technical data on resistors which are capable of dissipating considerable energy; also data on the ordinary resistors used in resistance-coupled amplification. THE CRESCENT RADIO SUPPLY COMPANY.
62. RADIO-FREQUENCY AMPLIFICATION—Constructional details of a five-tube receiver using a special design of radio frequency transformer. CAMFIELD RADIO MANUFACTURING COMPANY.
63. FIVE-TUBE RECEIVER—Constructional data on building a receiver. AERO PRODUCTS, INCORPORATED.
64. AMPLIFICATION WITHOUT DISTORTION—Data and curves illustrating the use of various methods of amplification. ACME APPARATUS COMPANY.
65. RADIO HANDBOOK—A helpful booklet on the functions, selection, and use of radio apparatus for better reception. BENJAMIN ELECTRIC MANUFACTURING COMPANY.
66. SUPER-HETERODYNE—Constructional details of a seven-tube set. G. C. EVANS COMPANY.
70. IMPROVING THE AUDIO AMPLIFIER—Data on the characteristics of audio transformers, with a circuit diagram showing where chokes, resistors, and condensers can be used. AMERICAN TRANSFORMER COMPANY.
71. DISTORTIONLESS AMPLIFICATION—A discussion of the resistance-coupled amplifier used in conjunction with a transformer, impedance, or resistance input stage. Amplifier circuit diagrams and constants are given in detail for the constructor. AMSCO PRODUCTS INCORPORATED.
72. PLATE SUPPLY SYSTEM—A wiring diagram and layout plan for a plate supply system to be used with a power amplifier. Complete directions for wiring are given. AMERTRAN SALES COMPANY
80. FIVE-TUBE RECEIVER—Data are given for the construction of a five-tube tuned radio-frequency receiver. Complete instructions, list of parts, circuit diagram, and template are given. ALL-AMERICAN RADIO CORPORATION.
81. BETTER TUNING—A booklet giving much general information on the subject of radio reception with specific illustrations. Primarily for the non-technical home constructor. BREMER-TULLY MANUFACTURING COMPANY.
82. SIX-TUBE RECEIVER—A booklet containing photographs, instructions, and diagrams for building a six-tube shielded receiver. SILVER-MARSHALL INCORPORATED.
83. SOCKET POWER DEVICE—A list of parts, diagrams, and templates for the construction and assembly of socket power devices. JEFFERSON ELECTRIC MANUFACTURING COMPANY.
84. FIVE-TUBE EQUAMATIC—Panel layout, circuit diagrams, and instructions for building a five-tube receiver, together with data on the operation of tuned radio-frequency transformers of special design. KARAS ELECTRIC COMPANY.
85. FILTER—Data on a high-capacity electrolytic condenser used in filter circuits in connection with A socket power supply units, are given in a pamphlet. THE ABOX COMPANY.

ACCESSORIES

22. A PRIMER OF ELECTRICITY—Fundamentals of electricity with special reference to the application of dry cells to radio and other uses. Constructional data on buzzers, automatic switches, alarms, etc. NATIONAL CARBON COMPANY.
23. AUTOMATIC RELAY CONNECTIONS—A data sheet showing how a relay may be used to control A and B circuits. YAXLEY MANUFACTURING COMPANY.
25. ELECTROLYTIC RECTIFIER—Technical data on a new type of rectifier with operating curves. KODEL RADIO CORPORATION.
26. DRY CELLS FOR TRANSMITTERS—Actual tests given, well illustrated with curves showing exactly what may be expected of this type of B power. BURGESS BATTERY COMPANY.
27. DRY-CELL BATTERY CAPACITIES FOR RADIO TRANSMITTERS—Characteristic curves and data on discharge tests. BURGESS BATTERY COMPANY.
28. B BATTERY LIFE—Battery life curves with general curves on tube characteristics. BURGESS BATTERY COMPANY.
29. HOW TO MAKE YOUR SET WORK BETTER—A non-technical discussion of general radio subjects with hints on how reception may be bettered by using the right tubes. UNITED RADIO AND ELECTRIC CORPORATION.
30. TUBE CHARACTERISTICS—A data sheet giving constants of tubes. C. E. MANUFACTURING COMPANY.
31. FUNCTIONS OF THE LOUD SPEAKER—A short, non-technical general article on loud speakers. AMPLION CORPORATION OF AMERICA.
32. METERS FOR RADIO—A catalogue of meters used in radio, with connecting diagrams. BURTON-ROGERS COMPANY.
33. SWITCHBOARD AND PORTABLE METERS—A booklet giving dimensions, specifications, and shunts used with various meters. BURTON-ROGERS COMPANY.
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36. Charging A and B Batteries—Various ways of connecting up batteries for charging purposes. Westinghouse Union Battery Company.
37. Choosing the Right Radio Battery—Advice on what dry cell battery to use; their application to radio, with wiring diagrams. National Carbon Company.
53. Tube Reactivator—Information on the care of vacuum tubes, with notes on how and when they should be reactivated. The Sterling Manufacturing Company.
54. Arresters—Mechanical details and principles of the vacuum type of arrester. National Electric Specialty Company.
55. Capacity Connector—Description of a new device for connecting up the various parts of a receiving set, and at the same time providing bypass condensers between the leads. Kurz-Kasch Company.
61. Dry Cells—Information on the construction and operation of dry cells with a description of the methods used in testing them. The Carbon Products Company.
68. Chemical Rectifier—Details of assembly, with wiring diagrams, showing how to use a chemical rectifier for charging batteries. Cleveland Engineering Laboratories Company.
69. Vacuum Tubes—A booklet giving the characteristics of the various tube types with a short description of where they may be used in the circuit. Radio Corporation of America.
77. Tubes—A booklet for the beginner who is interested in vacuum tubes. A non-technical consideration of the various elements in the tube as well as their position in the receiver. Cleartron Vacuum Tube Company.
86. Short-Wave Receiver—A booklet containing data on a short-wave receiver as constructed for experimental purposes. The Allen D. Cardwell Manufacturing Corporation.
87. Tube Tester—A complete description of how to build and how to operate a tube tester. Burton-Rogers Company.

Miscellaneous

38. Log Sheet—A list of broadcasting stations with columns for marking down dial settings. U. S. L. Radio, Incorporated.
41. Baby Radio Transmitter of 9xh-9ek—Description and circuit diagrams of dry-cell operated transmitter. Burgess Battery Company.
42. Arctic Radio Equipment—Description and circuit details of short-wave receiver and transmitter used in Arctic exploration. Burgess Battery Company.
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73. Radio Simplified—A non-technical booklet giving pertinent data on various radio subjects. Of especial interest to the beginner and set owner. Crosley Radio Corporation.
74. The Experimenter—A monthly publication which gives technical facts, valuable tables, and pertinent information on various radio subjects. Interesting to the experimenter and to the technical radio man. General Radio Company.
75. For the Listener—General suggestions for the selecting, and the care of radio receivers. Valley Electric Company.
76. Radio Instruments—A description of various meters used in radio and electrical circuits together with a short discussion of their uses. Jewell Electrical Instrument Company.
78. Electrical Troubles—A pamphlet describing the use of electrical testing instruments in automotive work combined with a description of the cadmium test for storage batteries. Of interest to the owner of storage batteries. Burton Rogers Company.
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RADIO BROADCAST

JUNE, 1927

WILLIS KINGSLEY WING, Editor

KEITH HENNEY, Director of the Laboratory — JOHN B. BRENNAN, Technical Editor

EDGAR H. FELIX, Contributing Editor

Vol. XI, No 2

CONTENTS

Cover Design - - - - - - - From a Painting by Fred J. Edgars

Frontispiece - - - - - - - - - Radio Programs at Sea 74

What Do We Know About Radio Waves in Transit? R. W. King 75

The March of Radio - - - - - An Editorial Interpretation 78

- Why Radio Home Construction Continues to be Fascinating
- Patent Licensing Points to a Bright Radio Future
- Stabilizing the Broadcasting Situation
- Pleas for a Blue Radio Sunday
- The Wisely Chosen Radio Commissioners
- What About the Canadian Demand for More Wavelengths?
- Conditions for Long Distance Receiving Do Vary
- Direct Advertising Over the Air from Corsets to Calliopes
- Latest Television Developments
- The Month in Radio

Why Shielding? - - - - - - - - - - - Edgar H. Felix 83

Building an Electrical Phonograph - - - - - James Millen 86

"Strays" from the Laboratory - - - - - - - - - - - - - 90

- Growth of the Laboratory
- The Facts About the A. C. Tube
- Crystal Control on Short Waves
- New Nomenclature for Our Tubes?

An Instrument for the Home Laboratory - - Keith Henney 92

The Listeners' Point of View - - - - - - John Wallace 97

- "Radio Pests" and How to Be One
- Making Up the "Sponsored" Program
- An Evening of Chain Programs
- Thumb Nail Reviews
- Microphone Miscellany
- Correspondence

Problems of A. C. Filament Supply - - - - Roland F. Beers 101

How to Design a Loop Antenna - - - - - - Homer S. Davis 104

As the Broadcaster Sees It - - - - - - - - - Carl Dreher 106

- The Difficult Business of Running a Broadcasting Station
- Man and Modulation
- Technical Problem No. 1
- Design and Operation of Broadcasting Station, 16: Studio Design
- Shrapnel from Cleveland
- Memoirs of a Radio Engineer: XVIII
- Solution of Technical Problem No. 1

Book Reviews - 110

- *Theory of Vibrating Systems and Sound.* Reviewed by Carl Dreher
- *The Radio Encyclopedia.* Reviewed by Edgar H. Felix

Analyzing the Power Amplifier - - - - D. E. Harnett 111

"Radio Broadcast's" Laboratory Information Sheets - - - - 116

- No. 97 Methods of Generating High-Frequency Energy
- No. 98 Audio Amplifying Systems
- No. 99 Data on the "Universal" Receiver
- No. 100 Circuit Diagram of the "Universal" Receiver
- No. 101 Lightning Arresters
- No. 102 Efficiency of Amplifying Systems
- No. 103 Audio Transformers
- No. 104 Socket Power Units

Equipment for the Home Constructor - - - - - - - - - - - 120

Manufacturers' Booklets Available - - - - - - - - - - - 123

What Kit Shall I Buy? - - - - - - - - - - - - - - - - 125

A Key to Recent Radio Articles - - - E. G. Shalkhauser 126

AMONG OTHER THINGS. . .

AS ANNOUNCED on page 78, the July number of RADIO BROADCAST will appear with a new cover design. For the last six months, we have been examining sample designs and searching the field for an artist who could supply us with a design which properly reflected the character of this magazine. Finally, Harvey Hopkins Dunn, of Philadelphia, presented a design which drew unqualified approval. Mr. Dunn is internationally known as a typographical designer and his most recent cover design has been used by *International Studio*. Our July cover will appear in an unusually attractive shade of yellow, green, and black, and is distinguished by its simplicity and effectiveness.

THIS number of RADIO BROADCAST contains an exceptionally wide range of editorial features, starting with R. W. King's review of present knowledge of how radio waves are propagated. Then comes a short article on what one should know about shielding, of distinct help to those who sell and those who buy shielded receivers. James Millen's second article on radio and the electric phonograph gives a wealth of practical information to those who are planning to make their present phonograph equipment work with their high-quality radio receiver. The spring and summer months offer an excellent time to make these not very difficult changes. We call especial attention to the "'Strays' from the Laboratory"—a new feature of this magazine, which will, from month to month, provide a place where our readers may find comment and news of great interest. Another new feature in the popular department "As the Broadcaster Sees It" is found in the presentation of a technical problem, and its appended solution. These problems will cover a wide range and will prove of value not only to the technical broadcaster but to the general reader as well. Homer Davis' "How to Design a Loop Antenna" has long been awaited by our readers and is of distinctly practical nature. The second of Roland F. Beers' articles on the problems of series filament connections in receiving sets appears, presented in a very clear manner. The Radio Club of America paper this month casts more light on the design of power amplifiers and should attract wide interest because of the increasing popularity of this accessory.

PRINTERS' INK, in its tabulation of advertising lineage for April magazines shows that RADIO BROADCAST printed 15,315 lines, being exceeded only by *Radio News* with 15,454. *Radio* printed 11,129 lines, *Popular Radio* 10,510 and *Radio Age* 3,728.

ANSWERS from our readers to the question posed in our May number: "Which Stations Shall Broadcast?" are coming in great numbers, and are rapidly being tabulated for the Federal Radio Commission. These reflections of opinion from our readers provide an unusually reliable cross-section of opinion and important information about local conditions from the entire country and from Canada.

THE July magazine, among many other important features, will contain an exclusive article on the new Raytheon "A" tube, showing its use and value in A-battery charging circuits; two complete constructional articles will tell how to use the QRS 400-mA. rectifier tube and the Raytheon 350-mA. tube.

—WILLIS KINGSLEY WING.

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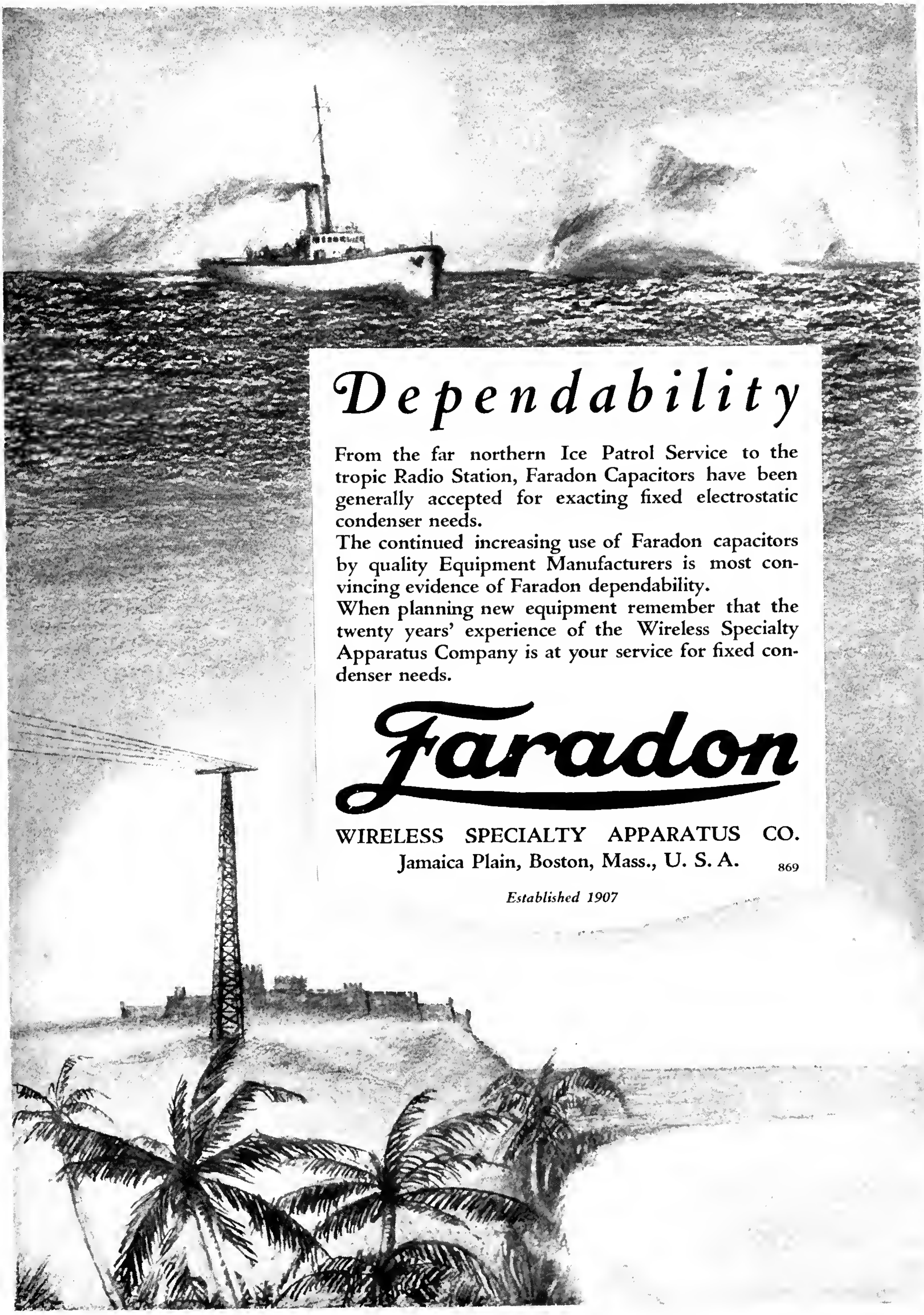
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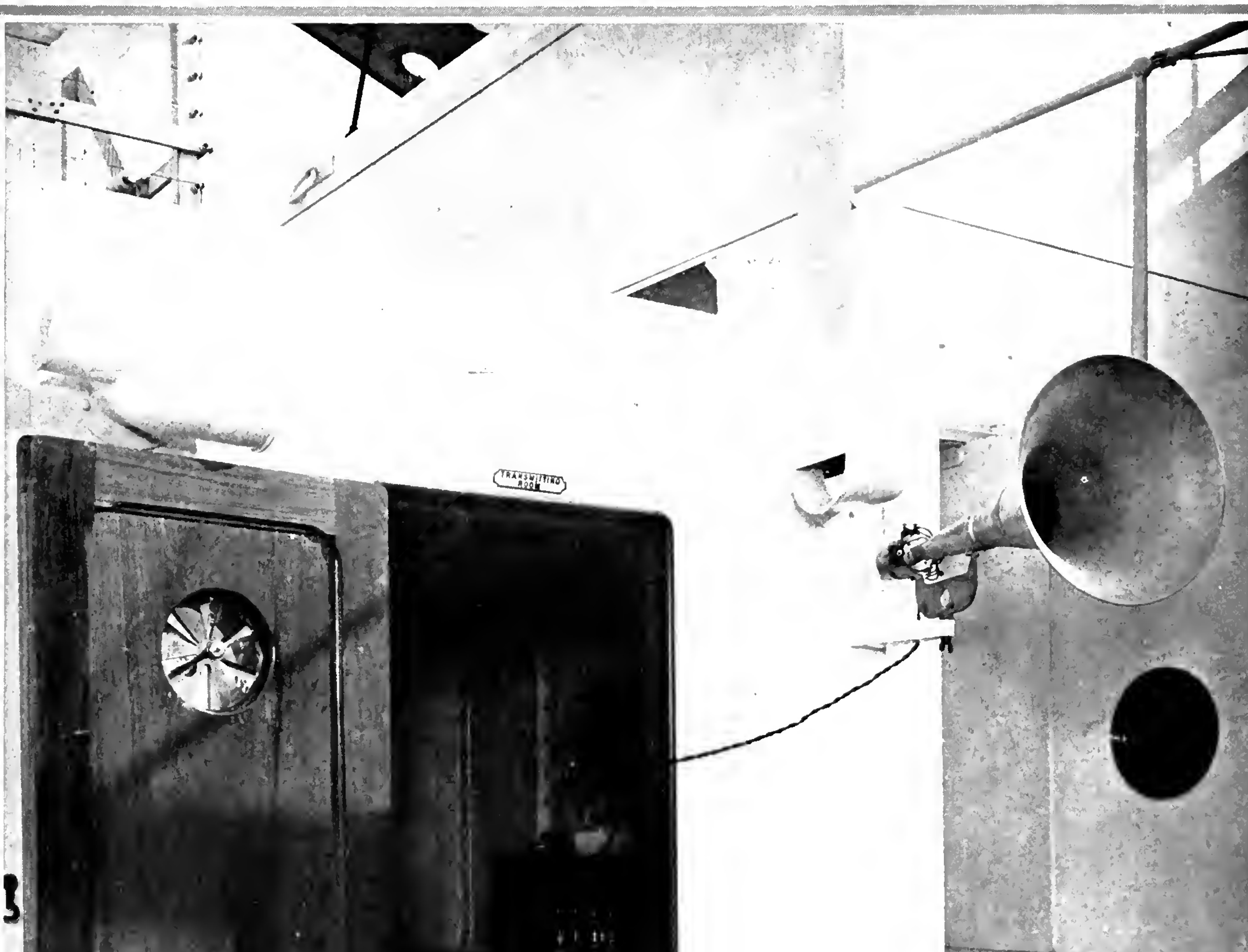


RADIO PROGRAMS AT SEA

One of a number of loud speakers of the speech equipment installed aboard the motor vessel Asturias, *one of the newest passenger ships. The various loud speakers may be connected to an electrical attachment to reproduce phonograph music, to a local microphone, or to the output of a broadcast receiver. The transmitting room of the ship's radio installation is in the foreground, while at the top left extreme can be seen the antenna frame of the radio direction finder*

RADIO BROADCAST

VOLUME XI NUMBER 2

JUNE, 1927

What Do We Know About Radio Waves in Transit?

How Radio Waves Behave After Leaving the Transmitter—The Queer Influence of Various Phenomena Upon Them

By R. W. KING

American Telephone and Telegraph Company

THE ancient Greek god with the winged sandals has been replaced by invisible electric waves. These waves are the conveyors for all of our many forms of electrical communication. Speeding at well-nigh incredible velocities, they bear alike the code message of the familiar Morse telegraph, the voice that flows over the wires of the household telephone, and the music which leaves the antenna of the radio broadcasting station.

In the case of the wire telephone and telegraph, the waves are closely harnessed and obediently follow a given pair of wires or a single wire with "ground return." As radiated from the broadcasting antenna, we commonly think of the waves as being free and spreading out in all directions. Yet they cannot be entirely free and unconstrained. Apparently the atmosphere exerts upon them a sort of guiding influence sufficient to prevent their being lost in space. A fundamental fact of radio transmission as we observe it on the earth is its following not straight but curved paths. The earth is a ball and radio waves, instead of traveling out along a tangent plane, curve their course sufficiently to conform to the rotundity of the earth.

Just how great is the curvature involved we can visualize more readily by constructing a small-scale model. If we have a single medium propagating waves without absorption or dispersion, a principle of optics states that all wave paths remain similar when the scales of time and space are reduced in the same ratio. Application of this principle leads to the result that if, on the one hand, we have waves 100 meters long traveling over an earth 8000 miles in diameter, and on the other hand, waves of red light (rather less than one millionth of a meter long) and a sphere about two inches in diameter, then the geometry of the two cases will be identical. Experience tells us, however, that red light would not creep to any appreciable degree around a sphere the size of a billiard ball. The sphere would cause a very apparent shadow if held so as to intercept light falling upon a screen, and if radio waves crept around the earth to no greater extent than this light would around the darkened portion of the ball, long-distance signaling by radio would be quite impossible.

Among those skilled in the science of optics no small amount of surprise was occasioned, therefore, by Marconi's announcement about twenty-five years ago that radio signals had been successfully transmitted across the Atlantic Ocean. This at once gave rise to speculation as to how the beam of waves could bend itself around the protuberance of the curved earth, it having naturally been taken for granted that to such waves the atmosphere would be merely a uniform and transparent medium.

Besides constraining radio waves to travel around our spherical earth—a very fortunate fact—the atmosphere causes in them variations of strength with

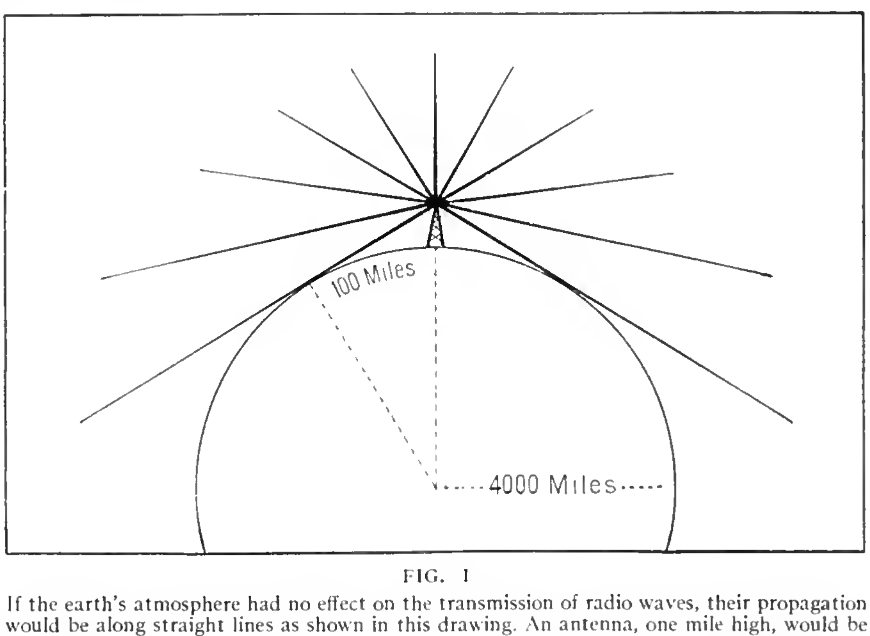


FIG. 1

If the earth's atmosphere had no effect on the transmission of radio waves, their propagation would be along straight lines as shown in this drawing. An antenna, one mile high, would be capable of transmitting signals to a distance of about 100 miles before the shadow cast by the earth's curvature would cut them off. If the receiving antenna were also a mile high, the distance of transmission would be increased to about 200 miles time of day and year, erratic fluctuations known as "fading," and sometimes irregularities of such a sort as to result in serious loss of quality to the messages it carries. These latter effects of the atmosphere are not particularly fortunate so far as the radio engineer is concerned. However, all effects, fortunate and unfortunate, may be so related in cause that if the atmosphere were to yield the secret of why it guides waves to follow the surface of the earth, it might also yield secrets helping to master the troublesome phenomena of fading and loss of quality. The near future is likely to see us in possession of the reason why the atmosphere acts as a guide to waves and if, in acquiring this knowledge, we gain an insight into other facts, the radio engineer will have occasion to be thankful that he lives on an earth that is round.

Unfortunately it is only in thought that we can pass from considering 100-meter waves traveling around the earth to waves of red light traveling around a billiard ball. If we could but experiment with the latter with its proper diminutive atmosphere surrounding it, we might hope to vary one factor at a time and thus more readily discover the cause or combination of causes for radio waves traveling in curved beams. But it appears that we are limited to experiment on the full-scale earth itself. And here not even Joshua of old, commanding the sun to stand still, could help us very much. By stopping our celestial luminary, he could, to be sure, supply uninterrupted daylight and night conditions, and these would undoubtedly help in understanding the differences they present to radio transmission, but it seems likely that the presence or absence of daylight is only one of many factors entering the problem. To mention just a few others, there are lightning flashes attended by the possible liberation of very high speed electrons, the "cosmic rays" which are known to increase in intensity as we ascend to high altitudes, probable electric discharges from the sun (these are now commonly supposed to be the principal cause of the aurora borealis), and, in turn, the pressure, temperature, and compositions of the upper strata of the atmosphere.

Here is a complexity of influences almost sufficient to satisfy the mathematician who aspired to develop his technique to the point that he could predict the orbit of a house fly.

Returning to the original problem, an explanation of why radio waves bend around the earth has been sought in many directions. One of the first attempts was to call upon the fact that the earth is an electrical conductor. Waves started from a grounded antenna would, of course, be in contact at the outset with the earth, and it was thought possible that the interaction between the waves and the currents they would induce in the surface of the earth would be such as to cause them to remain closely attached to the earth as they spread out. This tendency actually does exist but calculations soon showed that it was far too minute to account for the known strength of signals received at a great distance.

The way was prepared, however, for the suggestion of the so-called Heaviside layer, a conducting region in the upper atmosphere which would imprison radio waves between itself and the conducting earth below, and constrain them to move only in the annular region between. Whether such a conducting layer actually exists, it is as yet impossible to say. So far as the electrical properties of gases are known, it could result only from rather sharply defined ionization in the upper atmosphere. When we speak of a gas as ionized, we mean that certain of its molecules have been robbed of one or more of their normal electrons. These ionized molecules then constitute freely moving positive charges. The electrons which they have lost may continue to circulate as individual negative charges, or they may attach themselves to neutral molecules of gas, still retaining their negative charges but losing considerably in mobility because of the relatively heavy molecules with which they are associated.

The air at the surface of the earth is always somewhat ionized—on an average to the extent of perhaps 1000 negative ions and 1000 positive ions for the 30 quintillion molecules actually present per cubic centimeter of gas. A small amount, indeed, but very important perhaps. This ionization may originate partly through radioactive materials in the earth and in the air, and to a smaller extent through the agency of the so-called cosmic rays. Ultra-violet light from the sun may also cause appreciable ionization in the upper strata where it is largely absorbed, but this doubtless does not persist through the night, and therefore is merely one of the agencies causing radio waves to behave as they do.

It should be borne in mind, however, that the current explanation of the aurora is based upon ions which are hypothecated as streaming from the sun and bending around into the darkened hemisphere under the influence of the earth's magnetic field. It may be such ions as these that account for the bulk of both day time and night time conductivity in the upper atmosphere. See Fig. 5.

Another factor, recently pointed out by Professor C. T. R. Wilson, which may be by no means the least important in determining the electrical state of the upper atmosphere, is thunder storms. From a statistical study of the distribution of thunder storms, the English Meteorological Office concludes that about 1800 thunder storms are, on the average, in progress at a given moment, producing about 100 lightning flashes per second. The quantity of electricity discharged in a flash is of the order of 20 coulombs, and the potential difference which causes the discharge may rise to as high, it is estimated, as one billion volts. Thus Professor Wilson suggests that the power expended in producing lightning by thunder clouds the world over may be as great as one ten-thousandth part of the total power received by the earth from the sun. Now, as a celestial receiving set, the earth does a very creditable job, picking up, from the power which the sun broadcasts, about one hundred trillion horsepower. It is indeed noteworthy, therefore, that if 1–10,000th part, or even a much smaller fraction, of this power is turned loose in the form of lightning—and therefore in a form which generates *static*—it offers to our man-built radio stations competition of no insignificant order of magnitude.

Not only is the electric power expended by thunder clouds large, but both the current and the voltage involved are of the order of magnitude which suggests the possibility of important effects on the electrical state of the upper atmosphere. Thus, the voltage of a thunder cloud is such that it may act as a source of extremely high speed electrons and also X-rays.

It is conceivable that high-speed electrons or beta rays from lightning flashes may pass upward through the outer atmosphere, and, due to the earth's magnetic field, reënter the atmosphere in widely scattered regions contributing, perhaps, to auroral phenomena and to the

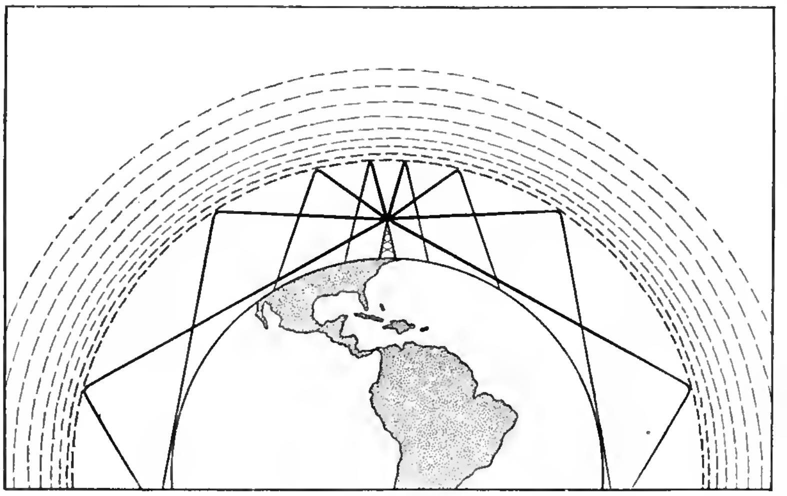


FIG. 2

This drawing illustrates the general manner of radio propagation assuming a rather sharply defined conducting (reflecting) layer in the upper atmosphere. The Heaviside layer is ordinarily assumed to possess this character. By means of the conducting stratum of air above, and the conducting earth below, radio waves are guided essentially as waves are guided along a pair of wires in wire communication

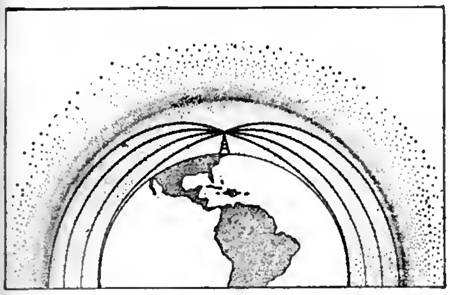


FIG. 3
This drawing illustrates the bending effect of ionization permeating the atmosphere. Downward refraction toward the earth would be due to an ionization that becomes greater with increased altitude

penetrating "cosmic" radiation as well as to such atmospheric ionization as is important in radio transmission. In this connection, it is interesting to recall that the green spectrum line which is so characteristic of the light of the aurora has been found by Lord Rayleigh in the radiation from the normal night sky.

Attempts are being made to associate radio reception conditions with the weather (see articles by J. C. Jensen and Eugene van Cleef in RADIO BROADCAST, and a recent paper, by G. W. Pickard read before the Institute of Radio Engineers) and, in accordance with this theory of C. T. R. Wilson, it may not be impossible to find a connection between reception, aside from static and thunder storms, both local and remote.

Another theory, and one of the latest to be proposed (Sir J. Larmor, *Phil. Mag.*, Vol. 48, page 1025, 1924), is based upon ionization in the atmosphere but does not require that this exist in the form of a layer whose lower surface is sharply defined. Larmor shows that if the amount of ionization increases with altitude, the more elevated portions of a wave train will travel faster than the portion near the earth and the train as a whole will be deflected downward. This downward deflection may easily be sufficient to cause the wave train to conform to the curved surface of the earth or even to dive into the earth at a slight angle. On this theory the bending of radio waves downward is rather analogous to the bending upward of light waves to produce a mirage. It will be recalled that a mirage is seen across a flat, heated, landscape, such as desert sand, the layers of air closest to the earth being most highly heated and, therefore, of lowest density, transmitting light with a slightly greater velocity than the cooler overlying layers

Which of these two theories is better, or whether there is some theory, or combination of theories, as yet unproposed, which will ultimately win out, it is, of course, scarcely worth our while to speculate at this juncture. As matters now stand, some may prefer to entertain the idea of a more or less sharply defined and reflecting layer of ionization, located perhaps ten miles, perhaps fifty miles, above the surface of the earth, while others may prefer to think in terms of a widely diffused ionization gradually increasing with increasing altitude, which acts prismatically to bend radio waves earthward. A paper given at the 1926 midwinter Convention of the A. I. E. E. by Baker and Rice, attempts a quantitative statement of the distribution of ions.

WORK FOR THE AMATEUR

IN THIS work the radio amateur occupies a very strategic position. Curiously enough, it is short-wave transmission that is bringing to light facts so striking that they cannot fail to be crucial to any theory of transmission. One of the outstanding pieces of work in this new field is that of Dr. A. H. Taylor who has correlated many results obtained by amateurs with the short-wave experience of the Navy. Among the striking phenomena now commonly recognized may be mentioned "skip distance." No one was very much surprised when it became known that short wavelengths die away very rapidly as one recedes from the transmitting antenna. But when these short waves, which presumably had disappeared entirely at a distance of, say, 200 miles, were found to reappear at a distance of 600 or 1000 miles, it became evident that a new phenomenon had to be reckoned with. Data recently published (for example, by Heising, Schelleng, and Southworth, of the Bell Telephone System) indicate, furthermore, that the "skip distance" lengthens as the wavelength decreases. This fact is not out of harmony with the theory of a refracting ionization distributed throughout the atmosphere, but neither can it be said as yet to prove that such ionization exists.

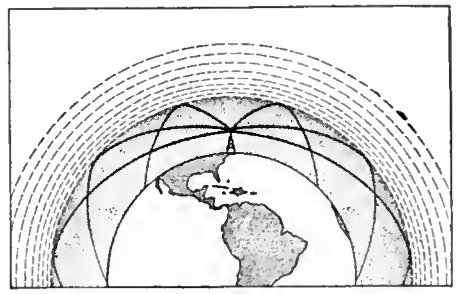


FIG. 4
If the effects shown in Figs. 2 and 3 were combined, they would result in a type of transmission shown in this drawing

The "skip distance" displayed by short-wave transmission seems to indicate that, of the waves which leave the transmitting antenna, those which travel near the surface of the earth are rapidly absorbed, while those starting upward, perhaps at a slight angle to the earth's surface, soon reach a rarified region through which they travel with little absorption, but which gradually bends them downward, either by reflection or refraction, until they again reach the earth, hundreds or even thousands of miles away.

If this view is correct, it means that a beam of short waves constitutes a messenger which we can send up perhaps to the outermost confines of the atmosphere and have return to us again. There is no doubt but what scientists will quickly devise means for determining what alterations these returning waves have undergone, and thus interpret the message which they bring back regarding the constitution of the upper atmosphere.

In studying electric waves as messengers returning from the upper strata of the atmosphere, it will be increasingly important to take into account the effect of the earth's magnetic field in such ways as were pointed out by Nichols and Schelleng in the Bell System *Technical Journal*, April, 1925. In enlarging the theory of Larmor to include the earth's magnetic field, they found that under some circumstances it is possible for a ray to follow the bend of the earth, even though the number of ions decreases with altitude. They also concluded that, for low frequencies (long wavelengths), the magnetic field prevents the electrons from moving in as large orbits as they otherwise would describe, which results, in turn, in smaller absorption of energy and therefore in reduced attenuation. A magnetic field permeating the ionized atmosphere may also divide a beam into differently polarized components, thus giving additional data on the nature of the transmission path supplied by the upper atmosphere.

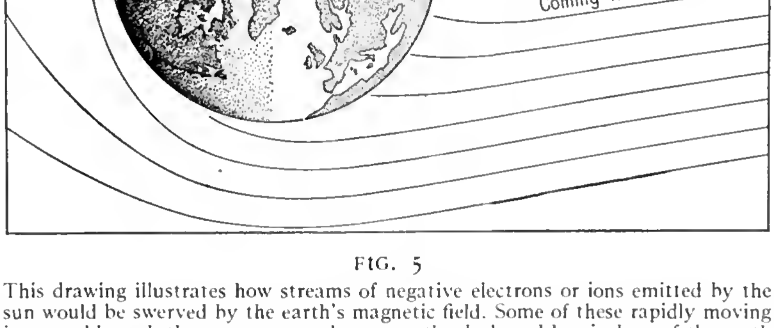
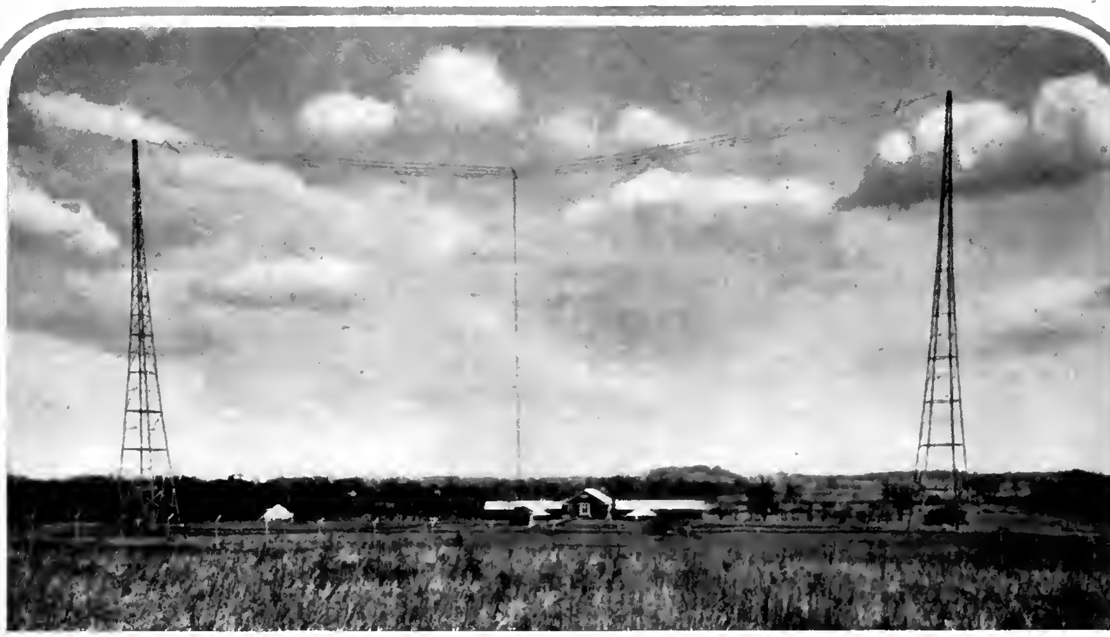


FIG. 5
This drawing illustrates how streams of negative electrons or ions emitted by the sun would be swerved by the earth's magnetic field. Some of these rapidly moving ions would reach the upper atmosphere over the darkened hemisphere of the earth and would therefore be available to influence night-time transmission. A stream of positive ions coming from the sun would be deflected downward and not upward



THE MARCH OF RADIO

News and Interpretation of Current Radio Events

Why Radio Home Construction Continues to be Fascinating

WHEN the moguls of the radio industry gather nowadays, they no longer discuss heatedly the relative prospects of the home-built versus the manufactured receiver. The normal level of the parts business is now founded upon that percentage of listeners which finds pleasure and satisfaction in its own receiver; economy no longer acts as the chief stimulant to augment the ranks of the army of set builders. It is easier and in many cases, cheaper to buy a good receiver of all around efficiency than to build one. The man who builds his own does so because he likes to work with his hands or because he prefers exceptional performance in one or more particular qualities, like selectivity, sensitivity, efficiency, or economy. Other hobbies and pastimes in a similar position have thrived for years with no firmer foundation for their prosperity.

The small tool business, for example, owes half its volume to the man who putters with tools for the fun he gets out of them. There is no economic reason for building your own chair, desk, or bookshelf. With less trouble and expenditure, you can buy an article. But no one worries especially about the future of the small tool business.

Our contact with thousands of readers through questionnaires and letters shows that the set builder recognizes his enthusiasm as a pastime and not altogether as a money making proposition. A very significant point, brought out by a recent study, is the fact that many set builders have made ten and fifteen sets in the last few years and eagerly await new and superior designs so that they may make more. Set building is a habit; the turnover in set builders is small, while their ranks continue to grow steadily. These same home constructors stated that they recommend manufactured sets to their friends, sets possessing characteristics frequently different from those of the delicate and sensitive receivers which they delight particularly in making. Predominant in their recommendations for the many friends who consult them as radio experts are such well recognized manufactured types as the super-heterodyne, the neutrodyne, and tuned radio-frequency receivers, a decided contrast to the sensitive, super-efficient, and often more difficult to tune, radio frequency-regenerative detector sets which are the favorites of the home constructor.

This stabilized relationship between the parts and the complete set business removes to a large degree any uncertainty prevailing as to the future of the parts business. So long as parts engineers continue to show ingenuity in developing really improved and novel designs for the home builder, the position of the parts business remains impregnable. True, the number of complete set owners grows more rapidly than that of set builders, but the fruitfulness of the latter field is ample enough to warrant a hopeful and promising outlook.

One important recommendation which we would make to the complete set manufacturer as a result of our investigation is that advertising in the radio magazines be prepared with better appreciation of what

WATCH FOR OUR NEW COVER

STARTING with July, RADIO BROADCAST will make its appearance with a new cover, designed by Harvey Hopkins Dunn of Philadelphia. Mr. Dunn, who is internationally known as a decorative designer and typographer, in creating this new cover, has provided one of unusual and effective design, which we feel will add great distinction to the magazine, and be a just reflection of the quality of contents which we strive always to maintain.

—THE EDITOR

The photograph forming the heading shows the antenna system of station 3 XN, the experimental station of the Bell Telephone Laboratories at Whippany, New Jersey. Important radio television tests were made between 3 XN to New York. Transmitters of from 5 to 50 kw. are installed here.

kind of information their readers want. All of them are better informed on radio subjects than those who respond to general advertising; in fact, one third of our readers are professional radio men—dealers, manufacturers, and engineers. Many have asked us to give them technical and quantitative analyses of the performance of manufactured products in order that they might be better qualified to advise those who seek them out as experts. The advertiser may well take heed of this demand by substituting for his general claims about tone quality, selectivity, and sensitiveness, in his radio magazine advertising specific facts about the mechanical and electrical construction of his receiver and its efficiency and performance as indicated by gain, selectivity, and frequency curves. The reader of radio magazines is entitled to this special attention because he is the local radio oracle, whose advice influences the purchase of from three to twenty individual radio sets a year, while his professional activities control huge quantity purchases.

A WAVEMETER FOR BROADCASTING STATIONS

A Bureau of Standards employee with a portable type wavemeter for use in measuring the emitted frequency of a broadcast station

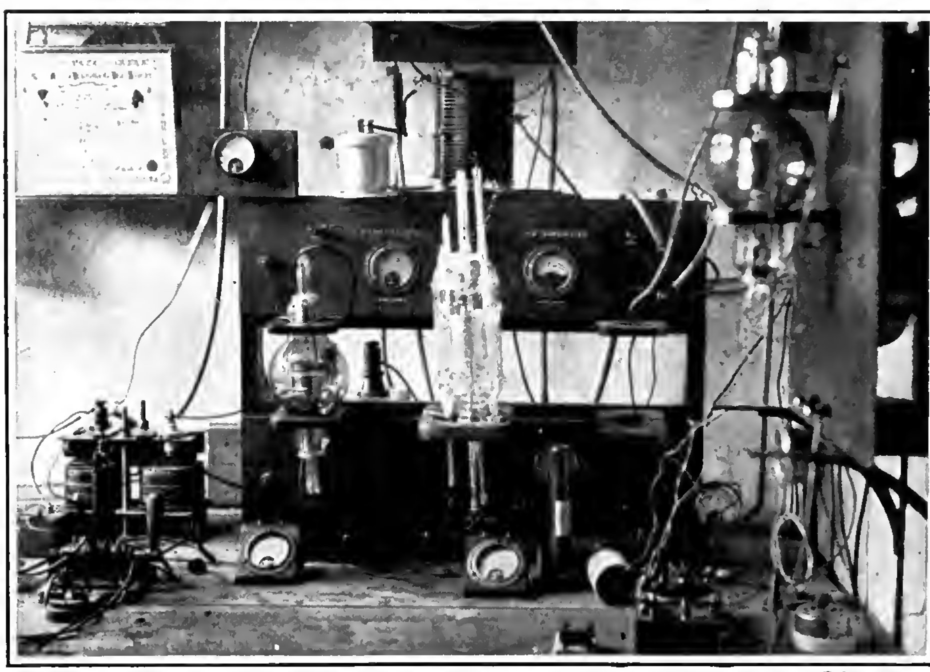
Patent Licensing Points to a Bright Radio Future

THE recent licensing by the Radio Corporation of the Radio Receptor, Zenith, All-American and Splitdorf companies is the first step toward widespread inter-licensing somewhat along the lines suggested by the articles by French Strother in this magazine, for October, November, and December, 1926, which aroused widespread and favorable comment in the industry. Upon the heels of these encouraging signs comes notice of the Hazeltine suit against Zenith over their Latour patents. The impending battle between these powerful interests, Hazeltine and Radio Corporation, already preceded by many preliminary skirmishes, promises at last to enter into a final and decisive stage which will make possible a comprehensive and satisfying appraisal of the value of their respective rights. It is a question of weighing the work of Latour and Hazeltine against that of Alexanderson Langmuir, Rice, Hartley, and others. We regard the peace which will follow this engagement as perhaps the last important step in patent stabilization which will establish definitely the position not only of the interested parties but of all the independents as well. We are certain, also, that liberal licensing on an equitable basis will end the patent bootlegging now current and establish the industry finally on a sound business basis.

Stabilizing the Broadcasting Situation

BRIGHT and hopeful as our two preceding items are, even more significant are the encouraging aspects of the broadcasting situation. We write just as we return from the public hearings before the Federal Radio Commission in Washington. At these hearings, there were practically no representatives from the listening public. Only the interests of the broadcasting stations themselves were actually represented. Nevertheless, out of this group, came the exposition of sound principles and promising recommendations which we hope will be translated into action before these lines appear in print. RADIO BROADCAST presented a plea for the broadcast listener along lines familiar to our readers through these columns. It found before it four commissioners disposed to weigh and not to jump hurriedly to conclusions. They represent fearlessness and stability, if ever government commission represented those qualities. Until their course is finally set, these men are conscientious and open minded. They pleaded for a free expression of views and were rewarded by recommendations which, one by one, deprived them of means of accommodating all the 732 broadcasters who seek to continue to impress themselves upon the listener. Broadening the band was disposed of with a finality which leaves little hope for the revival of that pernicious proposition; division of time was frowned upon as uneconomical; narrowing the width of the ten-kilocycle channel and simultaneous broadcasting of interconnected stations on the same channel, were dismissed as technically unfeasible at the moment; power reduction by large stations was demonstrated as a restriction of the broadcast listeners' opportunity, so that, toward the end of the sessions, the commissioners were convinced that less stations was the only answer. Althought hundreds of stations were represented, no one was heroic enough to offer to close down voluntarily, although, doubtless, many realized that their doom had been spelled by the recommendations of the conference.

Two plans for the administration of broadcasting station allocation were presented. One suggested that two thirds of the broadcast band be given over to ten per cent. of the existing stations, a glorious and courageous conception, altogether too easily criticised as the forerunner of a monopoly. Rome was not built in a day and we rather doubt that radio heaven can be created by any means so drastic. A second plan provides a somewhat more liberal reprieve to the less able stations by confining them to fifty-watt power on thirty channels set aside for that purpose and



© Barratt's

THE TRANSMITTING STATION OF A FAMOUS BRITISH AMATEUR

The name of Gerald Marcuse, G 2 NM, is well known among the amateur operating fraternity throughout the world. The illustration shows his 1000-watt transmitter with a silica Mullard tube in the foreground permitting all the well established key stations to continue on their present powers. Eventually, it is likely that the fifty-watt station will prove uneconomic and, in the execution of that plan, lies hope that we will gradually find less than three hundred medium and high-power stations remaining, giving equitable service to the listener in every part of the country.

One could not help but be impressed by the way in which this commission went about its business. It hinted at no convictions or opinions; it was there to absorb. We regret that the fifth commissioner and chairman, Rear Admiral W. H. G. Bullard, could not be present. We heard occasional whisperings, from those having a sensitive ear to monopoly scandal, that the Admiral might have monopolistic leanings. These silly, back-stair comments arise out of the fact that he, almost alone, is responsible for the existence of an American owned system of worldwide communication, the creation of which he fostered as a measure of national defense, by encouraging the electrical interests to acquire the British owned Marconi Company and to form the Radio Corporation of America. For this accomplishment, he deserves the homage of his fellow citizens. Now that he has been entrusted with the equally important task of assuring an equitable service to the broadcast listener, we are sure he will be just as fearless in the attainment of that end. In that task, his eye will be ever vigilant to prevent the usurpation of the ether channels by any domestic monopoly just as he once so ably released American radio communication from foreign monopoly.

Pleas for a Blue Radio Sunday

THE church folk, as usual were present at the conference, seeking special privileges; in effect, they requested exclusion of all competition for their Sunday programs. At the risk of being called irreligious, we will take the liberty of trying to show that such a monopoly would certainly curtail the effectiveness of the Sunday religious radio offerings. We wish we could use the same subtlety and skill in presenting that argument as did Mr. George Furness before the conference. He answered the churchmen so effectively that we heard one of them remark that his reply was a "blamed good job."

The broadcast listener now has choice between two kinds of Sunday afternoon programs—second-rate jazz and unadulterated moral food. There are exceptions, of course, to so broad a generality. Purely from the broadcasting standpoint, neither of these program types are capable of attracting large Sunday radio audiences. Indeed it is fair to say that the one day of the week on which the largest radio audiences could be obtained is, from the program attractiveness standpoint, the weakest of the seven. Singing congregations if for no better reason than the acoustic conditions under which they appear before the microphone, naturally make poor broadcasting, while the spirited admonitory messages which predominate from the pulpit cause many sinful listeners to shut down their radio sets for relief. A monopoly of Sunday programs would serve only to eliminate those who like dance music from the listening audience; certainly it would not augment the "religious" listener group.

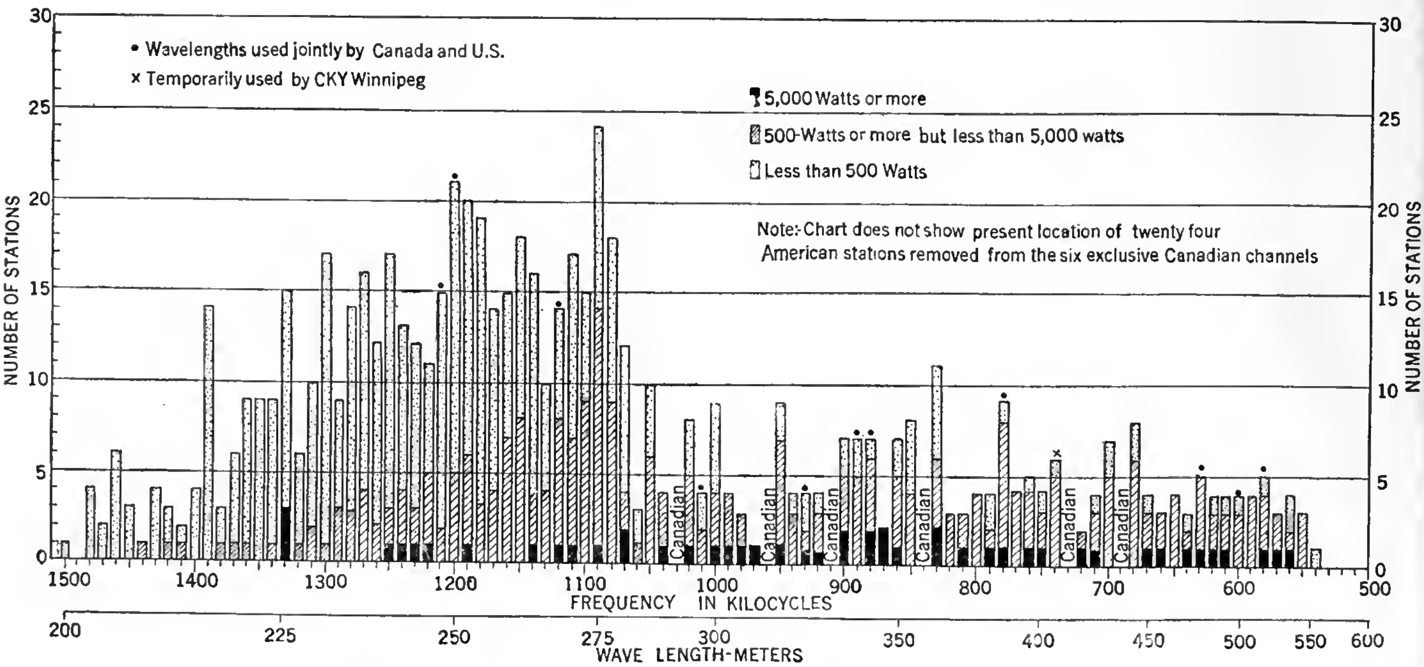
Now, supposing that Sunday programs were highly developed with a good balance of classical and chamber music, of educational material and well-presented religious material. The first effect would be to tenfold Sunday afternoon audiences. Better radio showmanship on the part of the churches would enhance the opportunity to win a following to the magnificence of church music. The religious element need not fear that its radio appeal will suffer seriously from good competition. There are no finer soloists than those of the great churches nor more impressive music than that of the church organ. With a larger Sunday audience, the church can find no greater opportunity than radio offers to augment its following.

The Wisely Chosen Radio Commissioners

BY THE generous coöperation of various governmental departments in the matter of space, furniture, and personnel, the Radio Commission is able to function despite Senator Howell of Nebraska who, at one time, was the only Senator to object to the passage of the appropriation bill which would give the commission funds with which to work. The Senate had time to confirm three of the commissioners but awaited the opportunity to better acquaint itself with two members of the commission. Confirmation was further complicated by the fact that one or two Senators had private secretaries whom they wanted to have appointed. The personnel of the commission has been so well selected, from the standpoint of ability and judgment, that there can be little doubt of their ultimate confirmation.

What About the Canadian Demand for More Wavelengths?

ONE of the first problems which focussed attention on the Radio Commission was the demand of Canada for additional broadcasting channels. Prior to radio chaos (we can now use that expression safely), Canada had six exclusive channels and shared twelve others. Inasmuch as the twelve shared channels were so allocated in the United States as to permit of the use of 500-watt Canadian stations on them, and considering that the populated



FREQUENCY DISTRIBUTION OF BROADCASTING STATIONS OF THE UNITED STATES area of Canada is roughly only one-fifth that of the United States and that its total population is less than one tenth that of the United States, eighteen channels for Canadian use seemed a fairly liberal proportion of the 95 available. This allocation permits the simultaneous operation of twelve stations of 500 watts power and six more of practically unlimited power. The latest Canadian demand is for fifteen exclusive channels in addition to the twelve shared channels, the granting of which would involve giving Canada substantially more channels and broadcasting facilities, in ratio to population and inhabited area, than we ourselves enjoy. The negotiations are being handled by the Department of State and they are seriously complicated by the antagonism which our ruthless wave jumpers so deliberately aroused by the appropriation of Canadian channels. Again we renew our plea that any station which took upon itself the endangering of our friendly relations with neighboring countries by injuring their broadcasting service, be promptly and forever disbarred from the ether.

Conditions for Long-Distance Receiving Do Vary

AN EXCELLENT indicator of the changes in the responsiveness of the ether medium to the transmission of radio signals is given by the varying experience of British listeners in hearing American broadcasting. During the 1923-1924 season, WGY was heard much more frequently than other American stations, although KDKA, WOR, and WJZ were occasionally reported. During the following season all of these except WGY disappeared from the picture, but WBZ and WPG took their places. The 1925-1926 season was notable for its complete absence of American signals, checking with our own season of mediocre long-distance reception. This season is remarkably good, many listeners having reported as many as five American stations on the loud speaker in a single evening. The improvement is in part due to the use of increased power, but also to better transmission characteristics of the ether.

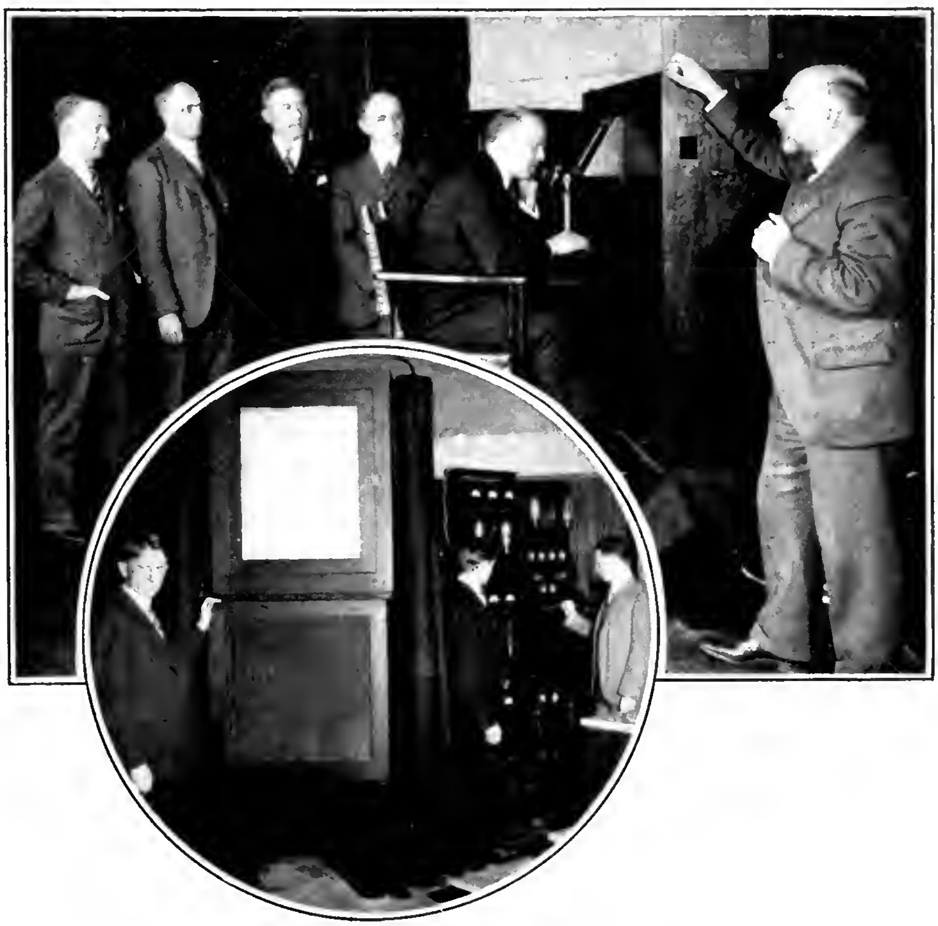
Direct Advertising Over the Air from Corsets to Calliopes

FROM the Middle-West come many complaints regarding certain undesirable broadcasting stations which do nothing but inflict atrocious direct advertising upon the listening audiences. Some of these stations are of considerable power and we have been able to hear them for short periods. The surprising thing about these disgraces is that the bargain corsets and harnesses which they offer are purchased by numerous dull-witted listeners who are thereby filling with numerous shekels the coffers of these miserable ether polluters. Easterners, accustomed to a comparatively pure ether from the advertising standpoint (and this includes only that large proportion which concentrate on the bigger and better stations), sometimes become irritated when WEAF ventures to tell with excessive detail how many gas, electric, and traction companies certain of its clients control. These listeners would have a surprising disillusionment were they to hear the bargain ballyhoo to which Central Western listeners must submit. Fortunately most of these stations are pirates of the worst order and will probably be among the first to go at the behest of our courageous radio commission.

Latest Television Developments

DURING the first week of April, a remarkable German film was showing in New York. The picture dealt with the mechanical advance of civilization. Television—the local reproduction of distant scenes, played a leading part. On April 7th, the American Telephone & Telegraph Company fulfilled the prophecy and demonstrated an operative television system which brought the voice and face of speakers in Washington over telephone wires to New York in an astoundingly clear fashion. After the wire television method was shown to be workable, the immensely more difficult television by radio was undertaken between the Bell Laboratories in New York and experimental station 3XN at Whippany, New Jersey, about 30 miles away. Visual and audible reproduction was excellent in this medium as well.

With the attainment of television, the Bell Telephone Laboratories have, in the space of but a few months, contributed to the perfection of three extraordinary scientific tools of modern life. First came the transatlantic radio telephone, then the Vitaphone, and now workable television. It is of course true that, in each of these accomplishments, the telephone engineers borrowed freely from all that had gone before, but all honor to the Telephone Company for actually accomplishing what others have attempted. Much notice has been attracted by the work of John L. Baird with television in England, and our readers will recall a descriptive article on his accomplishments in these pages recently. Since there has been no demonstration of the Baird system in this country, it is impossible to compare the two systems.



TELEVISION APPARATUS AT THE BELL TELEPHONE LABORATORIES

The large illustration shows President Walter S. Gifford of the A. T. & T. Company talking into an ordinary subscriber's set placed in front of the television screen which shows a moving and illuminated image about the size of a vest pocket size snapshot. Dr. Herbert Ives, the man who is chiefly responsible for the development of the system, is standing at the extreme right. In the circle is Dr. Frank Gray, standing next to the large glass screen which is used when the distant scene is made visible to a large group. A loud speaker is in the lower section of the standard. At present, the small screen for individual use is much more successful than the large screen, although the results with the large screen, considering the problems involved, are remarkable

Baird claims the use of a mysterious "secret cell" but, by the lack of full disclosure, aids the doubters. The Telephone Company state that they have done nothing essentially new and shroud their accomplishment with no mystery. It became necessary to use a large photoelectric cell; forthwith Dr. Herbert Ives developed the largest ever built (it is nearly as large as a 250-watter). An operative method of synchronism was required; H. M. Stoller and E. R. Morton developed a motor control synchronizing cleverly with 18 and 2000 cycles, and the requirement is met; a score of specialist-engineers work unceasingly on the wire and radio problems involved. Under the synthesizing guidance of Doctor Ives, television is accomplished. The story is simple and not dramatic, but the world of practical science owes much to these Bell Laboratories men. They are content to let the other fellow do the talking while they iron out the trouble.

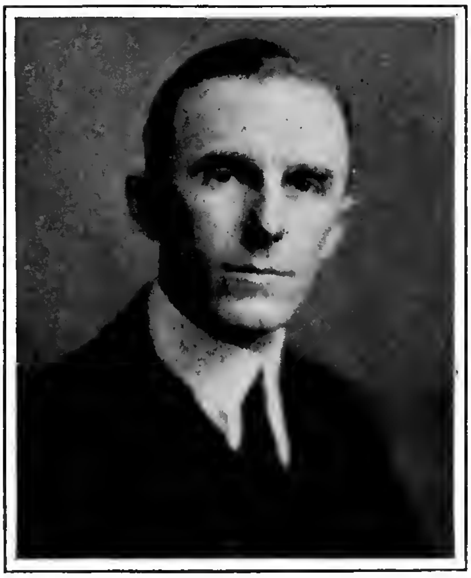
Speculation is wide and commentators both serious and humorous are hard at work pointing out what can and will be done with television. Application of the system is certainly not to be expected very soon, and time, not prophesy, will tell what use the world will make of this distance-conquering eye.

The Month In Radio

IN our March issue, we suggested the elimination of a great number of stations in the New York area and received in response a well-worded protest from WAAM which clearly demonstrated priority of service and adherence to its assigned wavelength, despite encroachments from wave-jumpers. These considerations entitle that station to better treatment than that suggested for some of those mentioned in our proposal. We are pleased to accord WAAM our assurance of continued support of the principle of priority, based upon length of service on the frequency actually in use when the Radio Act went into effect.

RUMORS of significant radio mergers are becoming more frequent. Many of these surround the already powerful Crosley Radio Corporation which has already, in effect, absorbed DeForest, Amrad, and other radio concerns. Now that patent and broadcasting stabilization is in sight, the next trend in the radio industry will be the merger of small concerns, which find their limited opportunities a handicap. The accomplishment of similar mergers in the automobile business has had an important influence in bringing that industry to its healthy and enviable position. Radio mergers will make for better and cheaper receivers and for more efficient coördination in the encouragement of good broadcasting.

WESTINGHOUSE engineers announce a new rectifier suited to use in A, B, and C battery elimination, consisting of units of copper and copper oxide which introduce some sort of electrolytic action. By the assembly of a sufficient number of units, currents of an order of magnitude adequate for radio reception purposes are secured. It must be kept in mind that this development is only in the laboratory stage. It is one of great promise because the life of the elements appears to be practically indefinite.



RAY H. MANSON

Rochester

Chief Engineer, Stromberg-Carlson Telephone Manufacturing Company, Rochester, New York. Especially written for RADIO BROADCAST:

"*Radio is, in my estimation, rapidly advancing into a new era. Much research has been made along electrical and mechanical lines in the laboratories of many radio manufacturers, but in the minds of many engineers this has not been sufficient and, accordingly, there has been established in a very few manufacturing plants what is coming to be known as the electro-acoustical laboratory. We of the Stromberg-Carlson Company, being thoroughly convinced of the necessity of this phase of the work, feel fortunate in having established at our plant one of the few such laboratories in the country.*

"*The electro-acoustical laboratory deals with the experiment and measurement of audio frequencies. The work, which, by the way, is just beginning, has made rapid strides and has furnished much data for the design of radio receivers, but the main work centers around loud speaker design.*

"*It is my expectation that through the work of the electro-acoustical laboratories of the country, a new conception of radio entertainment, and a new naturalness and realism of reproduction, will be effected.*"

THE National Electrical Manufacturers Association took gratifying cognizance (or at least we flatter ourselves that they did) of our series of articles by French Strother on the patent situation and also our recommendations regarding the limitations of the total number of broadcasting stations. Resolutions adopted at its recent Briarcliff Convention, urged cross-licensing and the reduction of broadcasting stations to 200.

ONE of the recommendations of the American Engineering Council to the Radio Commission provides the adoption of a unit of ten millivolts per meter as the criterion which should determine the service range of a broadcasting station. A signal of that strength, even with our huge layout of broadcasting stations to-day, is available in an area less than one per cent. of the total of the United States and therefore represents an ideal which is so far from immediate attainment that it is of little practical value. The practical service range of a broadcasting station is far in excess of that indicated by this ideal unit. It would be most unfortunate if this value were adopted by the commission on the basis that it represented the limit of satisfactory reception, because it would involve the acceptance of heterodyne interference on ranges beyond this ideal service range as being of no account. Thus, if a listener twenty miles from a 500-watt broadcasting station complained of heterodyne interference from a distant station, he would be disregarded on the ground that he is beyond the service range of the station in question. Admittedly, we would all be very happy to have a signal of this strength, but while that privilege is now available to so small a proportion of the country, we recommend the adoption of a substantially smaller unit, permitting of unheterodyned reception of 500-watt stations for at least 200 miles until better coverage of the United States is an accomplished fact.

WE ALMOST suffered collapse when we received the extraordinary and gratifying announcement that the Radio Manufacturers' Association and the National Association of Broadcasters had combined in the establishment of a single office to serve both organizations in New York, Washington, and Chicago. L. S. Baker has been chosen to direct this work. Such working together in the industry is an unheard of precedent, the result of coöperation during the difficult days of the halting progress of the radio bill through Congress. This new tendency toward coöperation and the disappearance of mutual jealousies will perform miracles for the rejuvenated industry. Now we are prepared for the shock of an announcement that the R. M. A. and the N. E. M. A. standards committees have joined forces, but perhaps that is too much to hope for at this stage.

STATION KFRC of San Francisco, has the distinction of being the first to rebroadcast a Japanese program. This feat was accomplished on the morning of March 16 when the listeners of the Frisco station enjoyed an hour's reception of JOAK, stated by the publicity men to be with "perfect volume and clarity." Considering that the distance is about six thousand miles, these Pacific coast geniuses must therefore be at least twice as good as the Radio Corporation engineers, whose transatlantic rebroadcasting was hardly of high standard.

THE following patents are now involved in litigation: 1,018,502, General Electric vs. Crown Electric Co. Inc. (bill dismissed without prejudice); 1,050,441, 1,050,728, and 1,113,149, Westinghouse Electric & Manufacturing Co. vs. W. Egert; 1,180,264, Westinghouse Lamp Co. vs. C. E. Manufacturing Co. Inc.; 1,195,632, 1,231,764, 1,251,377, Radio Corporation of America vs. Radio Receptor C. (presumably this is the case which resulted in licensing of the latter by the former); 1,231,764, 1,251,377 Radio Corporation of America vs. Epom Corp.; 1,018,502 and others, General Electric Co. vs. H. & D. Radio Co.; 1,271,527 and others, Lektophone Corp. vs. Brandes Products Co. (decree dismissing bill, January 27, 1927); 1,377,405, DeForest Radio Co. vs. North Ward Radio Co.; 1,571,501, Dubilier C. & R. Corp. vs. N. Y. Coil Co. (decree of D. C. affirmed); design 68,770, The Pooley Co. vs. Blue Bird Furniture Manufacturing Co.; 1,271,527, Lektophone Corp. vs. Western Electric Co. (claims 2930, held not infringed); 1,271,529, as above (claims 1 to 4 and 8 held not infringed).

THE number of radio beacons on the coast of France will soon be increased from four to ten, according to the Department of Commerce.

Why Shielding?

What to Look for and What to Look Out for in Judging a Set's Shielding

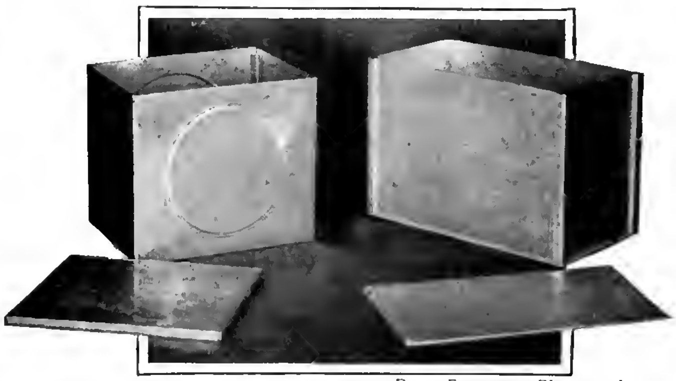
By EDGAR H. FELIX

THE superior performance of completely and carefully shielded receivers has led to the widespread adoption of the phrase "fully shielded" in connection with any set having a stray piece of sheet metal in its anatomy. Shielding is generally considered as a sort of electrical mudguard which prevents the spattering of undesired electrons upon neighboring circuits. So indeed it is, but the significant influence of shielding upon the performance of a receiver is hardly indicated by this limited conception. The confinement of the energy in every element of the receiver strictly to the performance of useful service, accomplished by effective shielding, tremendously enhances selectivity, sensitiveness, and permissible amplification of the instrument.

Specifically, the principal results of complete shielding are: (1) Compactness, permitting the embodiment of many stages of radio and audio amplification in a receiver of small proportions without destructive interactions; (2) greater permissible amplification because relatively large radio- and audio-frequency currents can be conducted through circuits without consequent couplings to neighboring stages; (3) stable neutralization throughout the wavelength range, because all unwanted inductive and capacitative coupling is eliminated; (4) increased selectivity resulting from the use of more stages of radio-frequency amplification with consequently greater filter action; (5) uniform amplification throughout the wavelength range without increased tendency toward self-oscillation at the higher frequencies; (6) elimination of electromagnetic pick-up (except that coupling purposely introduced through the primary of each stage's transformer) from the antenna and preceding stages and, with it, the resultant broadened tuning; (7) reduced influence of static and power line induction because pick-up is limited to the antenna circuit itself; (8) greater mechanical rigidity attained by supporting effect of substantial shielding and chassis construction; (9) foolproof wiring, largely concealed in enclosed cans; and (10) reduced losses due to dust and dirt on condenser plates and other exposed parts.

The term "shielding" describes any metallic conductor installed in the radio set for the purpose of eliminating undesired electrostatic or electromagnetic reactions, whether it be a modest strip of tin-foil pasted to the back of the panel near the dials to reduce hand capacity, or the complete sealing cases for each stage of amplification, embodied in the latest receivers. Shielding has been fully discussed in various technical papers, references to which are given in the bibliography at the end of this article. Our concern here, however, is not a technical discussion but a simple exposition on how to judge, by inspection and demonstration, the effectiveness of shielding in a receiver. This is a relatively difficult task, however, because a receiver can be built to appear perfectly shielded while the only thing actually accomplished by improperly applied shielding may be the introduction of high-resistance losses and consequent reduction in amplification and efficiency.

The theory of shielding is quite simple. Any circuit carrying a radio-frequency current is constantly surrounded by electromagnetic and electrostatic fields. The extent of these fields is proportional to the energy in the circuits. The greater the amplification, the greater the need for shielding or, in its absence, for great spacing between stages. With small amplification, no shielding is essential, although it may serve usefully even in a receiver consisting of but one stage of radio amplification combined with a detector. A receiver with four efficient stages of radio-frequency amplification, however, approaches the limit of practical amplification and also the upper limit of energy which practical shielding can confine.



RADIO BROADCAST Photograph

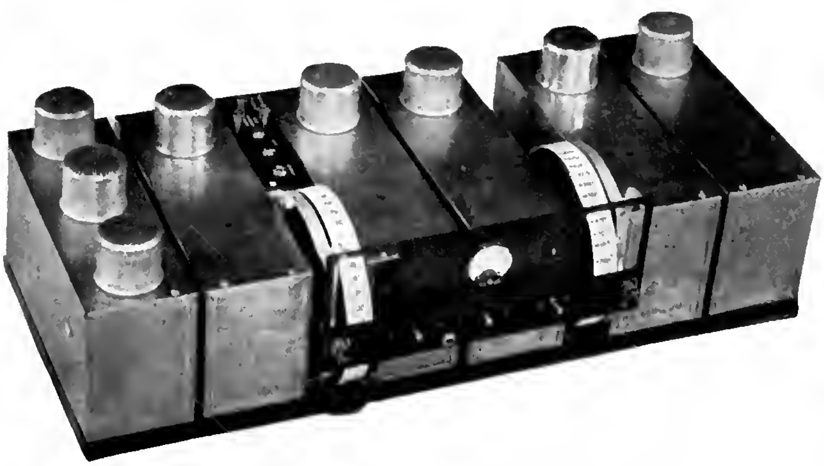
INDIVIDUAL SHIELD CANS

Several manufacturers now supply them in knock-down form

Experimenters who have tried to use shielding without a thorough understanding of its proper application have been known to argue against it because they have obtained poorer results by adding shields in their receivers. But to argue against any and all shielding because of an experience with mis-applied shielding is like condemning a twelve-room house because it cannot be built on a twenty-five foot lot. Unless a receiver is specially designed for it, shielding is as likely to decrease efficiency as it is to improve it.

The most fundamental and simple principles of electricity explain the functioning of shielding. You probably remember the experiment of rubbing a piece of glass with fur and using it to pick up small bits of paper. The effect of rubbing the glass rod is to charge it. The effect of the charge on neighboring objects is to induce an opposite charge on them, an influence sufficiently strong to actually lift a bit of paper to the glass rod. Any part of a circuit in a radio set, the potential of which is raised or lowered with respect to the potential in neighboring conductors, exerts its influence by drawing or repelling electrons in neighboring conductors. A condenser is a device especially designed to accentuate such electrostatic effects. Obviously, any change of potential in a conductor in a radio set will cause potential changes in all near-by conductors. Warding off the influence of the electrostatic field is simple and the most elementary application of shielding will accomplish it. The electrostatic influence is retricted by placing a grounded conductor between any point where potentials rise or fall, and neighboring objects which are likely to be influenced by the electrostatic effects resulting therefrom. If a good conducting path is provided to the ground, the influence of the electrostatic field does not penetrate beyond the shield.

In a circuit in which there are changes in current taking place, a varying magnetic field surrounds the conductors. The extent of the magnetic field is determined by the intensity of the current and the form of windings used. It is not difficult to cause response in a detector circuit following two stages of radio-frequency amplification with a coupling of two feet between the second r. f. stage and the detector grid coil, provided the incoming signal is strong. The interactions taking place in radio receivers are surprisingly extensive and complex, every tuned circuit actually influencing every other tuned circuit. Such effects are minimized, but by no means eliminated, by skilful placing of parts so that these influences are neutralized.



AN EXCELLENT EXAMPLE OF TOTAL SHIELDING

The five sections to the right all enclose tuned stages while the three audio stages are to the left

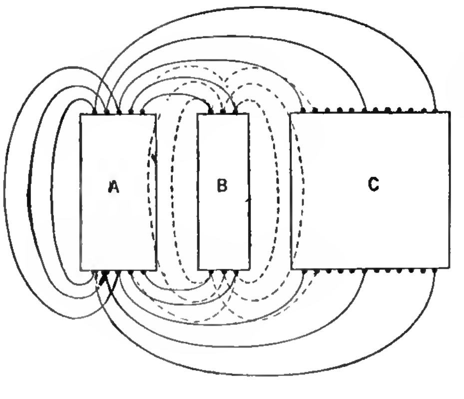


FIG. 1

With alternating currents of low frequency and through the audio ranges, the magnetic fields may be deflected by soft iron. The reason iron or steel reduces the extent of the magnet's field is because magnetic lines of force seek the easiest way and concentrate through the iron path so provided. The fields surrounding conductors carrying radio-frequency currents, however, are practically uninfluenced by the presence of iron or steel. Shielding accomplishes the constraint of magnetic fields, not by deflection or insulation, but by setting up equal and opposite magnetic fields; in other words, by magnetic neutralization. Recognition of this principle makes it easier to identify effective and ineffective shielding.

An elementary electrical theory calls to mind that a conductor within the influence of a changing magnetic field has an electric potential induced in it as a result. Suppose we have three coils, A, B, and C, as in Fig. 1, A being the primary and C the secondary of a radio-frequency transformer. A radio-frequency current in A induces a similar current in coil B, lagging half a cycle behind that flowing in A. The fields resulting from the current in B induce a potential in C, lagging half a cycle behind that in B. Now suppose these coils are so placed that the influence of coil A on coil C is exactly equal to that of coil B on coil C. The result would be two similar and equal magnetic fields, half a cycle apart, influencing coil C. Being equal and opposite to each other, each would neutralize the other's influence, so that their total effect would be nil.

A thick metal shield performs the same function as coil B in our illustration by having induced in it currents by any magnetic field playing upon it. These eddy currents, in turn, set up magnetic fields but, if the shielded conductor is sufficiently thick and of low resistance, the eddy currents are so diffused that the magnetic fields set up by them do not influence surrounding circuits. Even so, with five stages of radio-frequency amplification, the eddy currents are of such magnitude that the receiver is unstable.

It is clear that the effectiveness of shielding bears a close relation to the energy in the circuit. Since eddy currents are built up in the shield by radio-frequency energy withdrawn from useful purposes, the resistance of the shield should not be too high, or the tuning of the circuits will be broadened. Too thin shielding, or shielding of high resistance, broadens tuning and fails to eliminate magnetic interaction between circuits.

THICKNESS OF SHIELDING MATERIAL

PROFESSOR John H. Morecroft, in his comprehensive paper appearing in the August, 1925, issue of the *Proceedings of the Institute of Radio Engineers*, shows by a series of curves the influence of thickness of shielding upon its effectiveness. The general conclusion of authorities is that, for the shielding of broadcast frequencies, copper at least $\frac{1}{32}$ of an inch thick should be used in order that resistance losses are not introduced into the tuned circuits. Aluminum, having lower specific conductivity than copper, must be $\frac{3}{64}$ of an inch in thickness, and brass $\frac{1}{8}$ of an inch thick to secure the same result. Copper is widely used for effective shielding because it is easily nickel plated to give good appearance, and is easily soldered. Aluminum has the advantage of light weight and good appearance, but is difficult to solder. Sheet aluminum of the necessary thickness, though half again as thick as the equivalent copper sheet, is the lightest of the three materials; copper $\frac{1}{32}$ of an inch thick is half again as heavy; brass $\frac{1}{8}$ of an inch thick is six times as heavy as aluminum sheet.

The good conductivity of shielding must not be limited to the shielding plates themselves, but also to the connections through which they are grounded. This becomes of increasing importance in succeeding radio-frequency amplifier stages. The detector stage of the Freed-Eisemann shielded set, following four stages of radio frequency, has special bonding between the detector and and that of the third r. f. stage to insure it good ground. Referring again to Morecroft's paper, he states: "An ordinary piece of copper mesh was used as a shield for different frequencies and the results showed very little shielding effect. A border of solder 0.5 cm. wide was put around the edge of this shield so as to make good contact between the ends of the wires, and the shielding was increased approximately seventy-five per cent."

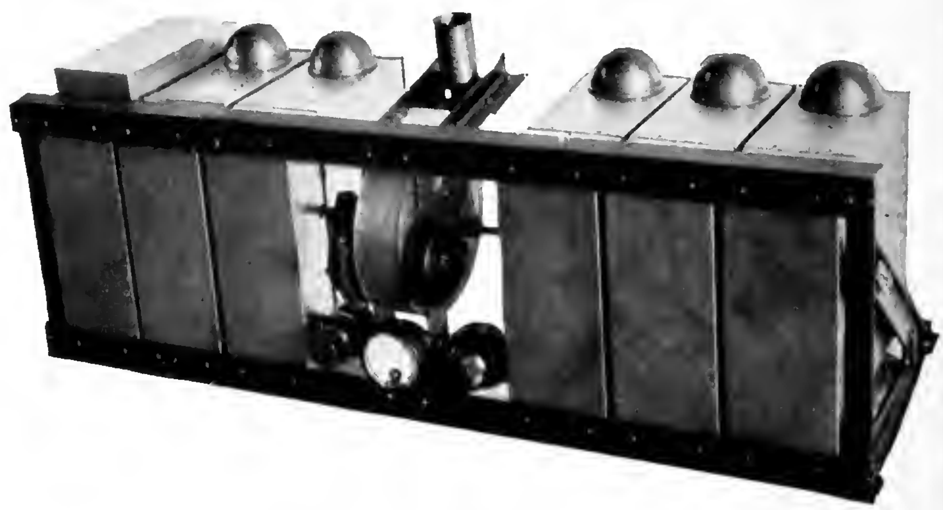
You need, therefore, not only a shield of adequate thickness and conductivity, but also it must have good electric contact with the ground and with neighboring shields along all its edges. To quote Professor Morecroft again: "Any imperfect joint in the shield, which tends to constrain the eddy currents to restricted paths, will seriously interfere with the shielding obtainable."

Furthermore, shielding can be reduced in effectiveness by horizontal slits or cuts at points where eddy currents are likely to be induced. Morecroft states in his paper that the effect of a slit diametrically across a shield of copper 0.021 cm. thick reduced its effectiveness as a shield by four per cent. and a second diametric slit, at right angles to the first, subtracted another four per cent. from the effectiveness of the shield. While Mr. Morecroft's measurements were made at audio and low radio frequencies, it must be borne in mind that shielding seriously cut up with slits to accommodate wiring is not as effective as solid sheet. For example, in Fig. 2, a long slit in the base of a shield will confine eddy currents to the two legs at A and B, thus building up relatively strong fields at those points, influencing the tuned circuits of the adjacent stage.

A receiver having each stage confined in a can of suitable thickness and conductivity, may yet fail to accomplish the desirable results of shielding if the power supply leads, both of the A and B sources, carry radio-frequency energy from one circuit to the next. Such shielding is about as useful as a pail with a hole in the bottom.

The Stromberg-Carlson receiver, the pioneer of fully shielded sets, has a 1-mfd. bypass condenser between the plus A and minus A filament terminals of each tube, and another condenser of the same size for carrying the radio-frequency currents to ground, thus confining the radio-frequency energy entirely within the cans of the radio-frequency amplifier. As a further precaution, a 200-henry choke is used in the detector circuit to keep all audio-frequency currents out of the B battery, while radio-frequency chokes are used in the r. f. plate power leads of each stage.

Speaking of these and other bypass and filtering precautions, Dreyer and Manson, in their valuable paper on the subject, delivered before the Institute of Radio Engineers, state that all of these are not necessary in a three-stage receiver but: ". . . . they become of more and more importance the higher the total amplification, and all of them appear to be necessary in a four-stage receiver. Even with precautions of this type, there seems to be an upper limit to the amplification that may be obtained at the broadcasting frequency. This limit is not reached with a three-stage receiver but may be with a four-stage one. It appears to be due to radio-frequency potentials which build up upon the shielding of the last stage. These potentials are capable of feeding back energy to the antenna through the inherent capacity between these shields and the antenna."



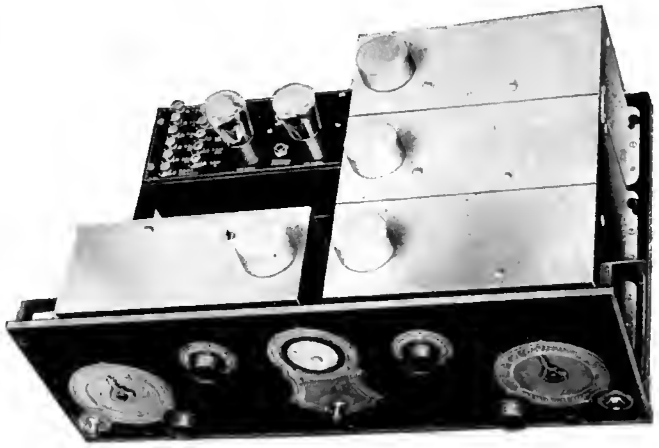
SELECTIVITY AND STABILITY ARE IMPROVED BY SHIELDING

Many modern commercial receivers are now totally enclosed in metal

A  B

FIG. 2

An added advantage of bypassing and filtering of audio- and radio-frequency currents from the A and B power sources is that it minimizes the effect of resistance coupling in the B power source. Increased B battery resistance of old batteries, or that resistance inherent in B socket power devices, with receivers having well filtered and bypassed power leads, does not contribute any tendency to whistle.



WHERE SHIELDING HELPS STABILITY

There are three stages of tuned r.f. in this receiver, a condition which calls for the utmost care in design. Shielding of the tuned stages greatly improves results

NEUTRALIZATION SIMPLIFIED

BY THE observance of these elaborate precautions, applied to expensive receivers, the useful energy of receiving circuits is limited and confined to where it belongs. There being no magnetic or electrostatic interstage influences to consider, except that unavoidably introduced by the capacity between the grid and plate of each tube, the problem of neutralization is tremendously simplified. There is only one capacity coupling to neutralize and that practically independent of frequency. As a consequence, not only is perfect neutralization obtainable, but the influence of neutralization is more uniform throughout the frequency range. The receiver, consequently, delivers more even amplification over the entire wavelength band Furthermore, the highest possible amplification per stage, by the use of r. f. transformers giving the largest gain, is made possible by shielding. The tendency toward oscillation at the high frequencies no longer limits the amplification of middle and lower frequencies. Thus we gain much greater sensitiveness by the aid of a correctly designed shielded receiver. Transformer design is largely a matter of compromise among selectivity, sensitiveness, efficiency, and tendency to oscillate. By elimination of the last consideration through effective shielding, the necessity for sacrificing the first three factors in favor of the last is practically done away with.

L. A. Hazeltine, commenting on Manson and Dreyer's paper, shows that we may select an r. f. transformer ratio which gives, within a few per cent., maximum amplification at resonance and, at the same time, gives twenty per cent. lower amplification at a frequency only ten per cent. off resonance. This applied successively through three or four stages gives a considerable advantage to a weak signal at resonance over a powerful signal ten per cent. off resonance. This accounts for the vastly superior selectivity of well-designed shielded receivers.

One of the rules of successful application of shielding is not to place any inductance too close to the metal shield itself. Look for at least an inch of separation between the shield, high potential wiring, and tuning inductances. The end of the coil is preferably so placed that it does not come up against a shielded plate, but at right angles to it. Variable condensers of higher maximum capacity are sometimes necessary in connection with completely shielded receivers. It is well to confirm when testing a shielded receiver, that tuning condensers of adequate size are used, by tuning in to stations at both ends of the frequency scale.

As we have seen, the electromagnetic and electrostatic fields surrounding a radio-frequency circuit are proportionate to the strengths of the radio-frequency currents flowing in it. Receivers employing but one stage of radio-frequency amplification and a regenerative detector have most of their energy confined in the detector circuit with comparatively small currents flowing in the radio-frequency amplifier. A single sheet of shielding between the end or side of the radio-frequency coil next the detector coil is often sufficient to eliminate a great deal of the interaction occurring. With two stages of tuned neutralized radio-frequency amplification, adequately spaced, it is possible to eliminate any serious influence of interaction, if the coils are properly placed. A small shield between the radio-frequency transformers contributes to stability. But any attempt at three stages of r. f. without heavy, highly conductive, shielding, completely enclosing each stage, is bound to result in so much interaction that stability, selectivity, and high amplification per stage is quite impossible. With four stages of radio frequency, we must not only meet the foregoing requirements, but also be certain that there is adequate bypassing of all r. f. and a. f. currents and, in addition, that filters are used in the power leads to further suppress any of these currents which tend to stray from their appointed paths.

The attainment of highest possible gain per stage is not so easily determined as the physical qualities of shielding which mark the well-designed receiver. However, any very marked indication of lower stability at the higher frequency end of the receiver than at the lower is one sign that shielding is not complete or that some element of design has not been successfully carried out. In testing a receiver, increase the filament brilliancy to the maximum and tune to the shortest wavelength of which the receiver is capable. If there is a tendency toward oscillation at that end of the spectrum, which disappears at the upper end, it is tell tale evidence that shielding has not been perfectly applied, or that the receiver is not properly neutralized.

Another significant indicator is the sharpness with which a near-by, high-power, local station is tuned out. With three or more well shielded stages, extraordinary selectivity without sacrifice of quality is attainable. This should manifest iself conclusively when tuning, both at the high and particularly at the low end of the frequency scale. The customary broadness of tuning experienced with average receivers at the upper wavelengths is due to reduced regenerative amplification and also to induction from the antenna and the first and second radio-frequency transformers upon the detector circuit. Good shielding should correct both of these undesirable effects.

Recapitulating, the obvious mechanical qualities of shielding are adequately thick shielding material of high conductivity, low resistance grounding and firm corner connections at all edges, absence of any extensive slits which tend to force eddy currents to a restricted path, and suitable placement of instruments in each stage at a sufficient distance from the shielding. Electrically, tuning condensers of sufficient capacity to cover the wavelength range and, for multi-stage sets, adequate bypassing and filtration of A and B power leads are necessary. In performance, watch for equal stability and sensitiveness throughout the frequency range and, with multi-stage radio-frequency receivers, for great selectivity even with high-power locals. There are an encouraging number of high-grade shielded receivers on the market which fulfill these exacting requirements.

SOME ADVANTAGES OF SHIELDING

SHIELDING Having the Following Properties:

1. Thickness adequate to assure dissipation of all eddy currents.
2. Conductivity of a high order to prevent resistance losses.
3. Bonding and grounding of a character avoiding resistance losses and concentration of eddy currents.
4. Solidity of material, by absence of long cuts or slits for wires.
5. Completeness, by confinement, through efficient bypassing and choking of power leads, of each circuit's magnetic and electrostatic fields within its respective shield.
6. Spacing between shields and coils sufficient to prevent excessive electrostatic capacity at minimum tuning adjustment and to minimize eddy currents in the shield.

—PERMITS the Design of a Receiver with the Following Properties:

1. Compactness, allowing the embodiment of many stages of amplification in a relatively small cabinet.
2. Higher permissible amplification because relatively larger radio- and audio-frequency currents can be conducted through circuits without interaction.
3. Stable neutralization throughout the wavelength range with more equal amplification of both low and high radio frequencies.
4. High selectivity, resulting from filter effect of added radio-frequency amplifier stages.
5. Elimination of external pick-up except that introduced by the antenna, reducing power line influence, static, and interference from near-by high-power stations.
6. Greater mechanical strength and reduced resistance losses from dust and corrosion.

Bibliography

John H. Morecroft and Alva Turner, "The Shielding of Electric and Magnetic Fields," *Proc. I. R. E.*, August, 1925.

John F. Dreyer, Jr. and Ray H. Manson, "The Shielded Neutrodyne Receiver," *Proc. I. R. E.*, April, 1926.

L. A. Hazeltine, Discussion of Above, *Proc. I. R. E.*, June, 1926.

Building an Electrical Phonograph

Suggestions for a High-Quality Combined Radio and Electrical Phonograph—Making a Baffleboard Loud Speaker —An A. C. Amplifier for the Electrical Phonograph

By
JAMES MILLEN

RADIO BROADCAST Photograph
THE AUTHOR'S RADIO-PHONOGRAPH COMBINATION
The circuit arrangement of this particular layout is shown in Fig. 2, the combination illustration on page 89. The cabinet originally housed only the Pathé phonograph

THERE are at least two distinct angles from which the design of an electrically operated phonograph may be approached. The first considers the phonograph as a companion instrument and component physical part of a high-grade radio receiver, while the second views it as an instrument entirely separate from the radio.

From the first point of view, it is hard to find as a basis for the design of the radio and electric phonograph a more satisfactory combination than that described in the January issue of RADIO BROADCAST by John B. Brennan and the writer. A two-tube "Lab" circuit receiver and a separate high-quality lamp socket powered resistance-coupled amplifier form a nucleus about which a console cabinet, record turntable, pick-up, needle scratch filter, and the other essential components of the combined radio-phonograph, may be gathered.

The writer's own machine, as shown in the accompanying illustrations, consists of a re-vamped Pathé console arranged to accommodate the receiver proper as well as the automatic relay switch and A power-supply unit in the left-hand record compartment. In the rear of the central compartment, formerly taken up by the horn, is placed the amplifier, while immediately behind the grille work is mounted a baffleboard type loud speaker. The electromagnetic pick-up is mounted in place of the mechanical one in the turntable compartment and the leads brought down through the hollow base and the opening to which was formerly fitted the neck of the horn. Such an arrangement is very satisfactory and if the reader decides to use this set-up, he should proceed as outlined in this article.

Before starting the cabinet work associated with the re-vamping of a console, remove the shelf carrying the turntable and motor. In almost every phonograph, this shelf may be removed by first removing the crank, and then unfastening the screws that hold the shelf in place. The entire back of the cabinet may generally be removed by taking out a few more screws. It is very seldom that the back is glued in place. However, should the back panel be glued, or prove difficult to remove, then leave it in place, as the primary reason for taking it off is to facilitate the removal of the horn. The horn may, with a little juggling, be unfastened and removed, when necessary, through the opening made by the removal of the motor shelf. The horns are usually fastened by means of wood screws but without glue.

To remove the partitions in the record compartments is not always quite as simple as removing the horn. In the case of the Pathé console shown in the illustration, it was necessary to slightly raise the entire left-hand section of the top, which is held in place with wood dowel pins. A small piece of wood was placed along the under edge of the top and gently tapped with a hammer until the glue holding the dowel pins became loose.

After the removal of the partitions, the panel for the radio set may be cut and fitted into place, keeping in mind that it must be set back sufficiently far to permit the closing of the compartment door without hitting any of the knobs. In many instances it will be found that one of the veneer partitions removed from the former record compartment will make a very fine panel for the radio set.

Should some readers have the parts for, or prefer to use some other type of set, such as the "Universal," the Browning-Drake, or any of the many other receivers, then such a receiver may of course be used in place of the RADIO BROADCAST "Lab" receiver. It is essential, however, that it be equipped with a good audio amplifier with an output power tube, or, if a separate amplifier is used, the amplifier may well be any of those combination power supply and high-quality audio channel units described by the writer in the last few issues of RADIO BROADCAST.

The amplifier unit shown in the photographs, and described in the January RADIO BROADCAST, consists of a stage of impedance and two of resistance coupling, with a phase shifting grid choke in the last or power stage. The power supply uses a Raytheon BH tube. Filament current for the power tube is obtained from a special filament winding on the power transformer while that for the first two amplifier tubes, as well as the tubes in the receiver proper, is obtained from an A power unit, such as the Westinghouse "Autopower." This latter consists of a battery and trickle charger combination. The receiver should be so constructed that the output of the detector tube may be fed directly into the amplifier unit.

The detector tube socket should be of the spring suspended type, such as the Benjamin, and a lead or heavy rubber cap or weight placed on top of the detector tube in order to prevent microphonic howling when the loud speaker is mounted in the same cabinet.

Some constructors may wish to place a lamp on top of the cabinet after the construction work has been completed. It will generally be found that when this is done some hum will be induced in the receiver due to pick-up from the lamp cord. Placing the lamp cord in a different position may eliminate the trouble but in those cases where this is not effective it will be necessary to use a shielded receiver. Also, when a lamp is placed on top of the console, it tends to place the tuning control in a shadow and for this reason any constructor who expects to top off the job by using a lamp on the console will do well to use illuminated dials in the receiver.

THE LOUD SPEAKER

GOOD loud speakers are of two types; the large cones, such as the Western Electric, and the small baffle cones such as those due to Messrs. Rice and Kellogg and used in the "Electrola" and "Panatrope." This latter type of loud speaker is particularly well suited, because of its small size and method of mounting, for use in a home-constructed electrical phonograph. Baffle cone loud speakers are made by several different loud speaker companies, such as RCA, Rola, Magnavox, and Peerless.

If an RCA No. 100 loud speaker is available it should be removed from its case and fastened directly to a baffleboard which should be constructed as follows:

It should be about ½ inch thick and of white pine or other soft wood. A round hole, approximately 8 inches in diameter, should be cut in the center of the board and so beveled that the outside diameter is slightly larger than the inside diameter. The cone frame-work is then bolted in place so that the cone is centered behind the hole.

Very thin veneer should not be used as a baffleboard as it may prove to be resonant at some frequency within the audible range.

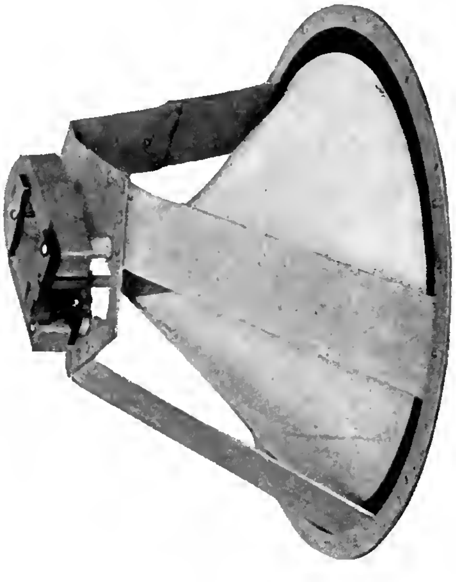
The baffleboard may be mounted so as to close the opening of the phonograph made by the removal of the horn. In mounting the baffleboard, it should be set back far enough to permit replacement of the silk-covered grille work if desired. By making the baffleboard slightly larger than the opening, it may be mounted from the rear in much the same manner as a glass is inserted in a picture frame. The filter circuit contained in the small box in the bottom of the RCA No. 100 loud speaker case should be disconnected from the loud speaker unit and discarded.

A large opening, which may well be covered with a light dust-proof silk curtain, should be provided in the rear of the compartment in which the cone is placed. Such an opening will be found to improve materially the acoustical performance of the loud speaker.

In the case of the Pathé console, it was found necessary to raise the shelf on which is mounted the motor and turntable, a quarter of an inch, in order to place the amplifier under the motor. The only difficulty encountered in this process was the necessity of enlarging the hole through which the crank passed.

While it is desirable to so place the amplifier that the controls are readily accessible, such a location is not of prime importance, as once the controls have been properly set, they will require no further attention.

When the mechanical pick-up is removed, a large hole is exposed through which the neck of the horn formerly passed. By mounting the electric pick-up in the same place as the former one, this hole is covered. Furthermore, the cord from the pick-up to the control switch may be brought down through a hole made in the base of the pick-up stand directly over the hole in the turntable shelf, thus exposing no wires. In mounting the pick-up, fasten its base in such a position that the needle, when swung to the center of the record, will rest in the exact center of the turntable shaft. Most pick-ups have a volume control located on the base of the stand. If not, then a 25,000-ohm resistance, such as a Royalty or the Centralab Radiohm, may either be mounted in the turntable compartment or on the panel of the receiver. The pick-up selected must be capable of high-quality reproduction or the best results cannot be expected. The Pacent, the Grimes "Gradeon," the Crosley "Merola," the Baldwin, and the Bosch "Recreator," have been found satisfactory.



THE RCA 100 CONE

Few will recognize this popular loud speaker as shown here. It is stripped of its surrounding bronze metal case and gauze front and back. An excellent baffleboard loud speaker can be made with this unit, as explained in the text

THE SCRATCH FILTER

THE scratch filter, as described in detail in the May article, is for the purpose of electrically removing from the output of the loud speaker the "hiss" due to the contact of the needle on the record.

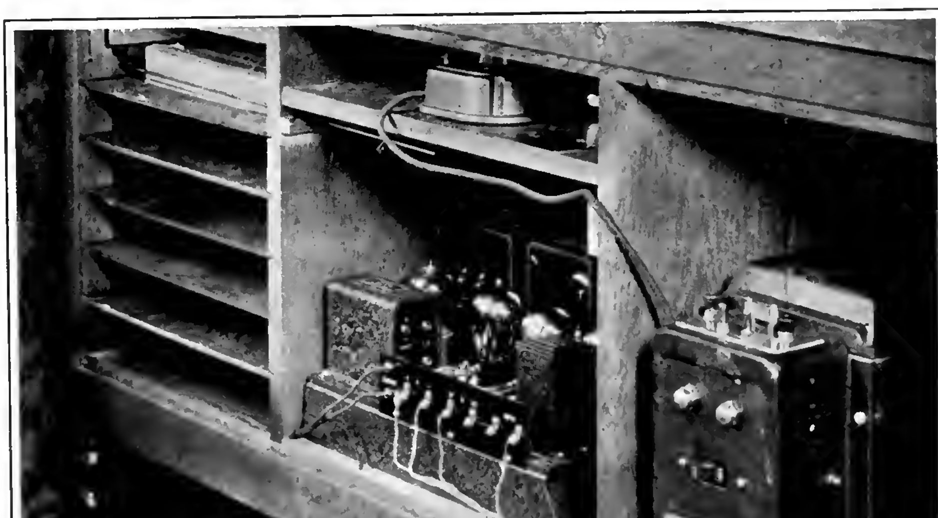
While the connection of a 0.006-mfd. fixed condenser across the output of the pick-up or input to the amplifier, will remove this noise, such an arrangement will also remove many of the higher audio frequencies and thus lower the quality of reproduction. For this reason an electrical filter circuit tuned to stop the passage of only those currents in the neighborhood of the scratch frequencies is used.

The difficulty in completely eliminating the scratch lies in the fact that the scratch frequency is not any one frequency, but quite a wide frequency band. If, however, the filter circuit is tuned to approximately 4500 cycles, the greater part of the scratch noise is removed without the sacrifice of tone quality. The residual hiss, when a scratch filter is employed, is practically unnoticeable and cannot be detected except for the first few seconds or so before the music starts.

Such a device may either be purchased as a complete unit (one is made by the National Co.), or may be home constructed from a choke coil and condenser so selected as to be most effective at about 4500 cycles. This frequency peak should be somewhat "broadened" by the use of a very small quantity of iron in the construction of the inductance. A scratch filter can be assembled by employing a 1500-turn honeycomb coil with a 0.008-mfd. fixed condenser. The circuit for the scratch filter is shown to the extreme left of Fig. 1.

A Yaxley No. 63 triple-pole double-throw jack switch is mounted at some place convenient and so connected, as shown in Fig. 2, that when in the central position, both the phonograph and the radio are shut off, while on one side the radio is turned on and the other, the pick-up system is thrown into use.

One pole controls the input of the amplifier, either radio or phonograph, while the other two control the A power either to both the amplifier and the radio set or just to the amplifier alone. A Yaxley automatic relay switch is used to control the 110-volt power, to both the amplifier and the "Autopower." The switch on the front of the "Autopower" must at all times be kept in the "off" position and connections of the two A leads soldered directly to the battery terminals and not fastened to the terminals provided on the "Autopower." This arrangement is necessary in



Radio Broadcast Photograph

A REAR VIEW OF THE AUTHOR'S OUTFIT

This picture gives some idea of the simplicity of the equipment necessary for the phonograph-radio combination. This is a rear view of the outfit shown in the photograph at the top of the first page of this article. The two-tube "Lab" receiver is hidden in front of the Westinghouse Autopower. Fig. 2 is the circuit diagram for this particular arrangement order to use the relay switch for automatic control rather than the manual switch on the front of the A power unit, which is generally rather difficult to get at.

And now, after the above changes have been made, we will have a truly modern instrument as far as performance is concerned. The only "antique" device in the system being the spring motor of the phonograph. Though the preferred arrangement for an a. c. operated phonograph is the use of an induction motor to operate the turntable, such motors of the proper size are rather difficult to obtain. Most phonograph dealers, however, stock excellent motors of the universal type, which, as they are only run when the radio receiver is not in operation and will therefore cause no interference, are entirely satisfactory. Such motors cost from $15.00 to $30.00, depending upon the type, and generally an allowance is made for the spring motor if it is turned in at the same time.

If the spring motor is retained in the phonograph then the amplifier should be so placed that the Raytheon and power tubes, which become quite warm in operation, are not directly under the motor, for such placement might result in the graphite in which the spring is packed being melted.

If the spring motor is replaced with an electric drive, then, of course, no thought need be given to the location of the amplifier.

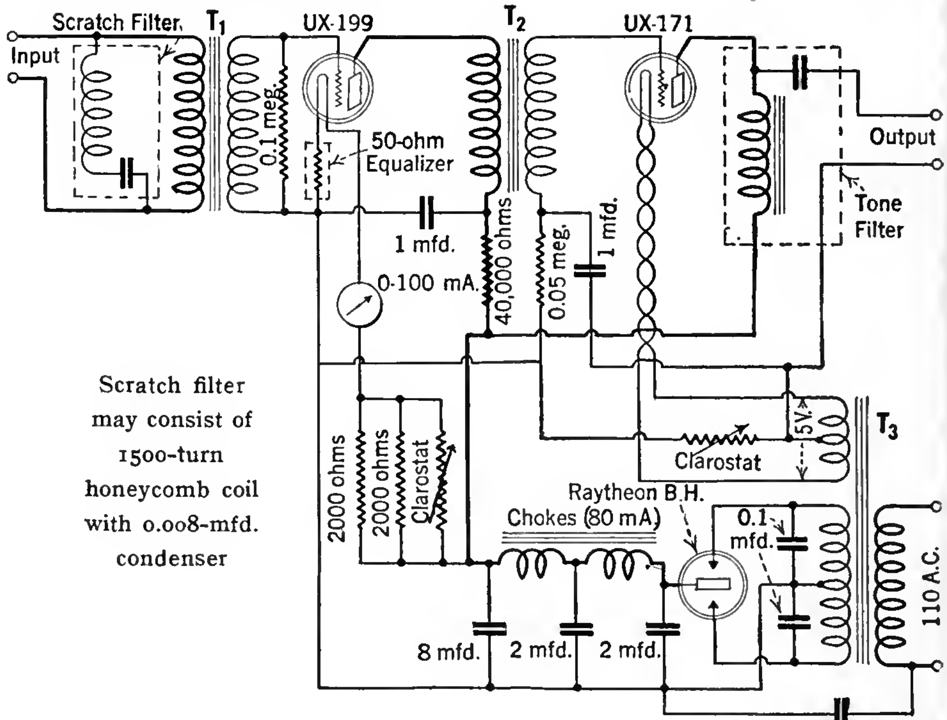


FIG. 1

For those who wish to build an amplifier solely for the purpose of using it with the phonograph, the diagram above should be followed. Both of the amplifier tubes obtain their A, B, and C potentials from the mains, no batteries whatsoever being required. A list of parts is given in the text—on this page and a photograph is shown below

ELECTRIC PHONOGRAPH WITHOUT RADIO

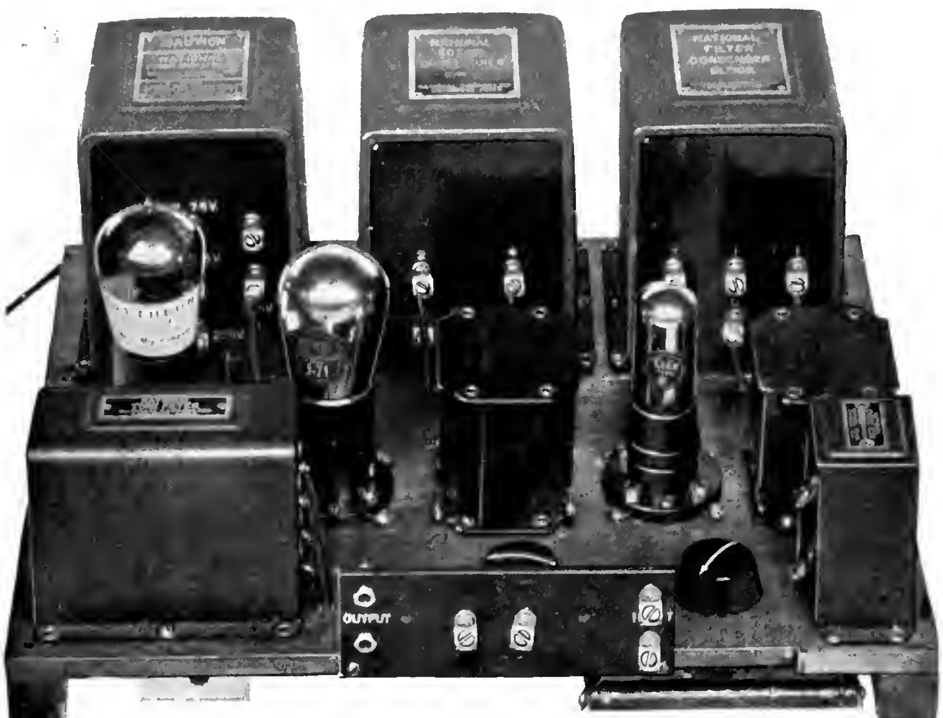
THERE are doubtless some who wish to modernize their old phonograph and make it electrically operated but entirely independent of the radio installation. Such a person will do well to construct a compact power amplifier, preferably lamp-socket operated, or to make up an ordinary amplifier and use it in conjunction with a B power unit capable of supplying sufficient voltage for a power tube.

Several manufacturers are at present working on completely a. c. operated amplifiers which will be satisfactory for use in conjunction with a phonograph pick-up. At the present time, however, there are no completely a.c. operated units on the market. It is, of course, possible for anyone with the necessary apparatus to home construct an a. c. operated power amplifier. The author has constructed such an amplifier and it gives very satisfactory results. The circuit diagram is given in Fig. 1. This amplifier consists of an input transformer, T_1, with a scratch filter connected in its primary, a first-stage amplifier tube of the 199 type supplied with filament current from the filter system, a second transformer, T_2, and a power tube feeding the output, to which should be connected a high-quality cone type loud speaker. The list of parts used in constructing this amplifier is given below:

	National Power Transformer	16.50
	National Filter Choke, Type 80	10.00
	National Filter Condenser Block	17.50
	National Tone Filter	8.00
	National Scratch Filter	5.50
1	Pair AmerTran DeLuxe Transformers	20.00
2	General Radio Sockets	1.00
2	Clarostats	4.50
2	1-Mfd. Tobe Condensers	2.50
1	2-Mfd. Tobe Condenser	1.75
2	2000-Ohm Wire-Wound Heavy Duty Resistors	2.50
1	0.1-Meg. Metalized Resistor	.75
1	0.05-Meg. Metalized Resistor	.75
3	Mounts	1.05
1	50-Ohm Fixed Filament Resistor	1.00
1	40,000-Ohm Resistor	1.10
1	Weston 0-100 Milliameter	8.00
1	Terminal Strip	.75
1	Baseboard	.50
1	Set Tobe Buffer Condensers	1.40
1	Ceco Type B (UX-199)	2.00
1	CeCo Type J-71 (UX-171)	4.50
1	Raytheon BH	6.00
	TOTAL	$117.55

In this amplifier two transformer stages are used so as to keep low the number of stages of amplification required. It is not essential that the parts specified be used, and other high-grade apparatus manufactured by other companies will be quite satisfactory provided their electrical characteristics are satisfactory.

It is essential that the chokes employed in the filter system be capable of giving satisfactory results with 80 milliamperes flowing through



THE A. C. AMPLIFIER SHOWN IN FIG. 1

With this amplifier, a pick-up device, and good cone loud speaker, we have all the essentials for converting a phonograph of the mechanical reproduction type to one of the electrical reproduction form. No batteries are required—not even the usual C batteries. The two center binding posts are for connecting the milliameter used to adjust the filament current of the 199 tube. The others are the input and output connections them. Two 2000-ohm resistors are employed in parallel rather than a single 1000-ohm unit, first because 2000-ohm units are more readily obtainable, and secondly because two 2000-ohm units in operation will heat up much less than a single 1000-ohm resistance.

C voltage for the 199 tube is obtained by taking the voltage drop across a 50-ohm resistance in the negative filament lead of this tube, while C voltage for the power tube is obtained by utilizing the voltage drop across a resistance in the lead to the center tap of the power tube's filament transformer. With this arrrangement there is no common interstage coupling in the C bias resistances and this is distinctly advantageous in preventing distortion. Care will be necessary in adjusting an amplifier of the type illustrated in Fig. 1, to make certain that the filament current in the 199 tube is exactly 60 mils. Unfortunately it will be found that using the resistance units that are available the current through the 199 will increase as the resistances heat up. It is therefore best to properly adjust the 199 filament after the amplifier has been in operation for about ten minutes. An occasional check on the filament current through the 199 should be made to make certain that it is not exceeding the rated 60 milliamperes. The two 2000-ohm resistors are shunted around the Clarostat controlling the filament current of the 199 in order to reduce the current that must be passed by this latter resistor. Also, the wire-wound resistor has a positive temperature coefficient whereas the Clarostat has a negative temperature coefficient and the combination of these two tends to neutralize each other and therefore keep at a minimum the variation current that occurs as the resistors heat up.

It is not at all essential that the amplifier be included in the phonograph proper, and the installation will be made much simpler if the old phonograph is not disturbed and the amplifier placed instead in a small external cabinet of its own. The pick-up can be mounted so as not to disturb the mechanical pick-up ordinarily used with the phonograph. Just how the installation is arranged will depend entirely upon the individual taste and desire of the constructor. Electrically, one arrangement is just as satisfactory as the other.

A great deal of information prepared by the author regarding the construction of satisfactory amplifiers can be obtained by glancing through several recent issues of Radio Broadcast (the January, February, March, and April issues) in which many different types of units have been illustrated. In the March issue of Radio Broadcast will be found a description by John B. Brennan of a simple two-stage transformer-coupled amplifier that might be used in conjunction with a separate B power unit to operate the loud speaker.

GROUND CONNECTIONS

A ground connection to the negative side of the filter circuit is absolutely essential. In most instances this connection may be obtained by connecting through a 2-mfd. condenser to one side of the 110-volt line as shown in Fig. 1. The 110-volt line connections may have to be reversed to see which way is best. This is readily accomplished by merely plugging into the lamp socket or base outlet first one way and then the other.

In conclusion, the writer wishes to emphasize the importance of using the new electrically cut records for obtaining the best of results with the electric phonograph.

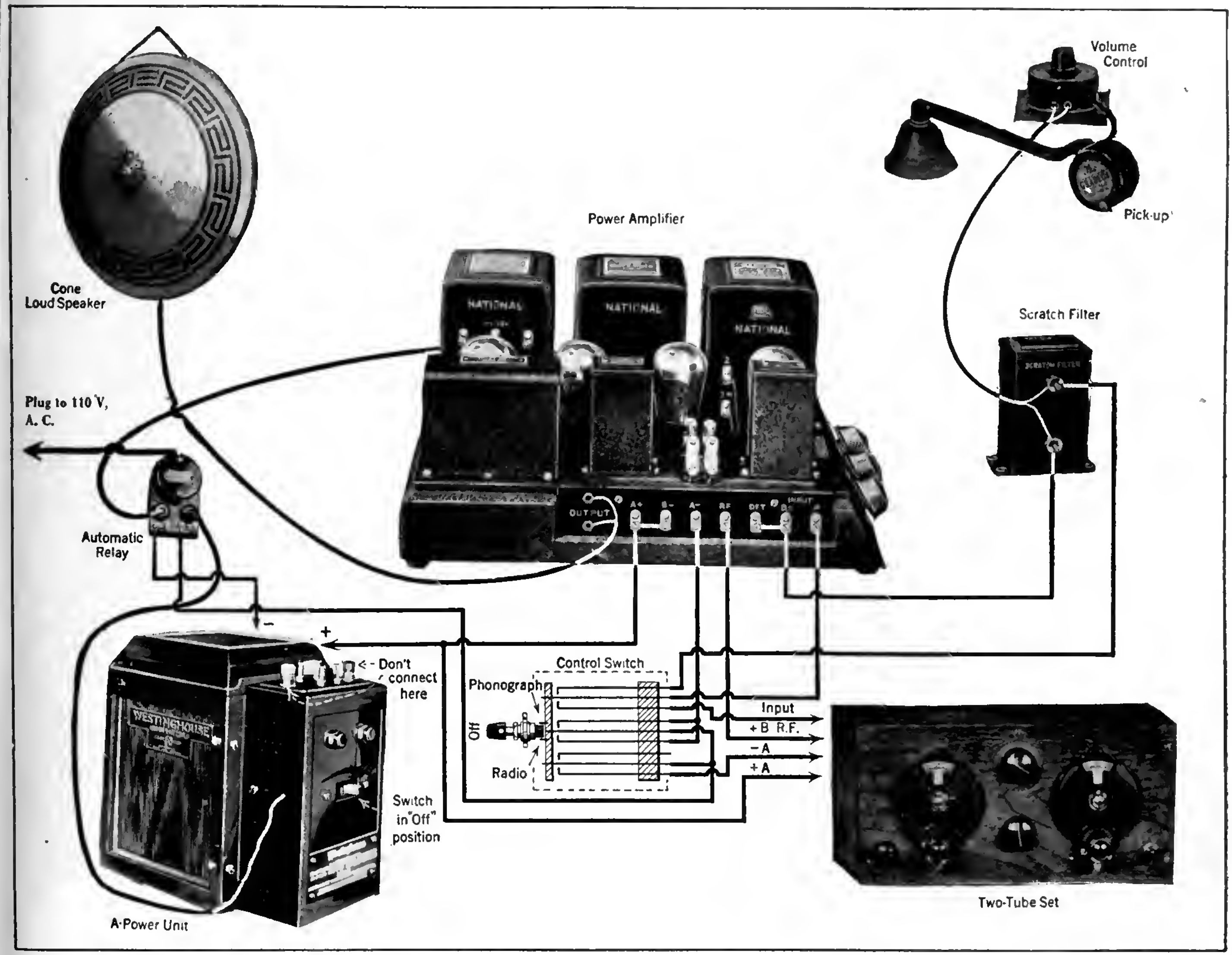


FIG. 2

This is the layout of apparatus recommended by the author for a combination electrical reproduction phonograph and radio, and employed by him in the phonograph illustrated on pages 86 and 87 of this article. The power amplifier was described in Radio Broadcast for January of this year, as was also the two-tube "Lab" receiver. By a simple turn of the triple-pole double-throw Yaxley jack switch (marked "Control Switch" in this diagram) either the phonograph or radio receiver is connected to the power amplifier, while a central position of the switch disconnects both. The automatic relay switches either the trickle charger or B socket-power device to the electric light mains, depending on whether the outfit is in use or not. Although this illustration shows a cone loud speaker (which may certainly be used) the author explains the construction of a baffleboard loud speaker in the text

"Strays" from the Laboratory

Growth of the Laboratory

RADIO BROADCAST Laboratory began its existence in its present form about the beginning of 1925. There were several reasons why a well-equipped and well-staffed laboratory was necessary. In the first place, nearly everyone who manufactured any kind of electrical apparatus, or automobile accessories, or did a seasonable business of any kind, had in some way or other got into the radio game. These manufacturers found it necessary to advertise their products in nationally known magazines with the result that the advertising staff of RADIO BROADCAST and the fellows that set type downstairs did a flourishing business. Since very few people knew much about radio—even in 1925—the sky was the limit to what a manufacturer could say about his product with the moral certainty that no one could catch him up on it. As a matter of fact the manufacturer himself probably believed what his advertising stated because he, too, was in a new field with little or no background of past experience.

About the middle of the 1925 season, however, a change was taking place. Already there were manufacturers in the field who were more conscientious and readers were becoming more critical—and a bit wary.

To protect the readers, not only of RADIO BROADCAST, but of all Doubleday-Page publications which ran radio advertising, and to protect those manufacturers whose products were wheat from those who made mostly chaff, as well as to aid the latter in case they desired technical advice, the Laboratory became a necessity. Soon the entire "Quality Group," consisting of *World's Work, Harper's Magazine, The Atlantic Monthly, The Golden Book, Scribners*, and *Review of Reviews*, availed themselves of the Laboratory's service so that their advertising pages too could be protected.

It was also true that radio circuits were coming out at that time in all radio publications so thick and fast that only a few readers could keep up. Here again it had become necessary to scrutinize carefully, to test receivers before they were described, and to develop circuits with the certainty that they were technically correct. Here was another crying need for a well-equipped laboratory.

Due to the far-sighted policy of the publishers of RADIO BROADCAST, the Laboratory was well equipped from the start — and this equipment has steadily increased. It is now possible to make practically any radio- or audio-frequency measurement with the aid of instruments that are always on hand in the Laboratory.

The very first task of the Laboratory is representative of what the staff has done from the time of its inception. Several pages of lurid advertising were sent in from a manufacturer of tubes for insertion in RADIO BROADCAST. These several pages contained some very exaggerated statements which, when boiled down, came to these claims:

> These tubes require half the battery current and deliver twice as much volume. Distance doubled. Will last indefinitely.

A simple test in the Laboratory did indeed reveal the fact that the plate current of the tubes was about half that of a normal 201-A tube under the same conditions of filament voltage and current. So far, so good. In a receiver, however, the volume was "way down," as was to be expected. The filament wire was poor, having low emission, which gave the tubes a high impedance.

When the advertising was rewritten to conform with more reasonable claims, the advertising manager of the manufacturer said "nothing doing" in emphatic tones, and the magazine lost the advertising.

Not long after, the largest retail store in New York refused to sell these particular tubes, and in a few months the manufacturer was out of business. During this time various other publications ran the advertising without any hesitation although they claimed to have tested and passed all apparatus before accepting advertising.

EVER since its establishment, the RADIO BROADCAST *Laboratory has served as a means of contact between our readers, the work of the manufacturer, and indeed, the entire technical field of radio. It is the purpose of these pages to extend that contact by presenting an opportunity for the Director of the Laboratory and his associates to discuss various subjects of technical interest in a way which should be of greatest value to our readers. "'Strays' from the Laboratory" will treat of a wide range of subjects —suggestions for productive fields of experiment, reference to interesting developments of manufacturers, brief abstracts of important technical articles, and suggestions from readers.*

—THE EDITOR.

Since that time the Laboratory has tested tubes of every manufacturer known to be building tubes in the United States. Not only have tubes come from the manufacturer for test but nationally known manufacturers of receiving sets have relied upon the Laboratory for information regarding tubes that could be recommended to their dealers and jobbers. Some tube manufacturers have sent representative lots of tubes as often as once a month for two years.

As a clearing house for unbiased technical data and information, the Laboratory soon became well known. It was possible to obtain data here that were untainted by manufacturing jealousy or secrecy. Representative apparatus from every manufacturer of note was examined in the Laboratory and data kept on file. It was possible for dealers and manufacturers to have various units tested in the Laboratory without the expense of building a laboratory of their own.

For example, a builder of an "extraordinary" new loud speaker came to Garden City bringing with him his inventor and one of the strangest contraptions we had seen. It looked like a butter bowl and was guaranteed to be more sensitive than any existing loud speaker. The inventor, who had little to say, was touted as having designed the Western Electric 540-AW cone which, we decided, was to be the basis of comparison.

Our "beat" oscillator, whose frequency is continuously variable from zero to 20,000 cycles, was wound up and applied to the two loud speakers in turn, and everyone noted when, in his estimation, sound could be heard from the 540-AW, and when the "butter bowl" took interest in the proceedings. The same process was repeated at 1000 cycles but with varying input voltages. The Western Electric cone could be heard long after the "butter bowl" was perfectly dead, not only with respect to frequency but to input voltage as well—all of which did not speak well for the inventor who, as he claimed, was responsible for the 540-AW.

"What do we care," said the manufacturer, "it's price that counts. People won't know the difference. I'm going to sell a million of these."

That loud speaker never came on the market.

In the two years and a half that the Laboratory has existed, its activities have gradually changed. Organized to protect the advertising pages of RADIO BROADCAST and other magazines, it was only a question of time until the chaff manufacturers were weeded out, and those who made wheat remained. There are few radio junk manufacturers who advertise nationally. Some newspapers still carry considerable wildcat claims, especially in their Saturday radio sections, and some magazines dig up advertising of this nature, but the Quality Group and RADIO BROADCAST no longer worry.

In those two years and a half the magazine has lost enough advertising to make the salesmen weep, but in nearly every instance the manufacturer went out of business before the accounting department could have collected, had the magazine run the copy.

At the present time the duties of the Laboratory staff are many and varied. It still exercises a strict censorship over advertising; it examines and tests all manner of radio equipment—every piece of apparatus that is described in RADIO BROADCAST for home constructors is put through its paces. It has complete laboratory tests on two thousand tubes from nearly one hundred manufacturers; data on socket power devices, many of which never saw the daylight of a dealer's shelf; life tests on batteries and tubes; tests on condensers, resistances, and audio transformers. The staff scans radio and scientific periodicals of this and many foreign countries in search of material for its clientèle—readers of the magazine.

In such foreign papers the staff finds material that delights the heart of any one who is interested in radio, and an attempt will be made to bring the gist of these articles to the readers of RADIO BROADCAST through this department every month as well as news that floats in on all manner of carrier waves, news from manufacturers, from technical laboratories, from amateur stations, and all other sources of radio information and trade gossip. It is the staff's fervent hope that these pages will bring the Laboratory into closer touch with those who are seriously interested in radio engineering and experimenting.

The Facts About the A. C. Tube

THE New York public, and that of other cities, has been stangely upset by an announcement, more or less premature, about the RCA's new tube that uses raw a. c. and, as the papers say, "eliminates all batteries." It seems that at every opportunity the papers use that phrase as though they had a grudge against batteries. Of course the tube is reported as "revolutionizing radio," another pet phrase.

The statements of Mr. Elmer Bucher, general sales manager of the Radio Corporation, and Herbert H. Frost, general sales manager of E. T. Cunningham, Incorporated, the following day, are significant, and will allay the fears of all who see in this news story the utter destruction of present plans for the coming year. The unipotential cathode tube has been known for years and engineers are excited periodically by reports of tubes with amplification factors of 20 and plate impedances of 2000 ohms, for such seems possible with tubes of this type. Many efforts have been made to bring it to a point of reality. The nearest approach is the McCullough tube. Mr. Frost says in the New York *Times* of March 26th:

Considerable publicity has been given this week to a so-called new a. c. radio tube. This alleged development has been designated as "revolutionary." The following statements and claims for this tube appeared in the news article in one of New York's leading morning newspapers on Wednesday, March 24th:

"Batteries and current supply devices will be dispensed with in broadcast receivers by a new alternating current tube . . ."

". . . a revolutionary development . . ."

"The tube seen here yesterday was marked UX-225."

". . . an alternating current detector and amplifier tube which could be used in direct connection with the 110-volt house lighting sockets in much the same fashion as an incandescent lamp, thereby dispensing with all B batteries, trickle chargers, storage batteries, dry cells, and current-supply devices, such as A and B eliminators."

". . . 1927's greatest contribution to the revolutionary developments in radio."

". . . a set which will not require batteries or current supply devices."

"The necessity for batteries and battery eliminators is obviated. . ."

Mr. Frost continues:

Type CX-325, our equivalent of UX-225, referred to above, has been in an experimental and developmental stage for nearly two years. Its output and capabilities are similar to those of our well-known type CX-301-A. In CX-325 we are attempting to replace the filament with a cathode heated directly by house a. c. supplied through a step-down transformer. When and if successful, this tube would eliminate the A battery, substituting raw a. c. It will not eliminate the B and C batteries, or B eliminators. This tube has not yet reached a commercial stage. It is difficult to manufacture and would have to sell at a price from $6.00 to $9.00 each. It is our opinion that the practical difficulties connected with the manufacture of CX-325 will prevent it ever being commercialized. If perfected, it could not by any stretch of the imagination be called a revolutionary development. The CX-325 tube could not be used in present equipment without substantial wiring changes, and then would not improve reception but merely eliminate the A battery.

PRESENT AMERICAN PLAN	REVISED PLAN	DESCRIPTION
UX-199	3VI06	Dull Emitter—General Purpose.
UX-120	3IV12	Dull Emitter—Power Amplifier.
UX-201-A	5IX25	Five Volt—General Purpose.
UX-112	5IX50	Five-Volt Power—Rp=6000.
UX-171	5IV50	Five-Volt Power—Rp=2500.
UX-210	7IX125	Seven-Volt—Rp=6000.
UX-216-B	7.5R125	Half-Wave Rectifier.
UX-213	{ 5R200 } { 5R200 }	Full-Wave Rectifier.
UX-876	50B170	Ballast Tube.
UX-174	90C50	Protective Tube.
UX-200-A	5D25	Detector (Vapor-Filled).
UX-877	{ 5P20 } { 3P90 }	Protective Tube.

Crystal-Control on Short Waves

ONE OF a number of excellent papers recently delivered before the Radio Club of America was the work of an old time amateur, Mr. C. R. Runyon, Jr., and described the equipment of his more or less "high-powered" amateur short-wave station. As is the case with many of our best stations, Mr. Runyon's 2 AG is crystal controlled, which brings up a point that many amateurs evidently debate among themselves: Is crystal control worth while?

A quartz-controlled transmitter is simply a master oscillator system in which a small tube whose frequency is determined by the crystal drives a large tube acting as an amplifier. Owing to the fact that the quartz plate oscillates only in an extremely small band of frequencies, the transmitting wavelength for all practical purposes is fixed. Changes in tube constants, antenna height, even adjustments of inductance and capacity have no effect upon the emitted frequency. It is also true that the note of the station will be distinctive, and that even with raw a. c. on the plates of the tubes, the note will be good.

All of this means that a crystal-controlled station will have a good note on a definite frequency.

For stations that carry on schedule communications, or point-to-point service, or transmit traffic for considerable periods, nothing could be better than absolute steadiness of frequency. For amateur work the case is somewhat different.

For example, at 2 GY, the experimental station of the Laboratory, considerable effort was put forth to make a 500-watt crystal-controlled station. The apparatus was as extensive as Mr. Runyon's. There were two 7.5-watt oscillators, two 7.5-watt amplifiers operating at double the oscillator frequency, two 50 watters amplifying the output of the two 7.5-watt tubes, and at the same frequency, and finally two 250-watt tubes which fed into the antenna. It was possible to deliver considerable power to the antenna on the 40-meter (7500-kc.) band and the note was beautiful, but no sooner had the station gone on the air than FW, in France, settled on the same frequency, or so near it that interference was unavoidable. The result was that distant amateurs could not hear 2 GY when the St. Assise station was in operation, which was from about 4:30 p. m., E. S. T. until much later in the morning than 2 GY could be kept open.

On amateur bands, and with purely amateur traffic, there is need occasionally to change the frequency slightly to avoid interference. Crystal-controlled stations are sadly handicapped here, unless several quartz slabs are handy and unless the operator can go through a somewhat complicated rigmarole in re-tuning. Quartz-controlled oscillators using a good source of plate supply (batteries or good d. c.), turn out a note that is extremely tiring to the ears; and on the higher frequency bands a series of tubes are necessary with more or less critical adjustments.

It is true that the Army stations which use raw a. c. for filament, grid, and plate voltage, have notes that are penetrating and fairly easy on the ear, and when night after night one hears them pounding away somewhat below the 40-meter amateur band, it is easy to get the idea that crystal transmitters are greatly to be desired. But few amateurs have the funds, few care to bother adjusting many circuits, and few seem to realize that a 250-watt tube which will handle 500 watts as an oscillator will only take care of 250 when used as an amplifier.

New Nomenclature for our Tubes?

ONE OF the most encouraging signs in the radio industry is the manifest desire for standardization on the part of the better manufacturers. Under the untiring efforts of Mr. George Lewis, chairman of the vacuum-tube committee of the Radio Manufacturers' Association, tubes have come in for their share of attention. At the Chicago convention and trade show of this association, June 13-17, an important question will be discussed, that of tube nomenclature. Criticizing our present system of naming tubes by nondescript numbers, *viz.*, 199, 213, 171, Mr. Lewis suggests the following system and will welcome suggestions. Tubes will be known by a number giving first the filament voltage in Arabic, then a Roman numeral denoting the amplification factor, and finally the filament current in Arabic. Special tubes will be designated by a letter indicative of the service performed. The table on this page gives Mr. Lewis' suggested nomenclature.

An Instrument for the Home Laboratory

How to Construct a Useful Device—a Modulated Oscillator—That Will Measure Coils, Calibrate Receivers, and Help Locate Trouble

By

KEITH HENNEY

Director of the Laboratory

Radio Broadcast Photograph

THE MODULATED OSCILLATOR

With the several tuning coils necessary to cover four slightly overlapping wave bands, is illustrated here. A specially made Karas dial, shown in front, was satisfactorily substituted for the aluminum one in the Laboratory

EVERY laboratory, regardless of its size, must possess certain equipment without which the investigator is handicapped. The home radio laboratory, housed in a corner of the den, or the attic, or the basement, and costing probably no more than a high-grade receiver, differs in this respect not a whit from the huge industrial or college laboratory with an endowment of many thousands of dollars within the walls of which may work hundreds of highly trained and skilled investigators.

One of these essential pieces of equipment was described nearly two years ago, September, 1925, in Radio Broadcast. It was called a modulated oscillator, and so many uses for the instrument have been found in the Laboratory and by the many readers who followed the series of articles written around that small generator of radio waves, that a new description at this time seems more than worth while.

The present unit differs but little from that described before. It consists essentially of two oscillators coupled together. As described, one covers the frequency range from 500 to 6000 kilocycles (50 to 600 meters), by means of four plug-in coils, and will be useful either as a source of radio-frequency waves for various laboratory experiments, or as an accurate and sensitive frequency meter or wavemeter. The other oscillator is a fixed frequency generator, oscillating at approximately 1000 cycles and providing a source of audible tone for certain other laboratory work. When desired, the radio-frequency tube may be operated alone, emitting a pure unmodulated carrier wave, or it may be modulated with the 1000 cycles of the second tube, and be useful in another set of experiments.

USES OF THE OSCILLATOR

THE most obvious use of the complete instrument is as a source of modulated high-frequency signals. By their aid, a receiver can be calibrated in kilocycles or wavelengths without the bother of waiting until broadcasting stations come on the air. The frequency of either the audio or radio oscillator can be varied, the entire outfit being under the control of the experimenter. The method of calibration is simple. A receiver is set up and the oscillator turned on. When the receiver is tuned to the same frequency as the oscillator the latter's tone will be heard in the loud speaker. Of course it is possible to set a receiver to a known frequency by this same process if, for example, the experimenter desires to listen for some definite station the frequency of which is known. It is also possible to measure the frequency of incoming signals. It is only necessary to tune the oscillator until its signals are heard at the same receiver condenser setting as the distant station.

The grid meter of the radio oscillator makes this unit a very sensitive and accurate resonance indicator. For example, suppose we have a coil and condenser combination and we desire its range in kilocycles or meters. Or suppose we have a choke coil for a short-wave transmitter and we want to know its natural wavelength so that it will not absorb energy on any wavelength to which the transmitter may be tuned.

The coil, or choke, is brought near the oscillator inductance, and when the latter is tuned to resonance, a sharp dip in the grid current reading will be noted. Extremely loose coupling can be used, materially increasing the sensitivity of the instrument. It is also possible to show the effect of coupling two circuits too closely together. As the tuning condenser is varied, there will be two dips, indicating that the two circuits are so closely coupled that neither has a chance to oscillate at its own frequency, or that the two circuits are not closely enough tuned to the same frequency to give a single response.

With the radio oscillator as a source of unmodulated energy, it is possible to measure the overall gain of radio-frequency amplifiers. The same is true of audio amplifiers, by using the low-frequency tube.

The tone alone, obtained from the low-frequency tube, can be used for testing circuits (where a dry cell and buzzer could not be used) or as a source of tone for bridge work in measuring inductance, resistance, or capacity.

The circuit diagram of the complete modulated oscillator is shown in Fig. 1, and is not difficult to follow; nor is the set-up difficult to get working. The tubes can be any of the general purpose tubes now used, *viz.*, 199, 12, or 201-A type. In the Laboratory WD-12 type tubes were used, since it was possible to place both A and B batteries for the oufit in the same cabinet which housed the tubes, transformer, and condenser, thereby making the combination frequency meter and oscillator a truly portable affair that can be "lugged" out of the Laboratory into the field for experiments on antennas, etc.

The layout of this useful instrument is due to Mr. John Brennan. The only important change in the circuit from that first described is the inclusion of the grid-current meter in the radio oscillator, which makes it an extremely sensitive frequency meter; other minor variations in the circuit resulted from the natural desire to make the completed equipment more useful.

Both oscillators follow the Hartley circuit, presenting several points of especial interest. One of these points relates to the inclusion of the grid-current meter in the radio oscillator, as stated above. The second point to note is the radio-frequency choke through which the B-battery voltage is fed to the second oscillator. This is necessary to prevent the radio-frequency energy from going into the center tap of the audio transformer, which is at ground potential with respect to r. f. voltages. It will be noted, too, that the tuning condenser is across half the coil only.

The grid meter increases the

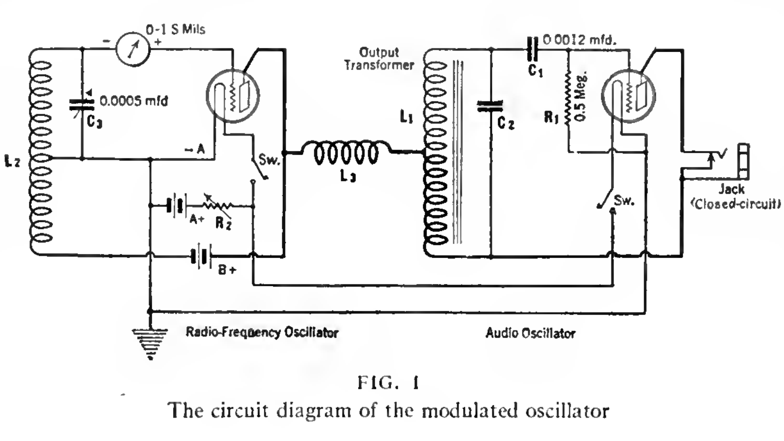


FIG. 1

The circuit diagram of the modulated oscillator cost of the instrument somewhat, and is not vitally necessary for the operation of the modulated oscillator. It does, however, make the radio oscillator into a sensitive wavemeter, extending the uses to which the complete equipment may be put. Its inclusion is strongly urged.

The low-frequency oscillator consists of an output transformer connected as shown in Fig. 2. A push-pull output transformer may be used if desired, as also shown in Fig. 2. The frequency of the audio oscillator is controlled by the inductance of the transformer and the capacity across

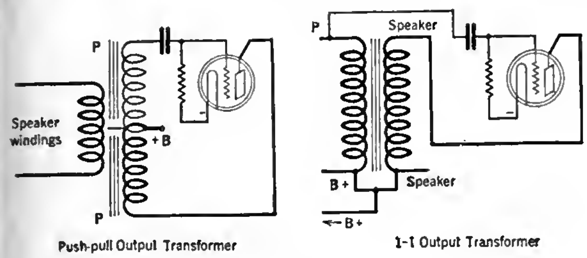


FIG. 2

Either push-pull or output transformer may be employed in the audio-frequency oscillator

it, as well as by the plate and filament voltage and grid leak values. In such a simple piece of apparatus it is neither necessary to know the exact audio frequency or to go to great labor to maintain it constant. The radio oscillator varies in frequency too, but not sufficient to be measured on an ordinary wavemeter.

A Jefferson push-pull output transformer, with 0.015 mfd. C_2 across the grid and filament of the tube, oscillated in the Laboratory at 900 cycles, and a Pacent output transformer 27B tuned according to the table below when a WD-12 tube was used and connected as shown in Fig 1:

C_2 Capacity	Frequency
None	3000 cycles
0.000125 mfd.	2000 "
0.0008 "	1000 "
0.00125 "	650 "
0.00275 "	550 "
0.012 "	240 "
0.02 "	160 "
0.04 "	130 "

If it is desired to use more than one tone from the oscillator, a pair of binding posts may be brought out on the panel and a small capacity unit, consisting of several condensers connected to a switch, may be attached to the low-frequency tube. The exact frequencies obtained may differ from those shown in the table. For this reason, it is not necessary or useful to get condensers of exactly the same capacity as specified. They may be obtained by connecting several condensers together so that the resultant capacities are similar to those given.

With the tuning condenser across the grid-filament half of the coil, the tuning ranges are approximately as shown below when WD-12 tubes are used as oscillators. If the dial is divided into 100 degrees, and has a straight frequency-line condenser, each degree will cover about the number of kilocycles shown in the table:

Coil	Wavelength Range	Frequency Range	Kilocycles Per Degree
15 turns	45–120	2500–6660	31.60
30 turns	80–210	1430–3750	23.30
60 turns	165–400	750–1820	10.70
90 turns	265–620	485–1130	6.50

The dial should be large and provided with a fine adjustment. That shown in the photograph was made for the Laboratory from aluminium by Mr. Harold Benner of Cruft Laboratory, Harvard University, and has the dimensions shown in Fig. 3. Very accurate adjustments are possible with this dial, and its accompanying vernier makes it possible to read to within one kilocycle in the broadcast frequency band, two kilocycles in the intermediate band, and three in the higher band. Any good vernier or slow-motion dial can be used.

An even more accurate instrument could be made by reducing the overlap so that each coil covered only the frequency band desired. In this way the smallest coil would cover exactly 3000 kilocycles, the intermediate ranges would be 2000 and 1000, and the largest coil would cover 500 kilocycles. Fewer turns will be necessary and the experimenter will be forced to rely upon his own ingenuity in winding them.

COILS

THE coils used in the Laboratory oscillator were General Radio type 277 and have the following dimensions:

Coil	Turns	Size Wire	Diameter	Length of Winding	Inductance
277-A	15	21	2 11/64	1 5/8"	0.014mh.
277-B	30	21	"	1 1/2"	0.055 "
277-C	60	21	"	1 5/8"	0.217 "
277-E	90	27	"	1 3/8"	0.495 "

CALIBRATION

IT IS a simple matter to calibrate such an oscillator. It is best to do this without the low-frequency tube oscillating. The accessory apparatus is not extensive, only a two-tube blooper, or any other receiver that can be made to oscillate, being necessary.

In addition to the oscillator and blooper, a single accurately known frequency is required. This is provided by any well-known broadcasting station, preferably near the lower edge of the frequency band, say 400 or 500 meters. If such a station cannot be heard in the daytime, or when the calibration is to take place, the station should be picked up wherever possible on the blooper (which should be set up and running for several minutes before the final tuning is done)and no changes made, except to turn off the tube. The next day, or whenever the calibration takes place, the tube should be lit for several minutes to permit it and the batteries to settle down to a steady state. The detector tube is made to oscillate and the blooper is set accurately on the broadcaster's frequency by tuning to zero beat with him. This must be done with a vernier condenser or with a single-plate condenser shunted across the large tuning condenser. As the blooper's frequency nears that of the broadcasting station, a lowering in tone of the beat note will be heard. It will soon become inaudible, to rise again on the other side of exact resonance, as indicated in Fig. 4. Halfway between the limits of this inaudible area is the exact frequency desired. With care, the experimenter can set his blooper to within 100 cycles of a station operating at 100 kilocycles.

The blooper is now oscillating at exactly, say 750 kilocycles (400 meters), and should not be touched or approached by the hand throughout the following procedure. At least one stage of audio should be used on the blooper and a pair of phones in the output of this amplifier should be used to indicate resonance between harmonics of the blooper and harmonics of the oscillator.

The blooper and oscillator have in their output not only the wavelength to which the coil and condenser are tuned but harmonics of this wavelength as well. That is, if the wavelength is 400 meters, in the output will also be one half,

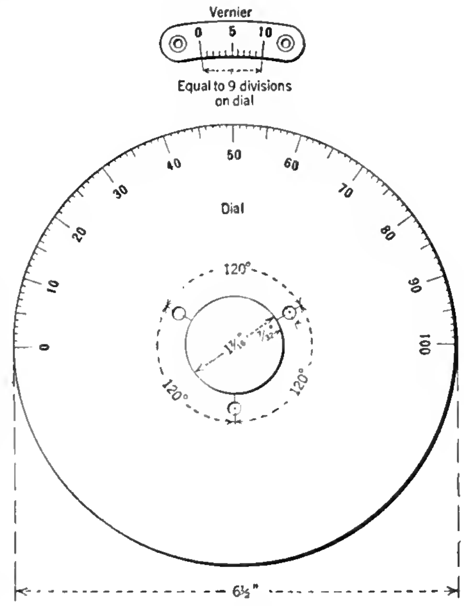
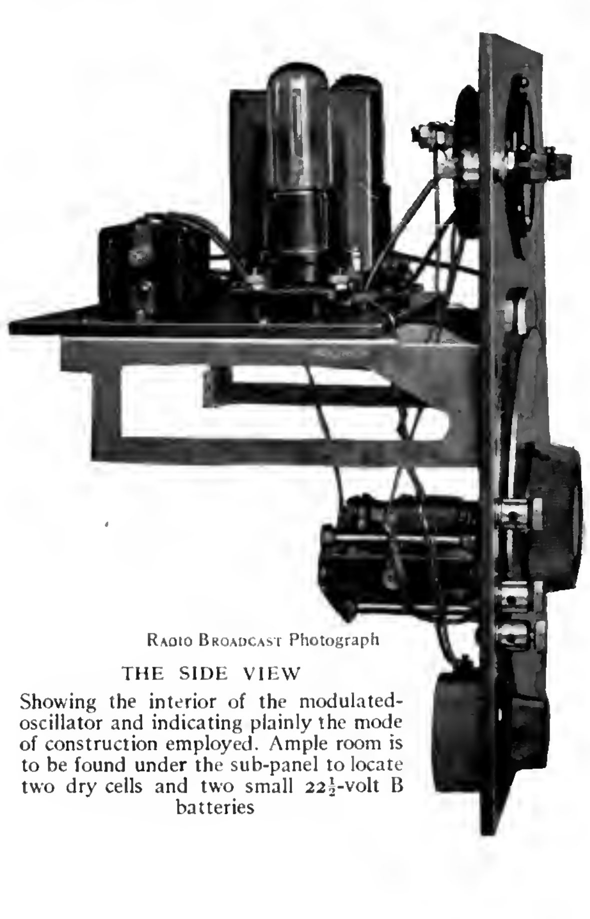


FIG. 3

The dimensions of the vernier dial



Radio Broadcast Photograph

THE SIDE VIEW

Showing the interior of the modulated-oscillator and indicating plainly the mode of construction employed. Ample room is to be found under the sub-panel to locate two dry cells and two small 22½-volt B batteries

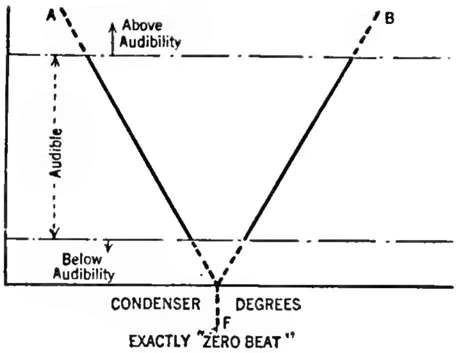


FIG. 4

one third, one fourth, etc., of this figure, or 200, 133, 100, etc., meters. Whenever the oscillator is tuned to one of these wavelengths a beat note between the oscillator fundamental and the blooper's harmonic will be heard. A beat will also take place when the second harmonic of the blooper beats with the third of the oscillator, and so on down the line. The number of wavelengths that can be secured in this manner are shown by Table No. 1. which has 400 meters as the basis of reference. The figures at the top represent the oscillator's harmonics, while those along the left-hand vertical line represent the harmonics of the blooper. For example, if the oscillator is set at 600 meters, its third harmonic will beat with the second of the blooper. The other wavelengths in the table may be found by multiplying 400 by $\frac{1}{2}$, $\frac{1}{3}$, $\frac{2}{3}$, $\frac{5}{7}$, $\frac{7}{5}$, etc. In calibrating the Laboratory oscillator with the coupling indicated in Fig. 5, twenty-two of these wavelengths were found and, with closer coupling all of those given in Table No. 1 and others should be found. The ones in this table to be expected are denoted by heavy type. In our note book we set down our data as shown in Table No. 2, noting the condenser setting for each beat note, and marking with an asterisk the strongest. These will correspond to exact harmonics of the blooper, that is, the second, third, fourth, etc., or small fractional harmonics, that is $\frac{3}{2}$, $\frac{2}{3}$, $\frac{4}{3}$, $\frac{3}{4}$, etc.

Now, all of this probably sounds complicated and difficult to the uninitiated. There is no reason, however, for getting stage fright at this point. Suppose we have set up the blooper and that it is tuned accurately to 400 meters. We are listening in the plate circuit of a stage of audio amplification behind this oscillating detector. The oscillator, too, is ready to operate, the filament having been lighted for several minutes. We place the 90-turn coil in the oscillator, arrange the coupling about as shown in Fig. 5, and turn the oscillator dial. We get a strong whistle at 34 degrees. We make mental record of how loud the beat note is and are certain that we have hit 400 meters, and turn the dial again. At about 92, 12, and 4 we get other squeals. Now we know that the 90-turn coil will go to about 600 meters and we note from our table of those wavelengths at which beat notes will be heard that, when the oscillator is tuned to 600 meters, its third harmonic (200 meters) will beat with the second of the blooper (also 200 meters), to produce an audible note. By the same reasoning, when the oscillator is tuned to 300 meters, its third harmonic, or 100 meters, will beat with the fourth of the blooper, also 100 meters. The loud beat at 4 degrees corresponds to 266 meters.

In the calibration process so far we have been certain of but one point, 400 meters at 34. If we listen closely, or use somewhat closer coupling, we shall also hear beat notes at 69, 59, 16, and 9 degrees on the oscillator dial. Using our table of wavelengths we guess again, and assume

Blooper Harmonics	Oscillator Harmonics									
	1	2	3	4	5	6	7	8	9	10
1	**400**	800	1200	—	—	—	—	—	—	—
2	**200**	—	**600**	—	—	—	—	—	—	—
3	**133**	**266**	—	**533**	—	—	—	—	—	—
4	**100**	—	**300**	—	**500**	—	—	—	—	—
5	**80**	**160**	**240**	**320**	—	480	—	—	—	—
6	**66.6**	—	—	—	**333**	—	466.6	—	—	—
7	**57.1**	**114.3**	—	**228**	286	**343**	—	457	514	571
8	**50**	—	150	—	250	—	350	—	450	—
9	**44.5**	89.0	**134**	178	222	—	311	356	—	445
10	40	—	120	—	—	—	**280**	—	360	—

TABLE NO. 1

that the wavelengths are 533, 500, 320, and 280 meters. Everything but the 400-meter point has been guessed at, but if we plot a curve of wavelengths against condenser degrees it will tell at once if we have erred. If a good curve results, our guesses have been correct. If one or more points refuse to fall in line we have guessed wrong and we must listen for beat notes again.

On the 60-turn coil, we get a very loud note at 98, weaker notes at 50, 37, and 15, and still weaker notes at 69, 65, 59, 45, 28, 24, and 6 degrees. By our process of guessing — assuming that the 98 degree point is 400 meters — we put down the wavelengths as given in Table No. 2. The same process is carried out in getting points on the 30- and 15-turn coils.

If the coils are well made, the smaller inductances having half the number of turns of the preceding coil, beats will be heard at approximately the same condenser settings as Table No. 2 shows. If a condenser with a straight wavelength calibration is used, the problem is simplified, since we can guess fairly accurately where the next beat note is to be found. The same applies with a straight frequency calibration except that we must think in terms of frequencies and not wavelengths. With a straight capacity-line condenser, the wavelengths can be estimated by remembering that the wavelengths corresponding to two condenser settings are proportional to the square roots of the capacities involved. If the condenser has one of the modified calibrations, the experimenter is up against it. He had better use a condenser whose calibration is known. Practically all well-known condenser manufacturers have units that will have a straight frequency-line. An excellent condenser is the National Equicycle, which uses a 270-degree arc instead of 180 degrees. This will spread out the frequency band considerably.

For general work around the laboratory, the modulated signal may be used, but for careful measurements the pure carrier wave is better. Coupling to a receiver using one stage of audio need be no closer than the opposite sides of a rather large room. When the high-frequency oscillator is modulated it is possible to pick up the tone in two places very near the carrier which will be comparatively quiet. These two signals represent the side bands which are one thousand cycles on either side of the carrier in the case of a thousand-cycle signal.

In a later article a bridge for measuring vacuum-tube characteristics will be described. The tone will be very useful in conjunction with this instrument. Among other articles in this series for the home laboratory will be methods of measuring inductance and capacity, and here again the tone will be necessary. Still another article has been prepared on the vacuum-tube

Blooper Set at 400 Meters							
90-Turn Coil		60-Turn Coil		30-Turn Coil		15-Turn Coil	
Condenser Degrees	Meters	Condenser Degrees	Meters	Condenser Degrees	Meters	Condenser Degrees	Meters
92*	600	98**	400	96*	200	77*	100
69	533	69	343	68	171		
		65	333				
59	500	59	320	58	160		
		50*	300				
34**	400	45	280			46*	80
		37*	266	36.5*	133		
16	320	28	240			28.5	66.6
		24	230	23	114.3		
12*	300	15*	200	15*	100	18	57
						11	50
9	280						
		6	171				
4*	266					3	44.4

TABLE NO. 2

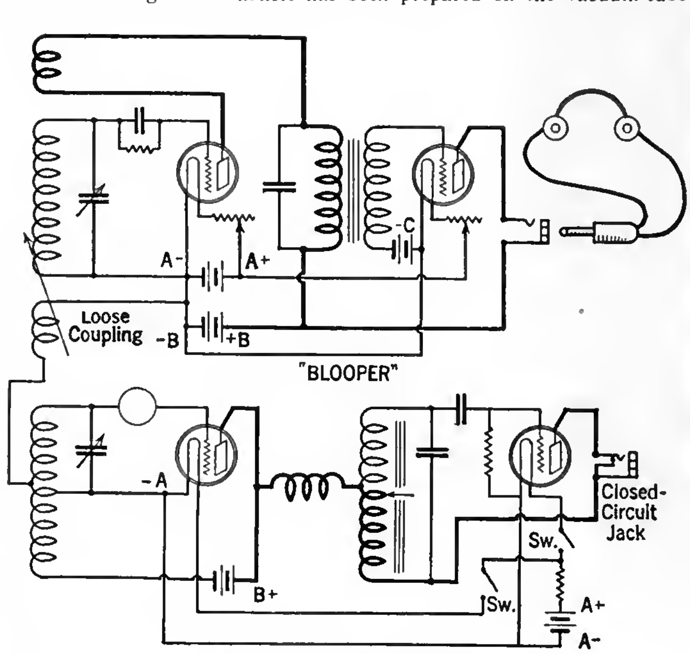


FIG. 5
The circuits employed in calibrating the modulated oscillator

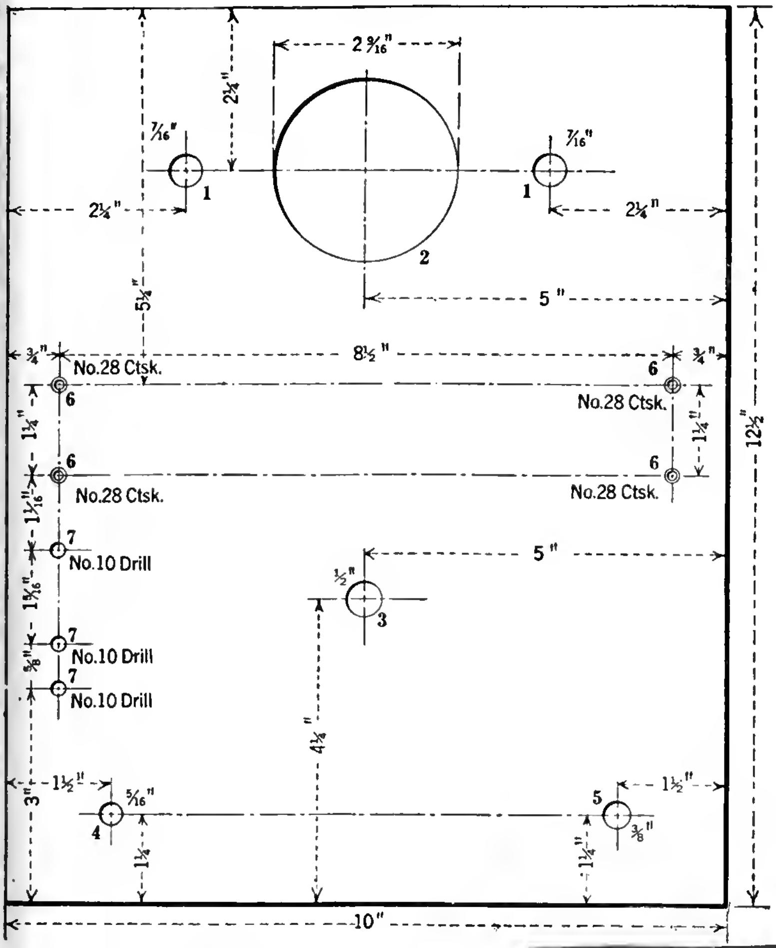


FIG. 6 (*Above*)

In this panel layout the various parts are mounted in the holes which are numbered, as follows: 1, filament switches; 2, meter; 3, tuning condenser; 4, rheostat; 5, output jack; 6, brackets; 7 binding posts

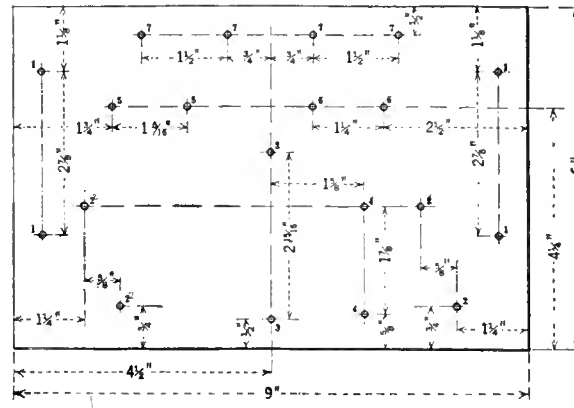


FIG. 7

The sub-panel layout, as shown here, supports the following pieces of apparatus, as numbered: 1, brackets; 2, sockets; 3, transformer; 4, grid leak; 5, radio-frequency choke coil; 6, fixed condenser; 7, binding posts or machine screws

USES OF THE OSCILLATOR

1. Radio Oscillator
- (a) Heterodyne wavemeter.
- (b) Radio-frequency driver.
- (c) Measuring gain and frequency range of amplifier.
- (d) Tuning range of coil—condenser combination.

2. Audio Oscillator
- (a) Source of tone for circuit testing.
- (b) Source of tone for measuring capacity, inductance, or resistance.
- (c) Source of tone for measuring gain of audio amplifiers.

3. Modulated Oscillator
- (a) Measure unknown frequencies.
- (b) Measuring tuning range of receivers.
- (c) Setting receiver to known frequency.

voltmeter, and for this instrument both the high and low frequencies will be needed.

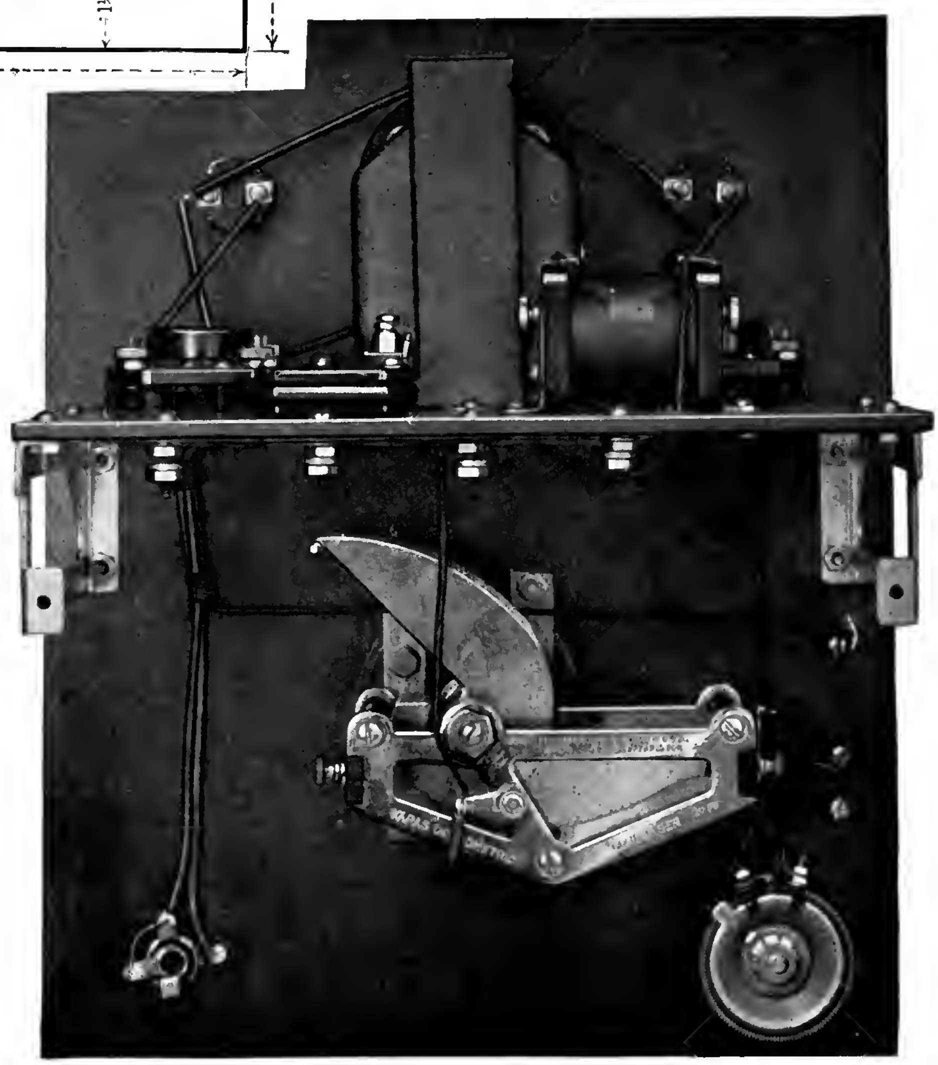
A jack is provided in the plate circuit of the low-frequency oscillator so that the tone may be utilized at any desired point.

The necessary dimensions and layout for the various pieces of apparatus are shown in the accompanying diagrams, and the following list of parts covers the apparatus actually used in the Laboratory oscillator:

LIST OF PARTS

L_1—1	Pacent 27B Output Transformer	$ 7.50
L_2—4	General Radio Coils	
	277-A	1.25
	277-B	1.25
	277-C	1.25
	277-E	1.50
L_3—1	Samson Radio-Frequency Choke No. 85.	1.50
C_1—1	Sangamo Condenser 0.0012 Mfd.	.50
C_2—1	Small Fixed Condenser (see p. 93)	.50
C_3—1	Karas Straight Frequency-Line Condenser, 0.0005 Mfd.	7.00
R_1—1	Carborundum Grid Leak, 0.5 Megs.	.35
R_2—1	Frost Rheostat, 10 Ohms	.50
2	Carter "Imp" Battery Switches	1.30

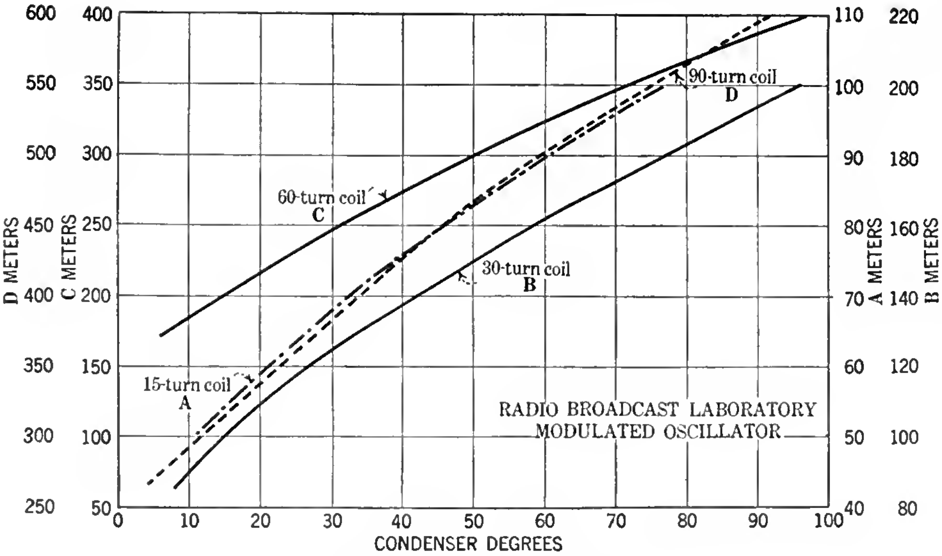
(*Continued on page 96*)



TO THE RIGHT

This picture shows clearly the disposition of the parts employed in the construction of the modulated oscillator

RADIO BROADCAST Photograph



THE CALIBRATION CHART

For the four coils employed in the radio-frequency end of the modulated oscillator, will closely resemble the one shown here, when a straight capacity-line condenser, such as the General Radio 247 type is used

1	Carter Closed-Circuit Short Jack	.80
1	Weston Milliammeter—0-1.5 Mils.	12.00
2	Benjamin Brackets	1.40
3	General Radio Binding Posts	.45
2	Benjamin Sockets	1.50
1	Main Panel 10" x 12½" x 3/16"	2.50
1	Sub-Panel 6" x 9" x 3/16"	1.08
	Machine Screws, Wire, Solder, Etc.	.50
	TOTAL	$44.63

Other parts than those specified in this list may be used provided they are of equal quality. The main requirements are that the condenser be rigid in its bearings, that the dial be easily and accurately read, and that the device be re-calibrated when tubes are changed. It is a good idea to lock the tubes and batteries into the cabinet.

Following articles will discuss in detail the varied uses of this modulated oscillator. The Laboratory will be glad to hear from readers at any time regarding the uses which they have found for the apparatus described here.

The following construction hints are from Mr. Brennan who is responsible for the construction of the unit used in the Laboratory.

The panel layouts shown are based on the use of the material listed here and should be altered accordingly if substitutions are made

The first step in the construction of the oscillator is the preparation of the main panel, Fig. 6, for drilling. The various hole centers should be spotted with the aid of a hammer and centerpunch, and then drilled with a small drill, say No. 28. Then those holes which require enlarging may be so enlarged by the use of Stevens tapered reamers, which are indispensable for such work. The hole for the meter may be made by drilling a number of small holes around the periphery of the circle and then filing it clean. Better yet, a circle drill may be used to make a clean-cut hole just slightly larger than the diameter of the body of the meter.

The sub-panel is next prepared, and after all the holes have been drilled in accordance with Fig. 7, the two Benjamin brackets are mounted in place on the main panel in the holes numbered "6." Round-head machine screws, ½" x 6/32", pass through the holes numbered "1" on the sub-panel to fasten it to the top of the brackets. After this operation is completed, the audio transformer, sockets, fixed condenser, r. f. choke, and grid leak are mounted on top of the sub-panel.

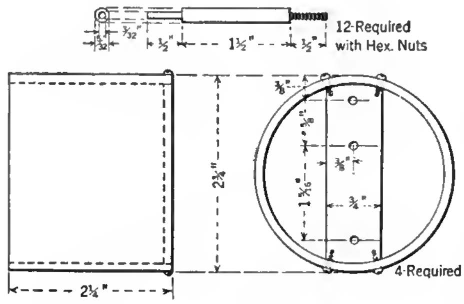
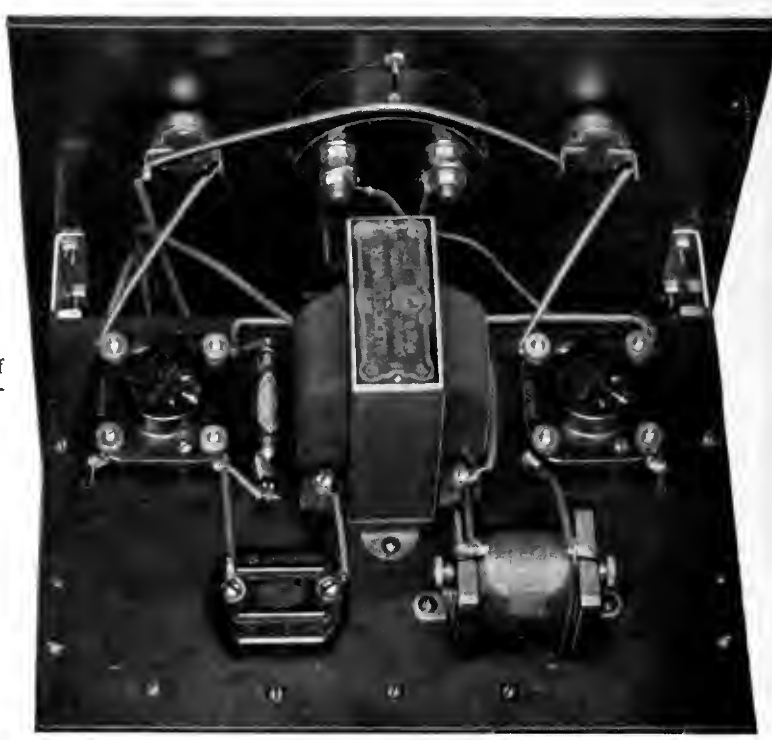


FIG. 8

Dimensions for the coil forms and connector pins



RIGHT

The layout of parts on the sub-panel

RADIO BROADCAST Photograph

Prop up the rear edge of the sub-panel to maintain the assembly in an upright position and then mount the main panel instruments thereon.

The wiring is next. Point to point connections are made which make for short direct leads. This system of wiring is more to be desired over the system where right-angle turns add to the neatness of wiring but otherwise do not materially improve matters.

The specifications for the coil forms are given in Fig. 8. If General Radio plug pins are used, a different arrangement for connecting them to the unit will have to be devised. The pins shown in Fig. 8 allow the coils to be mounted in the binding posts and to extend somewhat over the edge of the panel.

FOR CALIBRATION

SIGNALS from any of these stations may be used in calibrating wavemeters. They are maintained very closely to the frequency indicated here.

STANDARD FREQUENCY STATIONS

Station	*Location*	*Frequency*
WEAF	New York, New York	610
WRC	Washington, District of Columbia	640
WJZ	Bound Brook, New Jersey	660
WGY	Schenectady, New York	790
WBZ	Springfield, Massachusetts	900
KDKA	East Pittsburgh, Pennsylvania	970

CONSTANT FREQUENCY STATIONS

WHO	Des Moines, Iowa	570
KFRU	Columbia, Missouri	600
WOC	Davenport, Iowa	620
WTIC	Hartford, Connecticut	630
WMAQ	Chicago, Illinois	670
KLDS	Independence, Missouri	680
KPO	San Francisco, California	700
WLW	Harrison, Ohio	710
WCCO	St. Paul-Minneapolis, Minnesota	720
WTAM	Cleveland, Ohio	770
KTHS	Hot Springs, Arkansas	800
WJJD	Mooseheart, Illinois	810
KGO	Oakland, California	830
WJAD	Waco, Texas	850
WWJ	Detroit, Michigan	850
WLS	Crete, Illinois	870

THE LISTENERS' POINT OF VIEW

Conducted by John Wallace

"Radio Pests" and How to Be One

WHEN we proposed to the readers of this department the question: "Do you listen to your radio in the evenings as you would to a regular show or do you simply turn it on and use it as a background to other activities?" it was with malice aforethought. We were gathering ammunition for a little tirade against the radio pest who turns on his radio at about six A. M. and leaves it in that distressing condition until midnight.

The questionnaire showed that one out of every ten listeners employs his radio almost exclusively as a background. This does not mean that one out of every ten radio receiver operators is a pest; if that were true, it would put us in the pest class, for there are many occasions when we utilize the radio as a background. But the flagrant offenders are included within that number; just how large a part of it they make up you can decide for yourself.

At any rate you know the beast. When you open the door of his house for a friendly little call of an evening you are immediately greeted by a resounding blare from a loud speaker in the next room. And whether the order of the evening be bridge or poker, ping pong or conversation, that infernal loud speaker continues to vibrate viciously the evening through. It vibrates from string quartet to brass band, from election speech to bed time story, from wheezy soprano to musical saw player, from stock market report to bee keeping instruction, and back again—and all over again.

All the while nobody is paying it the slightest bit of attention. To add to the misery, some fluctuation in factors radio and electrical has thrown it out of tune and interference has been set up by some powerful local bird store.

When we say nobody is paying attention to it we refer particularly to its owner and the members of his family. They have, through long exposure, developed an immunity to it. But you, however (we assume you to be a sensitive being whose ears are normally free of impedimenta), are woefully aware that it is "going." Gradually its cumulative effect is to grind down your nerves to rather small shreds. Finally, at the end of a couple of hours, the one nerve left you unground tautens itself in the superhuman paroxysm and you arise, devour the pack of cards, kick over the receiving set, shoot your host, and rush out into the night.

To radio receiver owners of this ilk may be laid the blame for the not at all small army of scoffers who steadfastly refuse to consider radio seriously. The scoffer is a scoffer, nine times out of ten, because his first introduction to radio was in the home of a Radio Pest. Naturally he considers the device an instrument of the devil; for an instrument of the devil it is when so operated.

Any radio owner, no matter who he be, and including ourself, can profit by an occasional recalling of the old saw: "Familiarity breeds contempt." To get the maximum enjoyment out of a set it must be treated with a certain amount of respect. The greatest advantage of radio is that it requires no more than the flip of a switch to bring music and other entertainment right into your own home. But, paradoxical though it may seem, this is also radio's greatest drawback. By the time one has struggled into his dinner clothes, taxied a half hour or more to the theater, and laid out eight-eighty for tickets he is in a frame of mind to enjoy the performance or die in the attempt.

THE SMITH BROTHERS

"Trade" and "Mark" who in their non-microphone life are "Scrappy" Lambert and Billy Hillpot. You may remember hearing them with Ben Bernie and his orchestra. They are the Smith Brothers for a half hour beginning at ten p.m. over the WEAF network on Wednesday nights

REAL HAWAIIANS AT KHJ

The Moana Hawaiian Entertainers, reported to have come "direct from the Islands," played a week's engagement recently at KHJ, Los Angeles

The fact that it takes some effort to get to the source of entertainment undeniably adds something to the pleasure to be derived. On this score radio is at a decided disadvantage. Asking little it receives even less (that is, understand us correctly, in the home of the Radio Pest).

We hesitate to adopt such a smug and paternalistic course as to set forth a set of rules for the proper operation of a receiver, especially because we suspect that the great majority of our readers knows a lot more about it than we do. But perhaps you number a Radio Pest among your friends and would like to have the table of laws to clip and mail to him anonymously. Hence we advance these suggestions on:

HOW TO OPERATE A RADIO RECEIVER FOR MAXIMUM PLEASURE

First: Keep the fool thing in proper mechanical shape. A receiver with a defective tube or a weak battery or some other wheeze-provoking ailment should be immediately retired from service and kept retired until its ills are attended to. A distorting set is ninety-nine times worse than no set at all.

Second: As a general rule, don't use the radio simply as a background, at least while some sensitive soul like ourself is parked in your parlor. Like all rules this one is largely invalid because certain types of broadcasts are genuinely fitting as background. Almost any program of instrumental music (excepting jazz) may serve as a pleasant obbligato to bridge or conversation, or even reading, providing it is rheostated down to a sufficiently *sotto* volume. But speeches, songs, and static are a suitable background for nothing we know of outside of a tea party in a mad house.

Third: The most genuine enjoyment from a radio program is to be secured by preparing for it in advance and listening to it with reasonable reverence. Consult some advance program and find out the exact hour that some feature you want to hear is scheduled. Let the receiver remain deathly silent until two minutes before that hour. Then provide

ETHEL AND JANICE
Who are known to the listening world who tune-in on KMOX at St. Louis as the "music mixers," whatever that means

yourself with an easy chair (formal clothes not imperative) and tune-in the desired program right on the instant of the first word of the first announcement. If you can provide yourself in advance with an itemized program of the feature it will contribute to the illusion of being at a concert. Try it some time if you haven't already (selecting, of course, a program that's worth the ritual) and you'll be surprised how much this slight mark of respect for the program repays you in enjoyment of it.

Making Up the "Sponsored" Program

AN INTERESTING insight into the advertising man's ideas concerning radio advertising was afforded in an article by Uriel Davis in *Printers' Ink*. He suggests methods of procedure for the prospective air advertiser and says in part:

"The product or company should be humanized, dramatized. The narrator's voice, without which the dramatic element will not succeed, should be studied and analyzed for timbre, intensity, and pitch, and its quality so finely determined that a suitable musical accompaniment, in proper register, may be provided by a single instrument or an ensemble.

"The name of the company, or its product, should be introduced in as subtle a manner as possible. The announcement of the name or product could recur from time to time during the actual performance instead of between musical or other selections, which is the custom to-day. Under no circumstances should the advertisement appear too obvious. Where there is no good reason, from the standpoint of entertainment, to mention the name of the product or the company, it should be omitted.

"There can be no advertising loss in a plan of this kind. As a matter of fact, the value of subtle advertising of this kind should be far greater than that obtained from 'program interference,' as the present-day announcements may be termed.

"An hour or any period of radio entertainment must have continuity. Continuity is essential to hold the listener's attention over even a short period. He is constantly looking for something he likes to hear. When he attends a theatrical performance, his mind is not on the show appearing at another theatre. Why could not his mind be put in just as receptive a mood when he listens in on a radio hour? To obtain such continuity it it necessary to build programs upon a basis similar to that employed in the preparation of moving picture scenarios.

"Since music is essential in successful radio performance, there should be a continuous tie-up between the spoken word and the orchestra or whatever group of musical instruments that may be used. The music, when not an actual part of the program, may be employed as a background or setting for the voices used for descriptive purposes as well as for song.

"Pauses between selections as well as between the voices and music may be eliminated with ease if the scenario, so called, will provide for absolute synchronization whereby the music will always shortly begin before the voice ceases speaking, and *vice versa*.

"Continuity of performance or program, in other words, the use of a scenario, should enable advertisers to provide not only a high grade of entertainment, but a program sufficiently interesting to hold the listener's attention throughout its entire length. It should arrest the attention of the casual tuner-in to such extent that once the program is brought in on a set it will not be dismissed until completion.

"Successfully to carry out the suggestions I have made would require not only careful preparations of the scenario and attendent musical program, but a careful study of the advertiser's product as well."

We are glad if the advertisers are to be convinced that "where there is no good reason, from the standpoint of entertainment, to mention the name of the product or company, it should be omitted."

But we are filled with grief at the other doctrine Mr. Davis preaches: "An hour or any period of radio entertainment must have continuity."

Heaven deliver this listener from the type of "continuity" employed in the Don Amaizo hour. Such continuity smacks of the earliest days of the movie subtitle. It is not our business as a radio reviewer to tell the advertising men how to run theirs. So we will acquiesce to their superior wisdom and concede that there may be some necessity for continuity to hold the attention of some of the listeners. But it gives us the willies. If the artists on a given hour are good we will stay with them regardless of the omission or inclusion of such stuff as:

". . . . and now our Coral Throated Baritone and Sarah Szbisco, the Soprano with a Soul, bid tearful farewell to the sturdy Volga boatmen and boarding their Peerless Yacht Company Auxiliary barge they drift slowly down the Danube, past the lovely rock of the Lorelei, where, amid the twitter of the birds and the bees, we hear emerging from the forest, as from the mellifluous dulcimer, the tender strains of 'Down on the Mississip'."

It is notable that several of the most popular "hours" omit continuity entirely or use it very sparingly. But if we are to have it with us permanently, as seems inevitable, how's for the advertising agencies who handle these programs applying a little ingenuity to the writing of better continuity? It could be made non-obnoxious. In fact it could be made right entertaining. But it would take a lot more labor than it is now accorded. If one sixth of the time in an advertising hour is to be turned over to an announcer we do not see why he should not be supplied with text written by a first rate copy writer and at a fee at least equal to one sixth of the cost of the hired performers.

As a schooling for the prospective composer of continuity we can think of nothing better than a thorough study of the evolution of movie subtitles. As we said a while back, radio continuity is in the same stage of development as was the movie subtitle in the days of "Came The Dawn."

The "Came The Dawn" subtitles have largely disappeared and very excellently and succinctly composed ones have supplanted them. However, in the movies, it took fifteen years or more. Let the radio advertisers profit by this example and see if they can't cut down this fifteen-year wait by a month or two.

And now to present the broadcasting station's point of view of the advertising program, which, by coincidence, comes to our desk as we are writing this article:

Program features originating with the National Broadcasting Company fall into two main classifications—"sponsored" features put on the

A POPULAR FEATURE AT WTAM, CLEVELAND
Guy Lombardo's Royal Canadians are among the most popular of the Middle-West radio dance orchestras. Where the other instruments in the band are, we cannot say. The players at least, have reported for duty

air under the auspices of commercial concerns for the purpose of building institutional good-will, and "sustaining" features, including broadcasts by the various National Broadcasting Company "stock" companies, educational and religious and musical programs of all kinds from hotels, night clubs, and prominent motion picture theatres.

The life of a sponsored feature really begins, so far as the whole personnel of WEAF and WJZ is concerned, when a contract has been made between the Company's Commerical Department and a commercial concern for the use of time on the air. Immediately, the machinery of the Program Department of the station involved starts to function.

The contract itself may specify what entertainers are to broadcast during the time allotted to the new feature, and in this case, the work of the Program Department is lessened. Usually, however, the Commercial Department, the new client, the Station Manager, and the Program Department will combine to decide upon the artists, leaving the working out of the details to the Program Department.

The period of planning may involve almost any amount of work. The elusive idea must be pursued and captured and a definite scheme of entertainment mapped out. In some cases, three or four complete plans are made. Conferences are held between the Program Department, the Commercial Department, and the sponsor and the type of entertainment is decided upon. The time at which the feature will appear on the air must also be decided, a process which involves many considerations. The station management must balance its entire program for the evening and make sure that every feature attains as much prominence as possible. In other words, a whole evening's program must be varied if it is to be effective. Two periods of the same sort of entertainment should not follow each other, or both of them will lose in effectiveness because of the fact.

When a plan has been approved, work is begun on detailed programs. Artists are engaged, a process which may require auditions attended by representatives of the various departments and by the sponsor. A continuity is prepared for the opening program and an announcer is chosen for the feature. The artists are given the detailed program in order that they may start rehearsing. In short, a sample program is prepared for presentation.

In preparing the continuity, care is taken that the program shall merely create good-will rather than describe the sponsor's products. The spoken portion of any sponsored feature should relate to the musical selections, if the entire program is to accomplish its object. The detailed program is submitted to the Department of Musical and Literary Research in order that all copyrights on the various selections may be investigated. In some cases, numbers are changed to comply with copyright restrictions.

When the sample program has been prepared, it is assembled as a unit for rehearsal at the studio. This rehearsal is attended by a Commercial Department representative, a member of the Program Department, and the sponsor. In instances which involve unusual pick-up problems, a member of the Operations and Engineering Department is also present to work out proper microphone placement and insure the best possible pick-up.

In the meantime, three other activities have been begun, looking forward to the time when the feature will first be heard on the air. The Traffic Department has communicated with the various stations through which the sponsor desires his program to be heard and has arranged for telephone facilities to carry the program to these stations.

The clerical force of the Program Department has prepared program material on the feature and forwarded it to the Publicity Department, so that proper announcement of the coming feature may be made.

The rehearsal at the studio is criticized by those who attend it and any desired changes are made in the program. Other rehearsals will take place before the initial broadcast of the series goes on the air, and rough spots in the presentation will be smoothed off. Shortly after the first rehearsal, however, the various departments which have helped to get the first program ready start to work on the second and third appearances of the feature. Detailed programs are made up and given to the artists three weeks in advance so that every detail of each presentation may be carefully worked out. The final step in the presentation of the first program takes place when it goes on the air. The broadcast is listened to by the Station Manager or his representatives, for he is really the stage manager of the station. In every case where contact occurs between various departments, printed forms are used to make sure that information is transmitted accurately. No details are left to memory or to oral agreement. Once the first program has been broadcast, a regular rehearsal schedule is maintained for further features in the series. Every broadcast must be rehearsed in the studio twice before it goes on the air, necessitating an elaborate schedule.

LOUIS KATZMAN

Leader of the Anglo-Persians. The Whittall Anglo-Persian Orchestra has been a regular and well-liked feature of the WEAF network programs for many months

An Evening of Chain Programs

OCCASIONALLY there come to our ears certain distant mumblings and mutterings of rage against the "Big Radio Chain Monopoly." It is characteristic of the American to growl gutturally when confronted by anything exuding the faintest odor of monopoly. It is also characteristic of him to slough off his prejudices and form one himself the minute he gets a chance.

It may be that some of the epithets, such as "Radio Trust," "Un-American," "Capitalistic," etc., hurled at the big chain are not without justification. However, we do not propose to examine the facts of the case. For, frankly, we do not care. Our duty as radio reviewer requires us to make use, not of our vague recollections of Economics 51, nor of our theories of business ethics, but simply of our ears. And our ears find it good. As a "listener" we are little concerned with what goes on at the other end of this wireless transaction. Our concern is with the things that come out of the loud speaker and our special concern is with the things that are good.

So heark ye to the very pleasant evening we were enabled to put in on Friday, March 18, relying exclusively on chain broadcasts from three of the local (Chicago) stations:

WLIB—7 P. M. About the best brass band available to the radio audience, that of Edwin Franko Goldman, playing, with nice regard for the exactions of the microphone, such acceptable pieces as Tschaikowsky's "1812" Overture, the "Peer Gynt" suite, and the Procession of the Knights of the Holy Grail from Wagner's "Parsifal."

THE HERMANN TRIO AT WLW

This trio, composed of Emil Hermann, concert master of the Cincinnati Symphony Orchestra; Thomie Prewitt Williams, and Walter Hermann, is heard each Wednesday evening at 10, Eastern Standard Time. Indications are that this group of artists is one of the most popular heard from WLW

KYW—7:30 P. M. The Royal Hour featuring Helen Clark, the "Royal Heroine" and Charles Harrison the "Hero" in a series of solos and duets alternated with orchestral selections. This program was made up of popular songs of Arabian and Egyptian coloring, which same coloring, unauthentic though it may be, is responsible for one of the most ingratiating modes of popular composition. Such titles as "Sand Dunes," "Song of Araby," "There's Egypt in Your Dreamy Eyes," "Lady of the Nile" and "Africa."

WGN—8 P. M. The National Grand Opera Quartet composed of Zielinska, soprano, Nadworney, contralto, di Benedetto, tenor, and Ruisi, basso—all voices specially selected for their adaptability to broadcasting. They were able to sing the Rigoletto quartet so that it "came over" in assimilable form, without all the voices being blurred together like the kernels of over-cooked rice—a common enough fault with most radio renditions of this exacting and amazing composition.

KYW—8 P. M. Two Metropolitan stars, Mario Chamlee, tenor, and Florence Easton, soprano, and the violinist, Max Rosen, collaborating in a Brunswick Concert. To be sure, the program was made up of somewhat over-familiar compositions such as the Volga Boatmen's song, "Connais Tu Le Pays?" "Songs My Mother Taught Me," and so forth, but such is the practice of radio, and besides they were so well presented as to give new zest to the hearing. Florence Easton's is a good radio soprano voice.

WGN—9 P. M. Louis Katzman and his very good orchestra, the Whittall Anglo-Persians. Here was music well played, though again we might have been better pleased had the program been of less orthodox radio makeup. It included Thomas' "Mignon Overture," Sibelius' "Valse Triste," Gautier's "Le Secret," Dvorak's "Humoresque," and Jessel's "Parade of the Wooden Soldiers."

But all in all, we point out a most enjoyable and varied evening of music, and one which would require much jumping about in taxi-cabs, and the outlay of a pretty penny, to obtain first hand at the concert halls.

THUMB NAIL REVIEWS

WJZ—Announcing that, of the next three numbers to be played from the Commodore Hotel, the third was to be a brand new number from "Lucky," then only twenty-fours hours old on Broadway—a number which we particularly desired to hear. A miscalculation in time made necessary a return to the studio right in the middle of the second selection. Station WJZ offends too frequently in this respect.

WARS (New York)—An announcement to the effect that: "You are listening to Don Meaney's Midnight Frolics direct from KNX, Los Angeles." The fact that this was an itinerant company from a Californian station, broadcasting through a New York one, was announced, so it appeared to us, almost *sotto voce*. We wonder how many New Yorkers thought they got Los Angeles "direct" that night!

SUGGESTED SPORT FOR CALIFORNIANS

A READER in Los Angeles writes us: "In your article 'Why There Should be More Vice in Radio,' you have hit the nail on the head. In this city are two persons that I know thousands of listeners would get an enormous kick out of if they ever tangled over the air. One is a preacher and the other a female evangelist. If I could be drawn into a debate over the 'mike' of a neutral station I don't think the other stations in town would have 25 listeners apiece that night. The above mentioned each have powerful broadcasting stations. Draw your own conclusions." The which we print in hopes that our correspondent's suggestion may reach the "above mentioned" and start the fun.

WHAT CENSORS CENSOR

ON THE subject of the freedom of the air we note, since last writing, that complaint was registered by Representative Celler of New York that WEAF censored his address on George Washington of all statements that the father of his country liked his toddy, gambled, and in one of his Virginia campaigns, supplied rum and rum punch to the voters. Mr. Celler protested that "the radio management should permit discussion of the foibles of our great men if it adheres to the truth and is not phrased in a tone of disrespect. The things I proposed to say about Washington were not prepared with a view to belittling him. They are human qualities that detract none from his stature as a statesman or a man."

As a counterbalance to this censorship we have as exhibit B the extraordinary temerity evinced by KOA in allowing Judge Ben B. Lindsey to talk from its studio on companionate marriage, "the revolutionary theory that has scandalized society, brought down the wrath of the church, and set the whole world talking." We regret that interference kept us from hearing this decidedly controversial broadcast but we did "get" KOA the night before and heard advance information from director Freeman H. Talbot to the effect that: "Our station, like a magazine, will not assume responsibility for the principles advocated. But because of Judge Lindsey's prominence, because of his work in behalf of women and children, not only in the United States but in foreign lands, we believe he is entitled to an unbiased hearing."

Microphone Miscellany

BETWEEN the hours of eight and nine February 11, KFI, and ten other Pacific Coast stations presented what they termed an Interference Hour. The stations were paired off and so changed their wavelengths as to interfere seriously with one another.

After an hour of squeals, howls, indistinguishable announcements, and distorted music, the stipulated wave-lengths were resumed, following which pleas were made from each of the stations in support of the radio bill then before the senate.

WE ENJOYED Walter Damrosch's elucidation of Beethoven's Fifth Symphony considerably more than we were wont to enjoy his piano talks on Wagner. His enthusiasm is most contagious and he succeeds uncannily in making a piano sound like a section of a symphony orchestra, whether string or brass. His appearance on this "Beethoven Hour" was sponsored by the Columbia Phonograph Company, which company, in connection with its booming of Beethoven Week, made a canvass of the public's preference in composers. The comparative rating resulting from the ballot was:

Beethoven, 100; *Wagner*, 90; *Bach*, 87; *Mozart*, 82; *Brahms*, 78; *Schubert*, 76; *Chopin*, 75; *Tchaikowsky*, 62; *Handel*, 56; *Schumann*, 52; *Mendelssohn*, 47; *Haydn*, 38; *Liszt*, 32; *Verdi*, 27; *Debussy*, 26; *Grieg*, 26; *Palestrina*, 22; *Franck*, 20; *Dvorak*, 18; *MacDowell*, 16; *Puccini*, 15; *Strauss*, 12; *Saint-Saens*, 9; *Weber*, 7; *Rimsky-Korsakoff*, 7; *Gluck*, 4; *Moussorgsky*, 4; *Massenet*, 3; *Rossini*, 2; *Berlioz*, 2; *Mascagni*, 1; and *Leoncavallo*, 0.1

URIEL Davis, who controls the destinies of more than a thousand musicians, organized in a hundred combinations, made some observations in *The Billboard* on the selection of musical numbers for different kinds of audiences, which should interest every ambitious program director. He points out that the numbers selected for resort orchestras, for provincial towns, and for principal cities, vary greatly. The best index found to audience tastes of any locality is through the kind of phonograph records which sell the best. The resort audiences want popular music but numbers which have had an opportunity over a period of months to become well known; the small town and country audiences, time-worn numbers, known to the trade as semi-standard music; the big cities will not tolerate a number if the ink has had a chance to dry on the music. This may give a new angle to some program directors who have difficulty in accounting for the popularity of certain programs which nobody with whom they come in contact seems to like.

A DEPARTMENT of Commerce report states that the Tokio broadcasting station is soon to increase power to ten kilowatts. It states further that there are already 326,000 subscribers to the present one-kilowatt station. Eighty per cent. use crystal sets, although there is a strong demand now for much better vacuum tube receivers.

Correspondence

Los Angeles, Calif.

SIR:

Right here and now I want to protest your statement in the March RADIO BROADCAST. In the "Answers to questionnaires" story, you refer to the lack of feminine radio fans.

First, I am feminine,—and the most rabid kind of a fan,—tone, DX, quality programs, home-built, and factory-made sets. In fact, I have been completely "broke" buying radio parts ever since your magazine caused my downfall some eighteen months ago with a circuit. You see, the trouble was that the durn thing worked, otherwise I should have become discouraged and been saved! To date, I have built twenty-three sets, and lost hours of sleep trying them out.

But I believe that there is a reason; I have had no intolerant males to push me aside and let them show me how it is done. My trials and triumphs have been my own, and there have been considerably more trials than triumphs.

I'll make a wager with you: Let every woman who is even mildly interested, have her own set, tune-in her own stations, get that crackling, whistling elusive sound that means DX. She will show a longer log than friend husband.

It doesn't make any difference how much of a fan you are. Sit in a chair alongside your receiver, let the other fellow put the phones on and do the fishing; you'll be just as bored as though you didn't give a hang about radio.

Just try it!

Anyway, I like your magazine, even though it has kept me in a state of bankruptcy ever since I followed that circuit you published. And give me my choice between an evening at the theater and an evening at home listening to a really fine program,—I'll remain at home, thank you.

MARJORIE DOUGAN.

Problems of A. C. Filament Supply

Solving Some of the Difficulties Encountered in A. C. Operation of 201-A Type Tubes

By ROLAND F. BEERS

THE principles of series filament connections outlined in the first article of this group, published in the May RADIO BROADCAST, related the facts which pertained to 199 type radio tubes. It will be remembered that several typical circuits were discussed in detail, and two methods were outlined whereby the radio constructor could build up a receiver of this type.

In this, the second article of the series, the discussion will be extended to include 201–A type tubes, and data will be given regarding the theory of the power supply apparatus necessary to supply this type of tube.

The problem of supplying filament and plate current to 201–A tubes in series finds difficulties in the design and construction of the power unit rather than in the actual connection of the series filaments. There are three main problems which confront the home constructor of this type of unit. They relate to the transformer, rectifier, and filter circuit. In general, it is not possible to employ apparatus which is not specially designed for the circuit. The reasons for this statement will appear later.

In order to have an adequate understanding of the design of the power transformer, we must first consider the type of rectifier with which it is to be used. The requirements of the circuit demand a device of reasonably long life (say a minimum of 1000 hours), with uniform and stable characteristics throughout this period. The rectifier should also show good efficiency, particularly at full load. This quality is exceedingly desirable in order that the size and cost of the power transformer may be kept as small as possible. Early attempts of the writer to build a ¼-ampere power supply unit led to the design of a transformer which weighed nearly 25 pounds because it was called upon to supply a great deal of power which was lost by the inefficient rectifiers used at the time. It was not until efficient high-current rectifiers were available that an economically satisfactory transformer could be built. The efficiency of the rectifier also has considerable bearing on the design of the filter circuit, for the ease of filtering a given amount of power is dependent directly upon the voltage rectifying efficiency of the rectifier.

A third quality which must be considered in the design of a high-current rectifier is the voltage regulation which it contributes to the entire circuit. By this we mean the change in output voltage for either a change in load or a change in line voltage. What would be most desirable, of course, is a constant voltage output for all loads and for any line voltage. This is not entirely possible, on account of losses in the filter circuit which cannot be completely offset, but it is possible to achieve a great improvement in regulation over that of many existing power units. This improvement is to be found in the design of the rectifier, as will be shown from the following discussion.

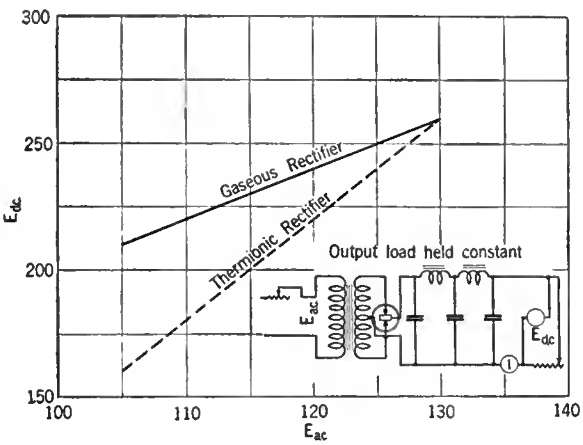


FIG. 1

Let us first consider the thermionic rectifier. The performance of a device of this type is so well known that only those features will be considered that are important when using a rectifier to obtain the high currents necessary to supply a 201–A filament. In the first place, a thermionic rectifier has a point of temperature saturation. Temperature saturation is that state which occurs when the plate draws the entire electron emission from the filament and under such conditions a further increase in applied plate voltage produces no increase in plate current. The effect of this characteristic is to limit the amount of current that can be taken from a power unit, and it is essential that in ordinary operation no attempt be made to exceed this limit.

Line voltage variations assume relatively major importance with respect to the regulation of a power supply unit using a thermionic rectifier, by virtue of this temperature saturation effect. For example, if the rectifier were to be entirely independent of line voltage for its filament supply, a 10 per cent. decrease in line voltage would produce a certain decrease in d. c. output voltage, but if the rectifier filament were entirely dependent on the line voltage, it too would drop 10 per cent. and there would be an additional falling off in d. c. output. The total loss in output would then be the sum of those two separate effects. The curve in Fig. 1, marked "Thermionic Rectifier," shows how the output voltage of such a unit varies with different input voltages across the primary of the power transformer.

A gaseous rectifier contains no filament and therefore this double effect upon lowering the input voltage is not noticed. As a result, the regulation for the gaseous rectifier is much better than for the thermionic rectifier.

There is yet another effect inherent in a thermionic rectifier which also affects the regulation of a power unit in which it may be incorporated, *i. e.*, the voltage lost in a rectifier increases with increases in load, as shown by curve A, in Fig. 2. The voltage loss constantly increases with increasing current, and at the same time the losses in the filter circuit increase in the same manner, and the overall effect of the tube and the filter is shown by curve A in Fig. 3.

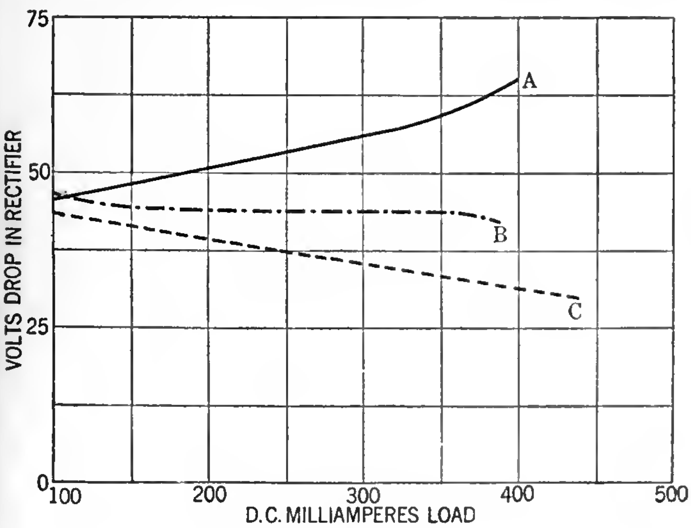


FIG. 2

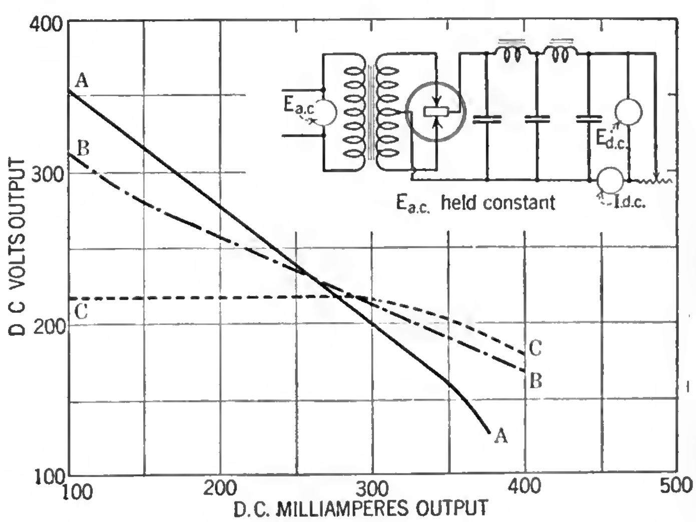


FIG. 3

It is possible to design a gaseous rectifier which will have a nearly constant voltage drop throughout the entire range of its load. Such a device will have a characteristic as shown in "B," Fig. 2. This rectifier would neither add to nor subtract from the overall regulation of a power unit, and the curve of this type of unit is shown at "B," Fig. 3. It can be seen that the improvement gained is considerable. However, a still greater benefit is available from the rectifier design. It is possible to construct a device of this type which will have a negative regulation characteristic such as that shown by "C," Fig. 2, in which the voltage loss in the tube decreases with increases in load. The advantages of a device of this type are at once apparent. If the negative slope of this line can be made equal in magnitude, and opposite in sign to the positive slope of the filter circuit, the overall regulation of the power unit will be nearly a horizontal straight line such as "C," Fig. 3. The curves in Figs. 3 and 4 were taken using various rectifiers constructed by the author.

The question might be asked most logically: Why is regulation so desirable in a series filament receiver? The answer is tied up in several fine points, no one of which seems important by itself, but their accumulated effect is great. In the first place, consider the result of removing a tube from its socket in a series filament receiver. The current load on the power unit drops from—say, 350 milliamperes to less than 20 milliamperes. In a unit such as that represented by "A," Fig. 3, there is immediately an enormous increase in the output voltage. This high voltage is extremely hazardous to the filter condensers and may puncture any of them. Therefore, in order to build a reliable power unit of this type a very costly condenser must be employed. If our power unit has the characteristics shown by "C," Fig. 4, it is readily seen that the no-load voltage on the condensers is not excessive. There is also much less danger to associated apparatus. The cost of construction is therefore lowered.

Further considerations for good regulation lie in the design of the filter circuit. If the rectifier has a characteristic such as that shown by "C," Fig. 2, it is possible to match this curve by the positive slope of the filter circuit regulation. There is the possibility of building a fairly small filter choke whose resistance would ordinarily be too great but which would give satisfactory regulation in connection with the improved type of rectifier. The fact that the rectifier has less voltage loss at high current than at low current contributes a considerable gain to the ease of filtering at high loads. All of these factors greatly assist in reducing the ultimate cost of filtering.

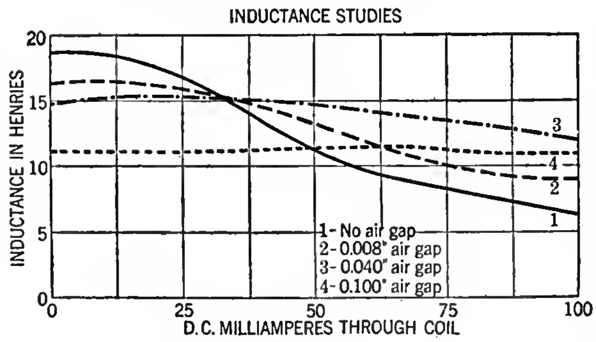


FIG. 4

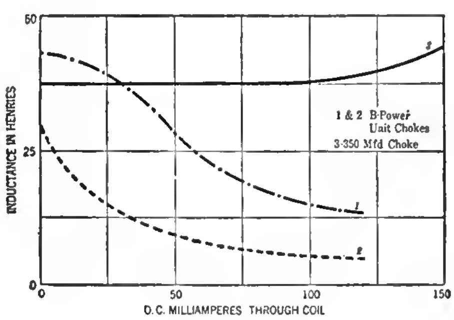


FIG. 5

A FILTER FOR 350 MA.

THE design of a filter circuit for 350 mA. presented a large number of problems at the outset. The main question was how to obtain satisfactory and reasonably proportioned filtering in a circuit. The first attempts along this line resulted in filter circuits weighing nearly 50 pounds, and while a device of this size might be acceptable to some set builders, it certainly would not meet universal approval. A study was therefore made to determine the smallest weight of filter circuit which would give satisfactory quality.

The first problem of design was that of the filter chokes. Very little data were available on the performances of inductances under high d. c. loads. It was known in a general way that the inductance of a given choke coil decreased as the d. c. through it was increased. The starting point of the design was therefore to determine the actual relations which obtain in high-current choke coils. Several different models were made up having different sized cores, a different number of turns, and adjustable air gaps. Fig. 4 shows the performance of various models constructed by the writer in the development of a high-current choke coil. The measurements of inductance were taken at the Massachusetts Institute of Technology. By the variation of different factors, a set of curves was finally evolved whereby a design for a given value of inductance at a given d. c. load could be determined. The curves of Fig. 5 show why it is not possible to employ ordinary filter circuits for 350 mA d. c. load. As the direct current through the windings of a choke coil is increased, the core becomes more saturated, until the effective permeability becomes very low. At extreme values of current saturation, the permeability approaches that of air. This portion of the saturation curve is shown by the dropping off of the inductance curves. Curves 1 and 2 show how ordinary B power-supply chokes lose their inductance with increasing d. c. load.

The second reason why ordinary filter circuits cannot be used at high 350 mA. load is that there is not sufficient condenser capacity in which to store up energy. The rate at which energy is being taken from the filter circuit is proportional to the current output. It is therefore apparent that more capacity will be required for high-current filter circuits than for low-current ones. The result of using insufficient capacity is an increase in the hum.

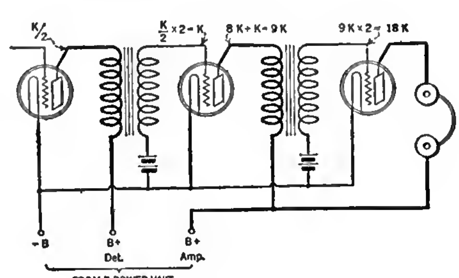


FIG. 6

The magnitude of this hum depends very largely upon the amplification characteristics of the radio receiver. Poor quality sets which give very little amplification at low frequencies can be operated from a power unit which has a large ripple in the output, without giving objectionable hum. As the amplification of low frequencies is increased, however, it is necessary that the ripple in the power unit be reduced to not more than 0.1 per cent.

One very bad effect which will be produced by the lack of sufficient capacity in the filter circuit is the tendency to audio regeneration in the receiver. From the standpoint of the power supply unit, this may come from two separate causes. The first cause is that the terminal capacity on the filter circuit is too small. If this is the case, it is possible that the effective impedance of the filter in the plate circuit of the amplifier tubes will be very large. It is, of course, well known that the impedance of a condenser, such as the last one in the filter circuit, increases as the frequency decreases. At ordinary audio frequencies this impedance may be a very few ohms, and in this case its effect on reproduction is negligible. If the amplifier is slightly unstable, it is possible that an incipient oscillation of from 2 to 10 cycles per second might arise in one stage, and being coupled to the other stages through the filter condenser, it might cause trouble. At this low frequency, the effective impedance of the filter condenser would be very large, and would offer sufficient coupling between the amplifier stages to induce sustained oscillation. This effect is commonly known as "motor-boating," and its remedy is frequently found in an increase in the terminal capacity of the filter circuit.

A second cause for this type of regeneration is found in the presence of a large a. c. ripple in the output of the power unit. If this variation exceeds 0.1 per cent. it can readily be shown from Fig. 6 that the amplification of the hum from the detector plate to the power amplifier stage would result in an enormous a. c. grid voltage.

Assume the plate voltage on the amplifier tubes is 100 volts and that the plate voltage on the detector is 50 volts. Also assume that the ripple in the power unit has a frequency of 120 cycles and that the transformer amplification at this frequency is 2. The amplification in the tube would be 8. If K equals the percentage ripple in the B supply source then:

$$\text{A. C. voltage} = K \times \text{D. C. volts}$$

$$\text{Detector} = \frac{K}{100} \times 50 = \frac{K}{2} \text{ volts}$$

$$\text{Amplifiers} = \frac{K}{100} \times 100 = K \text{ volts}$$

If we then calculate the a. c. voltage on the grid of the power tube at various percentages of ripple in the power supply unit we obtain the following values:—

K%	A. C. hum voltage on power amplifier grid
.05	0.9
.10	1.8
.20	3.6
.30	5.4
.40	7.2
.50	9.0
.60	10.8
.70	12.6
.80	14.4
.90	16.2
1.00	18.0
2.00	36.0

If the a. c. hum voltage is greater than the normal C bias on the power amplifier grid at any part of the cycle, there would result a great increase in the plate current of this tube. This increase would occur periodically, and frequently would attain such a magnitude that the output condenser of the filter would be almost completely discharged. It would result in a failure of voltage at the terminals of the power-supply unit, until the filter circuit could fill up again with energy.

The remedy for this situation is to improve the quality of filtering or to increase the negative bias on the power amplifier tube. The latter remedy sacrifices some amplification, and for best results it is therefore recommended to add capacity to the filter circuit until the difficulty is stopped. The subject of "motor-boating" is given such consideration here because it gives much more trouble in series filament receivers than is customary. The reason for this is that the failure of voltage at the power supply output caused by "motor-boating" results not only in decreased plate potential, but also in a dropping of the filament temperature. The addition of these two separate effects frequently stops the operation of the receiver entirely, because they are both accumulative in the same direction. One general method of overcoming the difficulty just mentioned is to isolate troublesome stages from the common power-supply source. This can be very well done by the use of choke coils and bypass condensers, which are placed in the plate circuit as shown in Fig. 7. These units effectively restrain the alternating currents to their proper paths and prevent mutual coupling in the impedance of the power supply unit.

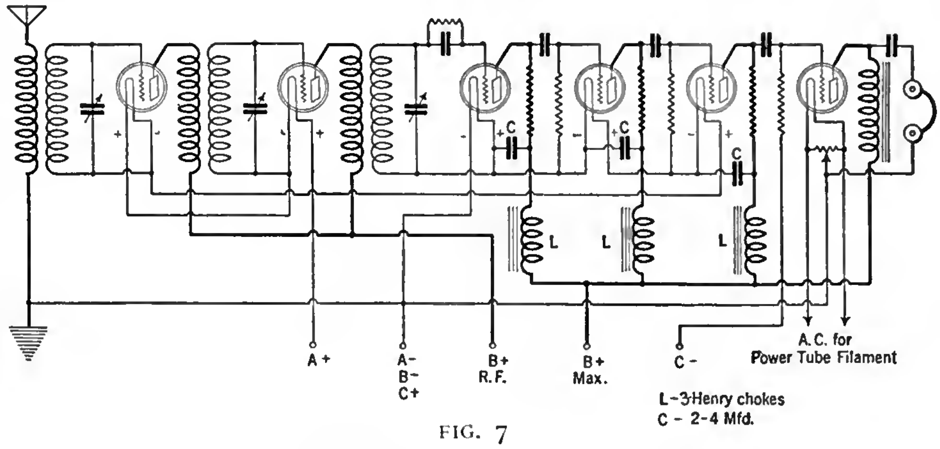


FIG. 7

When we actually connect up a radio receiver with 201-A tubes in series there are not more than two or three principles which must be remembered. The first of these is the manner in which grid bias is to be obtained, and the second is the order in which the tubes shall be arranged in sequence. As a matter of secondary importance there is a possibility that it will be necessary to place shunt resistances around certain of the filaments in series, in order to limit the current through them to safe amounts.

A method of obtaining grid bias is to place in the filaments, series resistances of the proper value, whose voltage drop will give the required grid bias. The value of resistance depends upon the amount of bias required, and is equal to the required voltage multiplied by 4. For example—if 4.5 volts grid bias is desired, this is obtained by a resistance of 4.5 x 4, or 18 ohms. This is placed in the circuit as shown in Fig. 8. and the grid return connection is made to point A. These biasing resistors carry the entire filament current, or 0.25 ampere. One convenient form in which they are obtainable is the customary 20-ohm rheostat, which can be inserted in the filament line as shown, and then adjusted to any required value. It is advisable to incorporate bypass condensers in this circuit.

The order in which the tubes are arranged has been discussed to some extent in the first article of this series. The main point to be remembered, of course, is the location of the detector filament nearest the B-minus or ground point. After that may come in order the first a. f. and second a. f. followed by the radio-frequency stages. Aside from the actual effect of a. c. fields on the performance of the receiver, another point to be remembered is the amount of effective plate voltage required in the various stages. It is apparent at once that those radio tubes which are nearest the A-plus terminal have a lower effective plate voltage than those at the negative end of the series. Very frequently increased amplification can be obtained by choosing the location of certain stages, so that they will receive the optimum value of plate potential.

As a matter of general procedure, it is not ordinarily necessary to provide filament shunt resistances for 201-A tubes in series. The writer has used as many as six of these tubes in series without bypass shunts, as a protection from plate-current overload. It was necessary, of course, to limit the plate current in the amplifier stages to moderate values by the use of proper C-bias voltages. If more than six 201-A tubes are connected in series, or if the total plate current consumed by a receiver of this type is more than, say 35 mA., it will be advisable to use the method described in the preceding article for protecting the last two tubes in the series, which consists of shunting the filaments with resistances of such a value that the current through the filaments is reduced to normal.

The proper value of protective resistance is found by dividing the normal filament voltage by the total plate current of the preceding tubes. For example, if the total plate current at the 6th tube in a series of 8 is found to be 40 mA., it is apparent that the total current in the 7th filament will equal 250 plus 40, or 290 mA. This represents an overload of 40 mA., which must then be bypassed through a resistor across the 7th filament. The value of this resistor will be equal to 5 divided by 0.04, or 125 ohms.

In the next article of this series the constructor will be shown how to build up an A, B, C power unit incorporating the principles previously discussed. It will also include a description of the new Raytheon BA 350-milliampere rectifier, which is a full-wave gaseous rectifier operating without a filament.

The characteristics of this rectifier have made possible the development and construction of an efficient and highly satisfactory power unit for 201-A tubes in series. This unit supplies complete radio power for any type of modern receiver, and several popular circuits will be discussed at some length.

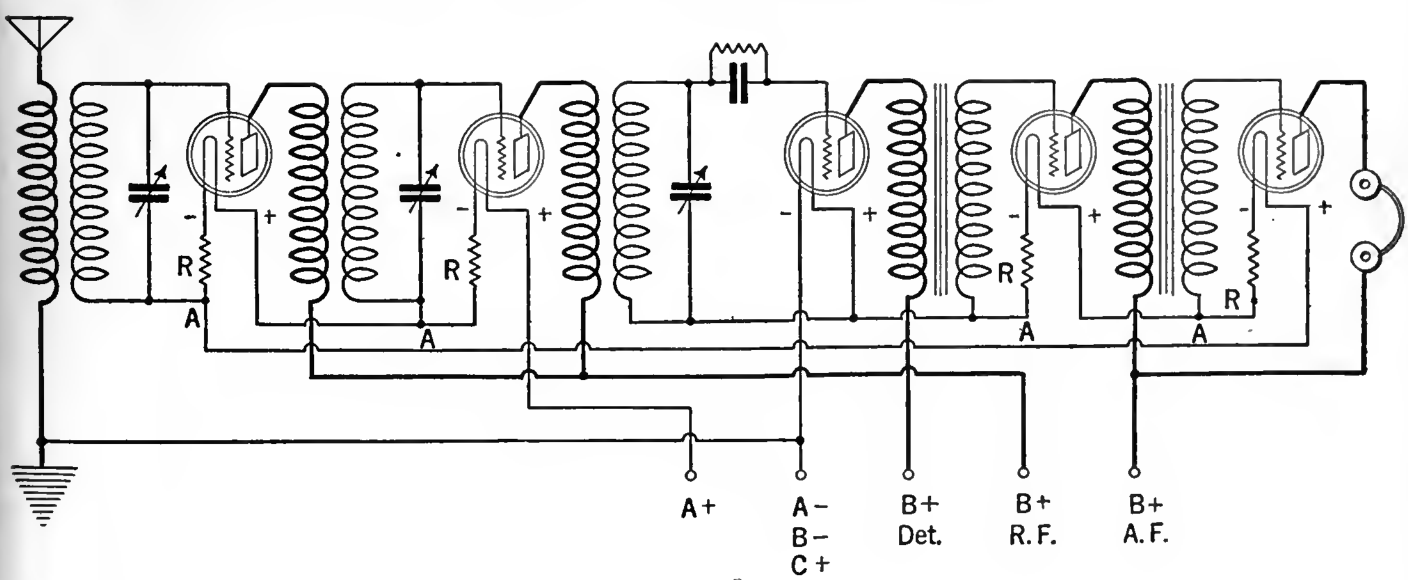


FIG. 8

How to Design a Loop Antenna

Details for Using the Accompanying Chart Which Makes Difficult Mathematical Calculations Unnecessary—Properties Governing Loop Efficiency

By HOMER S. DAVIS

THE loop antenna has been in use for many years and of course needs no introduction. For the broadcast listener it has a number of very desirable characteristics. Being compact and self-contained, it permits the placing of the receiver in any desirable part of the home, whereas the usual antenna and ground connections often make this location fall in a most unseemly place. The inherent selectivity of the loop is contributed to by its directional properties; that is, it receives best from directions parallel to its plane, and very poorly, or not at all, from directions at right angles to it. An interfering station, such as a powerful local, or one on a neighboring wavelength to the desired station, may often be thus eliminated by turning the loop at right angles to it. The loop is also generally regarded to be less susceptible to static and other atmospherics.

The outstanding disadvantage of the loop is that its effectiveness as an antenna is, comparatively speaking, small, usually only a very low percentage of that of the average outdoor type. Its use thus requires a very sensitive multi-tube receiver, such as the super-heterodyne. But this objection seems about to be overcome with the development of high-gain tuned radio-frequency amplifiers, and of many battery eliminators which are making the multi-tube receiver economical. Thus the popularity of the loop antenna is steadily growing.

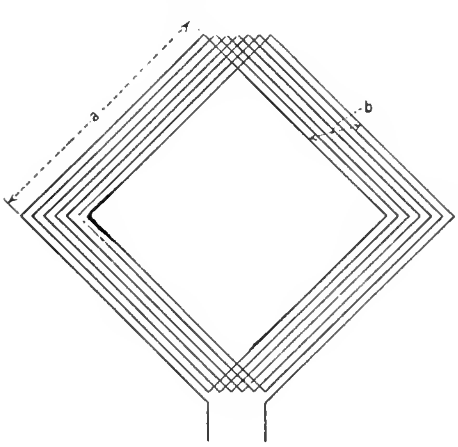


FIG. 1

The design of a good loop is largely a matter of compromise between a number of variable and often conflicting factors. It has been found that, with all other conditions remaining the same, the received current in a loop is greater. (1) the larger the number of turns of wire used, (2) the larger the area enclosed by the loop, and (3) the greater its inductance. The required inductance of the loop is determined by the capacity of its tuning condenser; the area or physical size is limited by available space, or good appearance in the home. The necessary number of turns of wire to obtain the required inductance depends upon the spacing of the turns.

As in the design of the inductance coils within the receiver, the distributed capacity of the loop should be kept as low as possible. This capacity increases with the number of turns, and is at a maximum when the turns are close together, but decreases rapidly as the wires are separated. Spacing the turns not only reduces the distributed capacity but enables a larger number of them to be used for a given inductance, thus adding to the received current. Distributed capacity of a loop is also increased by two factors seldom of importance with small inductance coils. One of these applies to the lead wires to the set, which should be kept short and separated. The other factor is that a loop is an arrangement of wires above the ground, and therefore forms a condenser with the ground, and also with various parts of the receiver. This tends to limit the highest frequency (lowest wavelength) to which the loop will respond, and there is little that the builder can do about it.

Two forms of loops are in common use, the "box," or single-layer square type, Fig. 1, and the "spiral," or flat square type, Fig. 2. The spiral loop is the simplest and cheapest to construct, but is less desirable since the inner turns rapidly become less useful as the area diminishes.

The first step in designing a loop antenna is to decide upon its physical proportions, keeping in mind the factors mentioned in the discussion above. A good idea of present practice may be had in a visit to the retail shops. Having chosen the most desirable size of the loop, and the size of the variable condenser for tuning, the next question is the necessary number of turns of wire to wind upon it. On page 264 of Bureau of Standards *Circular No. 74* is given the formula:

$$L = 0.008\, an^2 \left[2.303 \log_{10}\frac{a}{b} + 0.726 + 0.2231\frac{b}{a}\right] - 0.008\, an\,[A + B]$$

Even for one having the mathematical ability to use this formula, it is not possible to solve directly for the number of turns. But for use in designing loops for broadcast receivers, a simplified approximate formula has been developed, and the accompanying alignment chart constructed from it.

USING THE CHART

THE drawing of two straight lines with a pencil and ruler is all that is required to use this chart. It consists of four numbered scales. Scale "a" represents the effective side of the square; in the case of the box loop, this is the actual length of a side, as indicated in Fig. 1; for the spiral type, the average length should be used, as in Fig. 2, since the inner turns are shorter. The effective breadth of the winding, scale "b," is a little greater than the actual breadth indicated as "b" in Figs. 1 and 2, overlapping each side by half the space between wires. Scale "c" represents the capacity of the tuning condenser, while scale "n" is the number of turns of wire.

The procedure is best illustrated by working out one or two examples. Suppose a box loop is to be built with 18″ sides, for use with a 500-mmfd. (0.0005-mfd.) tuning condenser, and a 6″ effective breadth of winding is decided upon. The key at the bottom of the chart indicates which scales are to be connected together. Draw a line, therefore, from 500 on the "c" scale to 18 on the "a" scale. Then, through the intersection of the first line with the Index Line, draw a second line from 6 on the "b" scale across to the "n" scale, and you will read 16 as the number of turns of wire required. To take another typical example, it may be necessary to know the size of tuning condenser to use with a certain spiral loop of 18 turns, with 20″ sides at the rim and an effective breadth of 4″. The average length of a side is then 16″. According to the key, connect 18 on the "n" scale with 4 on the "b" scale, then draw another line from 16 on the "a" scale through the intersection until it crosses the "c" scale, reading 350 mmfd. (0.00035 mfd.) as the required capacity of the tuning condenser.

Care should be taken always to connect the proper scales as shown by the key. The chart is an approximation of the complicated formula reproduced elsewhere on this page and its accuracy is 5 per cent. or better, when used with a loop whose side is not more than about five times greater than its breadth.

In choosing the size of tuning condenser to use with a loop, it should be borne in mind that the distributed capacity of the latter will usually be found to be comparatively large, and a large condenser is desirable since it has a greater ratio of maximum to minimum capacity. With the smaller sizes, difficulty is likely to be experienced in reaching the higher frequencies (lower wavelengths). A capacity of 500 mmfd. (0.0005 mfd.) is usually regarded as most satisfactory, and has been adopted as standard by most loop manufacturers.

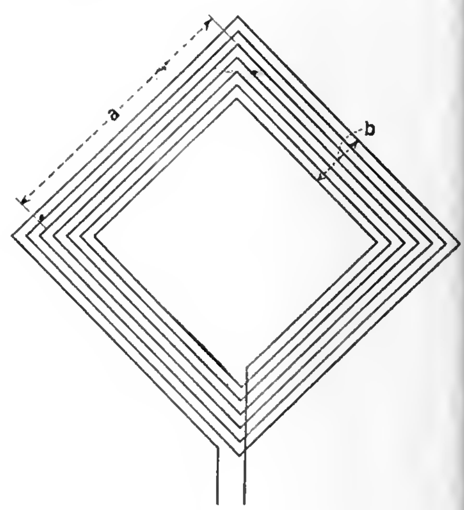
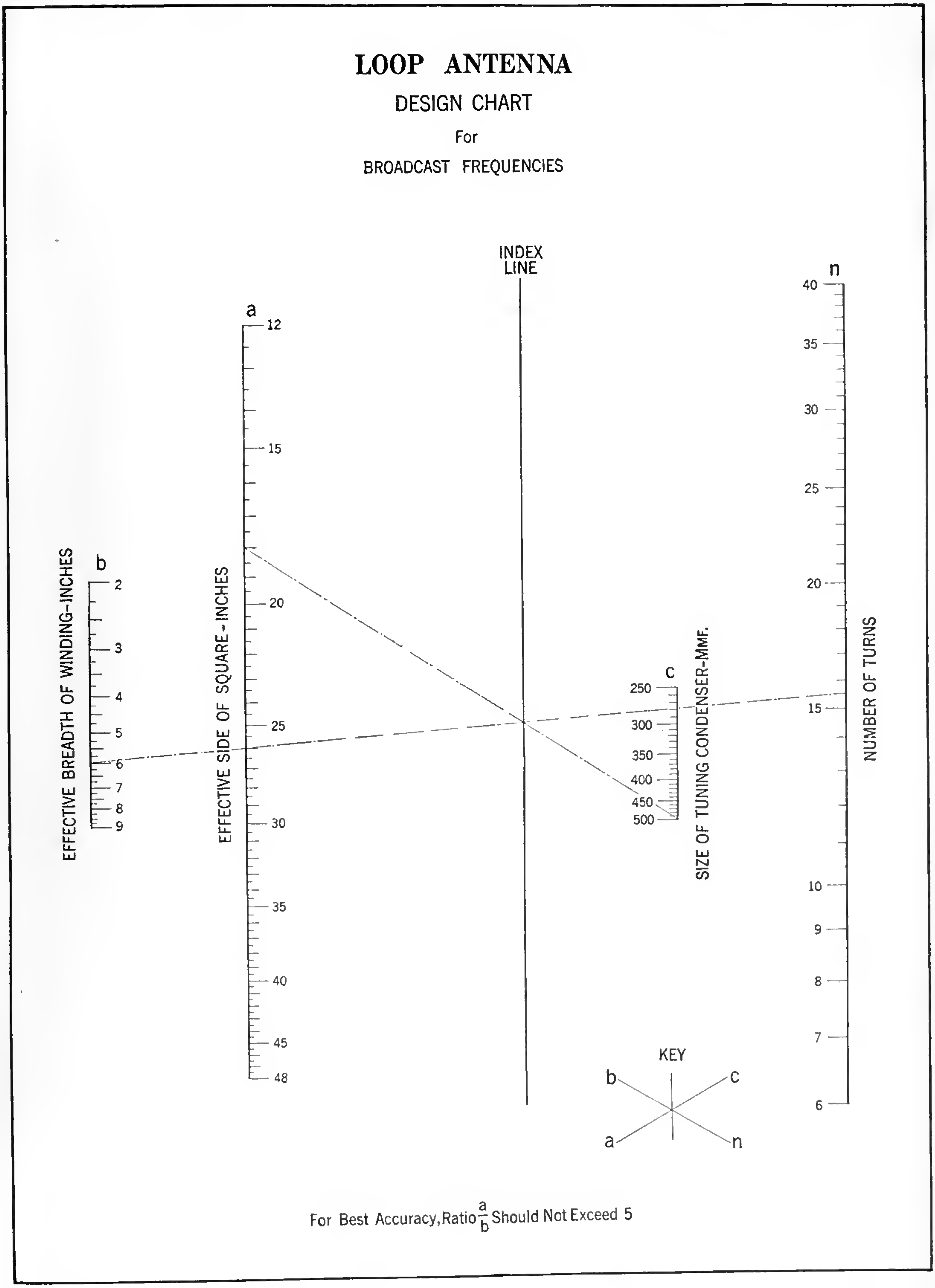
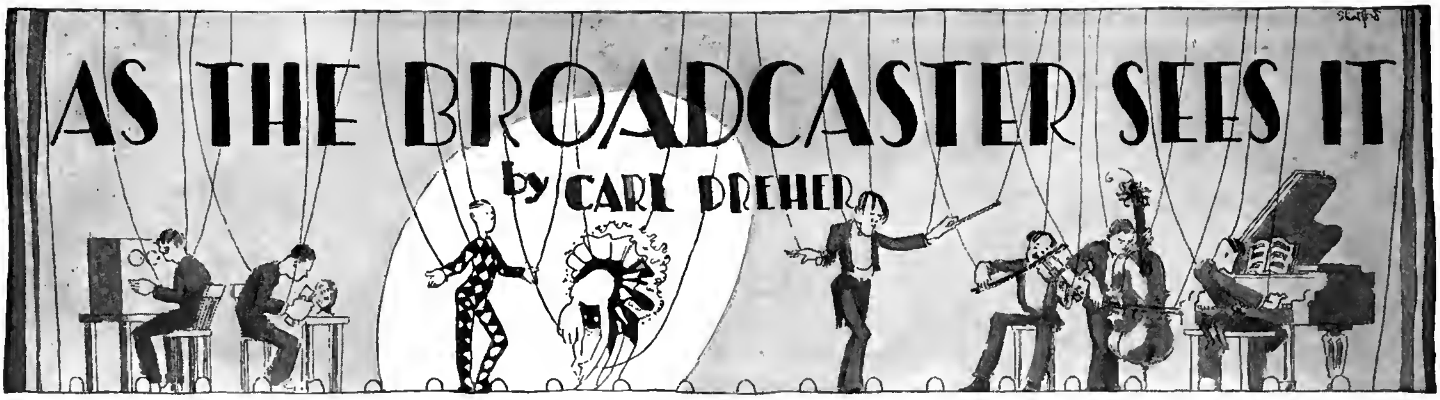


FIG. 2

Rectangular loops of artistic design have recently appeared, but the formula for this type is nearly impossible to chart. If the reader desires to build a rectangular loop, the chart for square loops may be utilized as a guide, first using it for the shorter side, then for the longer. The number of turns actually required will lie somewhere between these limits.



LOOP ANTENNA
DESIGN CHART
For
BROADCAST FREQUENCIES
INDEX LINE
EFFECTIVE BREADTH OF WINDING-INCHES
b
2
3
4
5
6
7
8
9
EFFECTIVE SIDE OF SQUARE-INCHES
a
12
15
20
25
30
35
40
45
48
SIZE OF TUNING CONDENSER-MMF.
c
250
300
350
400
450
500
NUMBER OF TURNS
n
40
35
30
25
20
15
10
9
8
7
6
KEY
b
c
a
n
For Best Accuracy, Ratio a/b Should Not Exceed 5



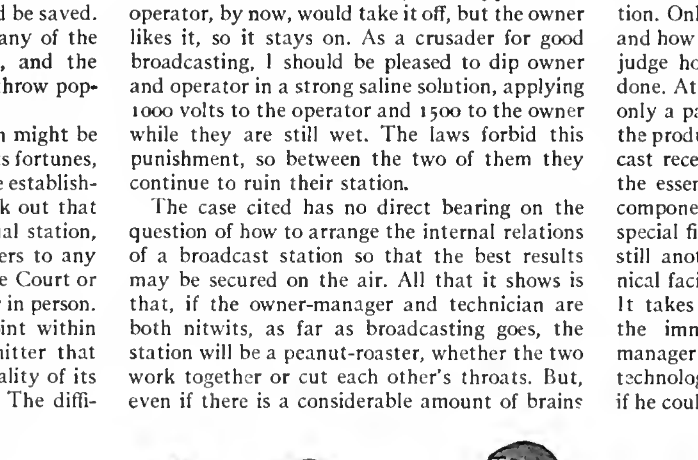
Drawings by Franklyn F. Stratford

The Difficult Business of Running a Broadcasting Station

EVERYBODY wants to run a radio broadcasting station. The general public, not having access to one, must do without this luxury, but among the fortunate beings who happen to be employed in the broadcasting business, from the owners of stations down to the functionaries who have dedicated their lives to folding and unfolding the camp-chairs in the studios—too many want to be broadcast admirals. There are considerable numbers of badly managed stations at which a tug-of-war, more or less violent, is constantly in progress, with the proprietors, program people, and technicians all trying to make final decisions and dominate the works. In general, this condition obtains at the smaller stations.

As a general rule, no one of the above groups is competent to run a broadcast station unaided. If they were, considerable money could be saved. The effects of undue domination by any of the functionaries will now be set down, and the audience is politely requested not to throw pop-bottles.

The owner of a broadcasting station might be thought a safe person to entrust with its fortunes, because of his monetary interest in the establishment, but it does not necessarily work out that way. I could offer in evidence an actual station, and will, in fact, whisper its call letters to any member of the United States Supreme Court or of Mr. Ziegfeld's chorus who will apply in person. My duties led me, recently, to a point within such a short distance of this transmitter that I was able to judge the technical quality of its emissions accurately. It was terrible. The difficulty seemed to be a harrowing loss of the high frequencies, the cut-off, apparently, being lower than that of a commercial telephone circuit. Speech was barely intelligible, and a jazz orchestra sounded like an organ. I thought the set had been built by the local tinsmith, but my informants told me that it was a 1 kw. product of a nationally known manufacturer, practically new, and secured at a cost of something like $20,000. After a while I got the story. The proprietor of the outfit, it appears, had objected to the microphone hiss—the "blow," as they call it in that neighborhood. The operator thereupon instituted experiments to eliminate this disturbance. His labors culminated in the connection of a 0.5-mfd. condenser *across the line between the output of the 5-watt amplifier and the input of the 50-watt stage,* these being 500-ohm circuits. The microphone hiss disappeared as by magic, and so did all other frequencies above 1800 or so. (The reactance of a 0.5-mfd. condenser is about 340 ohms at 1000 cycles; 170 at 2000; 85 at 4000, etc.) The operator had some vague idea of what he was doing, but, as he had got rid of the hiss, he let the owner listen to the results. The owner was pleased. He declared that the music sounded "mellow." So it does; if "mellow" means absence of high frequencies, then this is the mellowest station in the world.



THEY ALL WANT TO BE BROADCAST ADMIRALS

Possibly the proprietor has an ear unusually rich in subjective harmonics, or his receiving set may be so high-pitched that the combination of drummy broadcasting station and tinny receiver is fairly flat. At any rate, the station continues to run with the 0.5-mfd. bypass. The operator, by now, would take it off, but the owner likes it, so it stays on. As a crusader for good broadcasting, I should be pleased to dip owner and operator in a strong saline solution, applying 1000 volts to the operator and 1500 to the owner while they are still wet. The laws forbid this punishment, so between the two of them they continue to ruin their station.

The case cited has no direct bearing on the question of how to arrange the internal relations of a broadcast station so that the best results may be secured on the air. All that it shows is that, if the owner-manager and technician are both nitwits, as far as broadcasting goes, the station will be a peanut-roaster, whether the two work together or cut each other's throats. But, even if there is a considerable amount of brains in one or the other division, maximum efficiency cannot be attained unless there is a sound division of labor and power between the groups concerned.

In broadcast stations, as in other technical fields, there is frequently more or less of a gap between the technical and non-technical forces. This condition is only partly remediable. The fact is that most technical enterprises are run—and probably it is for the best—by laymen. The specialists and managers start with a totally different training and background. At some stations, they hardly seem to realize that the aim they have in common is to make the business run. It is admittedly difficult for the layman to be patient with the technician in certain situations. Technical development, for example, is tedious, costly, and apt to interfere with operation. Only the man who knows all the obstacles and how they must be overcome, one by one, can judge how well or how badly the job is being done. At a given stage in the evolution of an art only a partial solution may be possible. In 1921, the production of an acoustically excellent broadcast receiver was impossible, because several of the essential elements were still lacking. These components had to be worked out, in several special fields, before they could be combined by still another group of workers. Not only technical facilities were lacking, but also knowledge. It takes time to secure both the material and the immaterial elements. The non-technical manager often travels with the idea that all technology is built up on exact ideas, and that if he could only find the man who had the knowledge required, all would be well. Sometimes this is true, but as a matter of fact every branch of industry is constantly pushing out against a circumference of dubious knowledge, or downright ignorance; this is particularly true of radio communication and the arts of visual and acoustic reproduction. Again, while the modern engineer is forced to specialize, his work frequently carries him into fields where a broader training would stand him in good stead. He may be working out a problem in auditorium acoustics one day and wrestling with hydraulic equations the next. Some motion is lost with each change, but there is no help for that as long as we want to retain our present economic and technological structure. All these things make co-operation between technical and lay workers somewhat difficult, and where they are forced into intimate relations, as in a broadcast station, the fur is apt to fly. The managerial or program group presses for results, often unintelligently; the mechanical forces feel oppressed and inarticulate in the face of people who have power over them and do not speak their language. The solution lies in intelligent executive direction. The successful executive gives the engineers a free hand in their operations, within the economic limits of the enterprise, and yet exerts a constant, gentle pressure for results. The greatest weakness of technical men is their penchant for getting lost in the mazes of technical endeavor; they lose sight of the goal which they are paid to work for. At such times they must be firmly grasped by the bridle and led back to the path. But they do not require a check-rein every day of the year, and, as far as broadcasting specifically is concerned, one never sees a station functioning in healthy fashion unless the technical group is given latitude and power in their end of the business. If the special knowledge of the mechanical experts is ignored, the station is always pretty sick.

The program people suffer from similar disabilities. Program managers, like telephone operators and elevator runners, rarely receive praise for their efforts. Everybody thinks he could put on a better show, given the same money to spend. It is sometimes embarrassing when the owner of the establishment thinks so. The owner of a broadcasting station, also, takes a much greater interest in it than he might in some other business. The proprietor of a great merchandising enterprise, for example, will sometimes spend most of his time on his broadcasting station, even though it is a small proposition compared to other divisions of his business. This disproportion arises from the fact that broadcasting is more interesting, and richer in publicity, than other branches of commerce. It is a relatively romantic field of endeavor, and hard-boiled business men have a streak of romance in them, whether they admit it or not. Thus the employees of a broadcasting station, even when the boss is a man of great means and wide interests, generally work very much under his eye. This has advantages and disadvantages. They are subject to all sorts of caprice and unpredictable reaction. The technicians can always find some sort of refuge in their mechanical jargon, but the program people are pitiably exposed. Yet there is some utility in the situation. The object of the station, after all, is to please the public, and the owner is apt to be a pretty good representative of public taste. He may have more money than the average, but his general psychology, prejudices, emotional interest, and fears, are usually basically the same as those of the bulk of the audience. Broadcast entertainment falls within the wide latitude of middle class life, and a successful business man is generally well within the borders of middle class culture. If he owns a broadcasting station, and the programs make his high blood pressure worse, he is probably right in canning the impresario responsible. When the programs suit the owner, they will probably suit the Smiths, Joneses, and Robinsons likewise, and that is the purpose for which the amperes chase each other up and down the antenna.

The fundamental difficulty with broadcasting is that it is complicated, very complicated. It is one of the most intricate sectors of the whole tangle of industrial life. Telephone and radio engineers, musicians, program arrangers, advertising experts, salesmen, publicity men, executives, are thrown together helter-skelter and expected to coöperate in a common endeavor. It is a wonder that they work together as well as they do, and that the results are as good as they are.

Man and Modulation

MODULATION, in broadcasting, is a variation of electric carrier amplitude in accordance with the vibrations of sound. The result is the "intelligence-bearing side band"—one of the most important scientific creations of the twentieth century. But in its broad sense, "modulation" was known long before the days of radio telephony. Before radio phrases got into the vocabulary of the man in the street, modulation was any variation or inflection in tone, as in speech or music. The Greeks knew as much about modulation of sounds, or rather, they could modulate sounds as skilfully, as modern men. But they did not know how to generate or modulate electric waves, the advantage of which is that they can reach out to enormously greater distances than the unaided organs of speech.

"HARD-BOILED BUSINESS MEN HAVE A STREAK OF ROMANCE IN THEM"

Yet, while the purposeful generation of electric oscillations is a very recent invention, periodicity and radiation are among the fundamental processes of the universe. The cosmos is full of waves, short and long. The shortest and fastest of terrestrial origin which we know of now—if no faster ones are discovered in the interval between the writing and printing of this discussion, are the gamma rays of radium, which vibrate no less than 150 quintillion (150×10^{18}) times a second. The wavelength, therefore, must be of the order of 2×10^{-8} meters, or, expressed in the Angstrom units preferred by learned scientists (an Angstrom unit is 10^{-10} meter)—about 200 Angstrom units. Relatively speaking—and we can't speak in any other way—this is quite short. It seems still shorter when compared to the length of the radiation from a 60-cycle circuit, which emits waves 5,000,000 meters, or 3100 miles in length. (Inasmuch as radiation varies as the fourth power of the frequency, a 60-cycle circuit emits only feeble waves, but it does radiate. V. Bush has calculated that an antenna which radiates 100 kw. at a radio communication frequency of 30,000 cycles per second, will radiate only 1.6 microwatts if excited to the same potential at 60 cycles.) The ratio between the long wave which we have selected for purposes of illustration (60 cycles—5×10^{6} meters) and the short gamma ray (150×10^{18} cycles—2×10^{-8} meters) is 2.5×10^{14}, a figure which only an astronomer could gaze at unmoved. And there are waves of all lengths between the shortest and the longest, many existing in nature and others producible by man and therefore also existing in nature.

Man lives not by bread alone, but by radiation as well. Where would he be without the light and heat of the sun? He cannot even live without his share of ultra-violet rays. And recently the great spiral nebulae have been discovered to be sources of extremely short and penetrating X-rays, which, it is speculated, may have something to do with the origin and maintenance of life on the earth. "The primary radiation of the universe," according to Prof. J. H. Jeans, "is not visible light, but short-wave radiation of a hardness which would have seemed incredible at the beginning of the present century."

But, as found in nature, these electric waves carry only their own vibratory energy. It was left for man to generate sustained waves which he could modify intelligently, so that they would bear through space the murmurs of his speech and music, so transient and yet so important to this strange creature endowed with consciousness. The energy of these waves is insignificant. Were it abstracted from the sum total of energy in the universe, or even on this little earth, its absence, as energy, would not be noticeable. It is important only because it is a carrier of human emotion, which, ultimately, in endlessly varying forms, is what man lives for. It would avail him little if the blind energy of the universe, streaming through all living creatures, kept him alive as if he were a plant or a simple, satisfied animal. He would be bored to death. The skill he has developed in the art of modulation is one of his ways of seeking refuge from that fate.

Technical Problem. No. 1

EACH issue hereafter will contain a practical broadcast problem, involving some calculation, on which professional broadcast technicians can test their skill. The question will be stated, and the same issue will contain a full solution, confirming the answer reached by those readers who handled the problem successfully, and showing the others how they should have gone about it. The problem for this month (See Fig. 1) is the following:

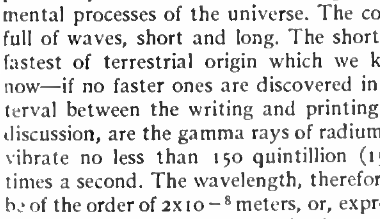


FIG. 1

A carbon transmitter M_1, whose output is 30 TU's down, is used in the studio of a broadcasting station, feeding the first stage of a series of amplifiers leading to the modulators. At a point 100 miles distant another transmitter of greater sensitivity, M_2, its output being only 20 TU's down, feeds a remote control amplifier which has a power amplification of 10,000 times. The line is largely open wire and has a loss of 12 TU's in all. What size of artificial line should be used at the control room termination of the 100-mile circuit to bring it level with the output of the studio microphone, assuming all impedances to be matched so that the line and studio microphone feed the first control room stage of amplification with equal efficiency?

(Solution on page 109)

Design and Operation of Broadcasting Stations

16. Studio Design

A LARGE part of the material in this discussion is taken from Bureau of Standards Circular No. 300, *Architectural Acoustics*, obtainable from the Superintendent of Documents, Government Printing Office, Washington, D. C., at five cents a copy. This pamphlet in turn leans heavily, as do all works on the subject, on the investigations of the late Wallace Clement Sabine, now being carried on by P. E. Sabine. These studies are concerned with the acoustics of auditoriums, but the results are adaptable to studios of broadcasting stations on the basis that the best reverberation time for electrical reproduction is about half that of an auditorium of the same volume where the performance is intended only for the audience physically present.

The principal acoustic characteristic of a room is its reverberation time, which, as originally defined and measured by Sabine, was the time required for a sound a million times audibility to die down to just audibility, both expressed in power units. In other words, you take a sound of a certain intensity, and let it die down 60 TU (in telephone terminology) in an enclosure, and the time you have to wait is the reverberation time of that enclosure. Actually, reverberation times are generally calculated, and their principal use is comparative and empirical. For example, you have a certain studio whose characteristics have been found to be satisfactory. Then, if you have occasion to design another studio, it is wise to calculate the reverberation time of the first room and duplicate it in the second, or to make such modifications as are indicated by past performance.

Sound may be reflected by the walls, floor, and ceiling of a room, or absorbed, depending on the materials of which the surfaces are composed, the frequency, etc. Generally, there is partial reflection and partial absorption. Open space is taken as the perfect absorbing material; thus, in a room, open windows are perfect absorbing areas. If a square foot of open window is taken as the unit of perfect absorption, various coefficients may be applied to square feet of wall materials to indicate their power of absorption. A few such absorption coefficients are given below:

Brick wall, 18 inches thick	0.032
Carpets and rugs	.20
Cork tile	.03
Linoleum	.03
Hair felt, 1 inch thick, unpainted	.55
Hair felt, 2 inches thick, unpainted	.70
Plaster on tile	.025
Marble	.01
Varnished wood	.03
Human beings	.90
Chenille curtains	.25
Curtains, in heavy folds	0.5 to 1.00

In many cases these coefficients vary with frequency; theory indicates, in fact, that a flat characteristic for a homogeneous absorbing material is impossible. The coefficients given are supposed to be correct for 512 cycles per second, which is a good mean musical frequency, as 800 cycles per second is a good mean speech frequency for commercial telephone calculations. As would be expected, hard materials like marble, plaster, etc., absorb sound very little, whereas curtains, felt, human beings, etc. have high absorbing power. This is borne out by practical observation; everyone has noticed the persistence of sound in empty rooms and auditoriums, especially where the walls are hard and unbroken, while when curtains, furniture, and persons are present, reverberation is reduced. As the volume of the enclosure increases, the reverberation time also increases. Given the volume of a room, and the areas and absorption coefficients of the materials used in its construction, the reverberation time may be approximately calculated by the empirical formula:

$$t = \frac{0.05\ V}{A} \qquad (1)$$

where t is the calculated reverberation time in seconds, V the volume of the room in cubic feet, and A the total absorption. We find A by taking the area of the various materials in the room and multiplying each by its coefficient of absorption, then adding the quantities so obtained. Obviously this assumes that the absorbing power of a surface depends only on its area and acoustic characteristics, and is independent of its position in the room. This is substantially true.

The application of the formula is most readily learned by the actual solution of a problem:

Given a room 20 by 15 by 10 feet, with plaster walls and ceiling, and a varnished hardwood floor, calculate the reverberation time, and apply acoustic treatment to reduce this period to an allowable value for broadcast purposes.

V equals 20 times 15 by 10, or 3000 cubic feet.

Let W represent the wall area, C the ceiling area, and F the floor area. Then we find in the above case that $W=700$ square feet, $C=300$ square feet, and $F=300$ square feet. A may now be calculated for the bare room:

Wall plus ceiling area (1000 sq. ft.) multiplied by the coefficient for plaster (0.025)	25
Floor (300 sq. ft.) multiplied by the coefficient for hardwood (0.03)	9
Total absorption (A)	34

Substituting in Formula (1) above, we have:

$$t = \frac{0.05\ (3000)}{34} = 4.4 \text{ seconds}$$

This is much too high for a small room. Sabine found that good musical taste required a reverberation time of slightly over one second, for piano music, in a room of moderate size. Musicians check each other with fair accuracy in such determinations. Even a large concert hall will have an optimum reverberation time of between two and three seconds only. (The allowable reverberation time increases approximately as the first power of the linear dimensions of the room, for the same absorbing materials, since V in the numerator of formula (1) is a cube function of the linear dimensions, while A, in the denominator, varies as the square of the linear dimensions.) Hence it is necessary to apply additional absorption to the room we are considering, in order to reduce the reverberation time to about 0.5 second. This is on the theory that the optimum period would be about 1.0 second, for a room of this size, considering results in the room only, and that this quantity should be halved for purposes of electrical reproduction at a distance.

Suppose, now, that the ceiling of our 20 by 15 by 10 room be covered with some acoustic board material, or hair felt under muslin, with a coefficient of, say, 0.5, and that the floor is carpeted, the walls remaining plaster. The total absorption, A, then becomes:

Ceiling area (300 sq. ft.) multiplied by 0.5	150.
Floor area (300 sq. ft.) multiplied by 0.2	60.
Wall area (700 sq. ft.) multiplied by 0.025	17.5
	227.5

Substituting in (1) above, we now have:

$$t = \frac{0.05\ (3000)}{227.5} = 0.66 \text{ seconds}$$

This is nearer a satisfactory value, and may give good results on the air. If, now, one of the 15 by 10 walls of the room, preferably that nearest the contemplated position of the microphone, be covered with curtains having an absorption coefficient of 0.5, the total absorption of the studio becomes 298.7, a value which the reader may readily verify by going through the simple computation himself. The reverberation time is then reduced to 0. 5 second. In order to provide margin against reflecting surfaces of the piano, tables, etc., and to allow variation of the period to secure different effects, it might be well to drape two of the walls of the room with curtain material suspended from rods and movable at will, and to have the rug only partly covering the floor. This will permit variation of the reverberation period between, say, 0.3 and 1.2 seconds, which gives sufficient latitude for experiments. Various other combinations are of course possible, and each designer may work out schemes to suit his own requirements or fancies.

In selecting patented sound proofing materials it is well to try to secure a curve showing variation of the absorption coefficient with frequency. The nearer this characteristic approaches to the ideal flatness between 100 and 5000 cycles, the more favorably it should be considered for general use. It is better to choose material with a moderate absorption coefficient which remains fairly constant over the audio range, than a highly selective surface which has high absorption at one or two pitches and reflects badly at other points.

Formula (1) above is not as accurate as a later equation worked out by P. E. Sabine, given by Crandall in his *Theory of Vibrating Systems and Sound* (D. Van Nostrand Co.):

$$t = \frac{0.0083\ V\ (9.1 - \log_{10} A)}{A} \qquad (2)$$

Formula (2) gives results for t slightly lower than (1), so that for electrical reproduction it is just as well to use the simpler expression (1), which gives additional margin against excessive reverberation.

Where lively surface materials are used in studio or auditorium design, a protection against echo and objectionable reverberation is to break up flat surfaces by recessing, coffering, etc., thus diffusing the reflected energy.

The circular of the Bureau of Standards referred to at the beginning of this article gives a table of allowable number of instruments in a room of given volume, for best artistic performance. This data should interest musical directors and broadcast technicians who habitually overcrowd their studios:

Volume of Room	Number of Instruments
50,000	10
100,000	20
200,000	30
500,000	60

While allowing 5000 cubic feet and over per instrument may be excessive, this table is probably nearer a sensible compromise than the comical broadcast practice of jamming thirty

Public Library Kansas City

instruments into a room of 6000 cubic feet, allowing about 200 cubic feet per instrument. The greater absorption of broadcast studios certainly does not justify such acoustic atrocities.

Shrapnel from Cleveland

FROM Mr. J. D. Disbrow and Mr. Ross J. Plaisted, of the Engineering Department of WTAM, come separate roars of protest, addressed to the Editor of this journal, regarding my remarks "Concerning B. C. Operators" in the January issue. Mr. Disbrow issues a warning: "Your yearly subscriptions will certainly drop if you continue to print such 'poison' as Mr. Dreher has in his columns this month." He adds: "This article may be correct for some of the operators but it certainly doesn't say very much for the fellows who have spent their life at radio and worked like slaves putting radio where it is to-day. . . . The men behind the scenes get little enough praise as it is, so why rub it in with an unjust article like this one." Mr. Plaisted adopts the *argumentum ad hominem*. "It is entirely possible," he writes, "that the class of operators of Mr. Dreher's station is that of which he speaks, but I must say that the majority of those I have met in the middle-west take their business seriously and spare no effort in learning everything they can about it."

The position of the gentlemen from Cleveland would be tenable, it seems to me, only if *all* broadcast operators read the literature and took their work seriously. Then the article in question would be uncalled for. But both critics admit that some technical broadcasters are more or less delinquent in these respects. What, then, makes it immoral for me to remonstrate with this minority, on occasion? There was nothing in "Concerning B. C. Operators" which could be taken as an assertion that all, or a majority of technical broadcasters, neglect the intellectual foundation of their profession. Therefore there was no offense. Those whom the shoe does not fit are certainly not forced to put it on. Those whom it does fit might be benefited by wearing it for a time.

As for my general attitude toward my fellow workers, I do not think that anyone who has read even a small portion of my material can accuse me of any desire to disparage the men of my profession. It is true that I am not a habitual dispenser of perfumed vaseline; that rôle I leave to those who have talent for it. I could point to numerous passages in praise of people who deserve recognition, and as for the technical men, I have consistently maintained that their work is the foundation of the art, supporting the whole superstructure of program service and commercial returns. I need not stress this point; let the articles speak for themselves. On the other hand, I do not feel, as apparently Messrs. Disbrow and Plaisted do, that radio men constitute a fraternal organization, existing for mutual praise and support through thick and thin. Radio is a business, with its good features and bad, personnel competent and incompetent, its failures, successes, and hopes. These things I discuss from month to month, as entertainingly as I am able, and instructively when my knowledge permits. I try to learn from what other radio men say and write, and I value criticism insofar as it is based on logical considerations and a desire to get at the facts. That sort of criticism we need badly in radio; we have none too much of it. When it comes to emotional bias we have an ample supply, and it does not help us in any of our problems, whether the question is a major one like the allocation of frequency bands, or a minor one like what should be printed in "As the Broadcaster Sees It." I invite Messrs. Disbrow and Plaisted to abandon what seems to me a singularly juvenile attitude. But on the basis I have suggested above, their opinions, as that of all other broadcasters and readers, are invariably welcome.

Memoirs of a Radio Engineer: *XVIII*

WE HAVE had to interrupt the publication of these yarns for several issues, but we shall now take up the narrative where we left off—with the entrance of the United States into the War, in April, 1917. The ink had scarcely dried on the official signatures to the Congressional resolution declaring war between the United States and Germany when the U. S. Navy, with a yell, clasped all domestic radio activities to its bosom and held them there for two years.

". . . . I MADE NUMEROUS CALCULATIONS"

Also with a yell, my classmates and I, who were receiving the benefits of instruction at the College of the City of New York, escaped from the academic groves, which, in fact, never saw us more. After some negotiation, the Dean of the College offered the five of us in Doctor Goldsmith's radio engineering course credit for the balance of the term, and our degrees, if we would engage in some radio enterprise helpful to the U. S. Navy. This was in May, 1917, and in June we would have graduated anyway—we were Upper Seniors, by now—but there was the opportunity to avoid the final examinations, and, anyway, we wanted to get out. Doctor Goldsmith took charge of the preliminary arrangements, saw us placed, gave us his benediction, and the class scattered. Freed went to the Washington Navy Yard, where, about then, were also gathered Lester Jones (likewise a C. C. N. Y. man), Hazeltine, and Priess, none as yet famous. Buchbinder occupied himself at the Philadelphia Navy Yard, where Forbes, Ballantine, and Commander Lowell were working. Kayser stayed nearest home; the Brooklyn yard was his berth. Marsten and I were allocated to the Aldene factory of the Marconi Wireless Telegraph Company of America, staggering under the weight of government contracts and groaning—so we thought—for our aid.

A comical incident of this period shows the atmosphere of suspicion, which assumed pathological intensity during the war, although in this particular case it was not unreasonable. The story begins in the radio laboratory of the College, before the United States entered the conflict. One of the requirements of the course was the writing of a thesis, which included the complete design of a radio station for a specific service. In my case I had the job of designing a transmitter, receiver, power plant, antenna system, and all auxiliaries for a vessel of the size and type of the SS. *Leviathan*, one of the requirements being that communication with land should be maintained throughout a transatlantic voyage. I made numerous calculations, most of them as mythical as the vessel, and got together a design after some months of work—it took this long because all the component parts had to be individually specified, the high tension transformer, for example, being detailed as to size of core, number of primary and secondary turns, gauge of wire, etc. I addressed a number of inquiries to manufacturers, including one to an antenna insulator factory in Brooklyn. I do not recollect whether they answered or not. I completed my thesis, and left for the Aldene front. A few months later I received the following letter:

NAVY DEPARTMENT
United States Naval Communication Service.
Office of District Communication Superintendent Third Naval District
Navy Yard, New York, N. Y.
July 26, 1917.

SIR:

1. This office has information that you desire to purchase Radio Antenna Insulators.

2. As all Radio Apparatus has been ordered dismantled by the Executive Order of the President, you are requested to forward to this office reasons why, and for what purpose, you desire insulators.

Respectfully,
J. C. LATHAM
Lieutenant (JG), U. S. Navy,
District Communication Superintendent

I replied with equivalent grandeur, and I presume gave the D. C. S. a laugh.

Solution of Technical Problem No. 1

The amplification of the remote control amplifier fed by the microphone M_2 is given as 10,000 times in power units. The gain in TU given by the formula:

$$TU = 10 \log_{10} \frac{P_1}{P_2}$$

is found to be 40. As M_2's output is given as minus 20 TU, the output of the amplifier is +20 TU, which, incidentally, is quite a whale of a level to put on a telephone line. This being done, however, and the attenuation along the line being given in the problem as 12 TU, the level reaching the control room is +8 TU. This is to be reduced to the output level of the microphone transmitter M_1, which is —30 TU. The artificial line required for this purpose will have to drop 8+30 TU, or 38 TU. A 38-TU pad is therefore required.

As an aid in the solution of this problem the reader may consult the following past publications in this department:

Technical Operation of Broadcasting Stations, No. 10. "Calculation of 'Gain.'" September, 1926. Abstract of Technical Article: *The Transmission Unit and Telephone Transmission Reference Systems*, by W. H. Martin, *Journal of the American Institute of Electrical Engineers*, Vol. XLIII, No. 6, June, 1924; October, 1926.

Book Reviews

A Scholarly Contribution to the Art of Sound Reproduction—A Comprehensive Radio Dictionary

Not for the Kindergarten

Theory of Vibrating Systems and Sound: *By Irving B. Crandall, Ph.D. Published by D. Van Nostrand Co., New York City. 272 pages. Price, $5.00.*

ALTHOUGH the reviewer considers this book an extremely valuable contribution to the art of sound reproduction, of which radio broadcasting is a part, it cannot be recommended as indispensable to every owner of a receiving set. Even the most sapient listeners, no matter how many sets they have built, and the most inveterate readers of the semi-technical press, no matter how many articles on flat amplifiers they have digested, will get into difficulties early in the volume. Let them but gaze at the list of symbols on Page 9, and they will recoil in fright from Lagrange's determinant of coefficients of motion, the kinematic viscosity, and Laplace's operator, the last denoted by a triangle standing on its apex, and squared. Doctor Crandall does not deceive them; he begins his preface with the statement: "This treatment of the theory of sound is intended for the student of physics who has given a certain amount of attention to analytical mechanics . . ." The material was first presented in one of the "out-of-hour" courses at the Bell Telephone Laboratories, where, since 1913, the author has specialized in the field of speech and various other phases of sound phenomena; a portion, also, was given as a course at the Massachusetts Institute of Technology during the spring of 1926. In other words, "The Theory of Vibrating Systems and Sound" is a serious work for the scholarly engineer and physicist, who has taken the trouble to arm himself with the requisite tools of analysis, and who realizes that the distinction between "theory" and "practice" is merely a convenient fiction for those who are unwilling or unable to think exactly in physical fundamentals. This book is theoretical and highly practical at the same time. It is not a handbook full of convenient tables which will enable one immediately to design a broadcast studio or a cone loud speaker, but there are problems at the ends of the chapters by which the student may test his progress in acoustic analysis, and one of the appendices consists of an invaluable summary of "Recent Developments in Applied Acoustics," containing references mainly to articles printed since 1922.

The book begins with a review of some of the fundamentals of mechanical theory applied to acoustics, such as the equations of motion of a simple vibrating system, free and forced oscillations, and the vibration of circular membranes in terms of Bessel's functions. Here the going becomes slightly heavy, and the reader who has not kept up with modern mathematical analysis will sink somewhat in his own esteem. He will find little relief in an analysis of air damping, in which the active portion of a condenser transmitter diaphragm is considered as an imaginary "equivalent piston," an assumption valid below the first natural frequency. This chapter is a good preparation for the experimental study of actual telephone diaphragms.

Systems of two degrees of freedom, in natural oscillation and the steady state, are described in considerable detail, references to the classical work of Rayleigh, Lamb, Heaviside, and others, being introduced, as throughout the book, to avoid tedious re-statement. Resonators are treated alone, and then coupled to a diaphragm. There follows the interesting problem of a loaded string—a stretched fibre weighted at equal intervals with equal masses, which is tied in with the highly important technical field of electrical networks.

The properties of the medium and the equations of wave motion carry the treatment into three dimensions, after a view of transmission in tubes and pipes, and resonance in such containers. Point and spherical sources, and the reaction of a viscous medium on a vibrating string, as in the Einthoven galvanometer, are some of the subjects.

In Chapter IV (Radiation and Transmission Problems) there is a brief non-mathematical interlude in the form of an outline of the underwater signalling experiments of Professors Pupin, Wills, and Morecroft, in 1918. It is not generally known that frequencies of the order of 50,000 cycles per second (which would correspond to a wavelength of 6000 meters in electromagnetic radiation) are employed in high-frequency submarine signalling. The analysis proceeds with other forms of radiation from a piston, into conical and exponential horns. Crandall cites Webster, Hanna, Slepian, and others in this section, but disagrees with one of the conclusions of Goldsmith and Minton relative to a comparison between exponential and conical horns. The analysis of the finite exponential horn is not sketchy; it covers eleven pages and a chart.

To a broadcaster, Chapter V, largely on "Architectural Acoustics," is naturally of greatest interest. The work of Wallace Clement Sabine is reviewed, with P. E. Sabine's additions. As it happened, while the reviewer was reading Crandall's book for this outline, he was treated to a swell luncheon by an experienced acoustic engineer. His practical ideas were sound, but when one of my colleagues inquired why some absorbing materials showed marked frequency selection, our host explained that it was because of the resonant action of the equal interstices between the fibres of the structure. I suspected at the time that this theory was not kosher, so to speak, but was too prudent to fight over the sweetbread patty. If you want the real explanation, take a day off and steep yourself in Section 51 and Appendix A of Crandall's book. There you will be led through the conception of the absorbing material as a honeycomb of narrow conduits in which sound waves are dissipated by frictional resistance, the impedance of the mouths of the conduits, the velocity of flow of air particles in the tubes, the resistance coefficients, the esoteric law of Poiseuille, kinetic viscosity, and calculations resulting in values for a certain absorbing wall of the absorption coefficient, showing how it varies with frequency. "If the absorption coefficient is plotted against frequency," writes Crandall, "a very good resonance curve is apparently obtained. This resemblance is evidently accidental, as no resonance phenomenon has been implied in the problem we are considering." Several other facile assumptions are unobtrusively knocked into cocked hats in Doctor Crandall's text. Space limitations preclude extended comment on the general treatment of reverberation in three dimensions and reaction of the enclosure on the source of sound.

The book is written throughout in elegant and forceful scientific English. The object—to train the properly prepared student in the handling of the mathematical and physical principles involved—is never lost sight of. The reasoning is pellucid from cover to cover. Doctor Crandall has made a worthy contribution to an understanding of the advanced classical literature in his field, and brought the treatment in various subdivisions up to date with distinguished competence.

Carl Dreher.

A Radio Dictionary

The Radio Encyclopedia: *By S. Gernsback. Published by Sidney Gernsback, New York City. 168 Pages. Price $2.00.*

THE "Radio Encyclopedia" is a comprehensive radio dictionary, clearly printed and, with the exception of the biographies, well illustrated. Messrs. Squier, Goldsmith, and Hogan we know to be much handsomer men than it would appear from their pictures in the encyclopedia, and probably there are others suffering similar injustices at the hands of the photographer, engraver, and printer.

The work will doubtless be useful to experimenters, particularly those who need occasional aid in the interpretation of technical terms used in newspaper and magazine articles on radio subjects. It is not sufficiently detailed for the broadcast or radio engineer and indeed, were it so, the work could hardly be simple enough for the broadcast enthusiast.

Such terms as "gain," "split announcing," "scrambling," "mixing panel," "vernier,"—the kind of thing a broadcast station employee might look up—are not defined, although the popular circuits, usual instruments used in the receiving set, electrical terms applying to broadcasting, etc., are fully and adequately defined. The cross reference notes with each definition are commendably complete and the work is obviously the product of meticulous labor. Since the book is primarily designed for enthusiasts, we regret the absence of definitions for a few words which occurred to us, such as "sound," "tone," "quality," "reproduction," "single-control," "blooper," "radiating receiver," "mike," and "condenser microphone."

A peculiarity of the indexing is that television is described under "television," but "telephotography" is listed neither under that term nor under "photographic transmission" nor "photographs, radio transmission of," but under "transmission of photographs by radio." Perhaps this is an outstanding exception to correct indexing and certainly one of minor importance. This the reviewer cannot judge because a reading of forty pages of material was considered sufficient to determine the general value of the work.

Terms, used in their correct and limited sense, will be found quite complete. The names of almost every conceivable receiving instrument and part, the more popular circuits, such as Cockaday, neutrodyne, Armstrong (Grimes and Roberts are not found under their names), and a scattering number of contemporary and historic biographies are included as the subject matter of Gernsback's dictionary.

Edgar H. Felix.

Analyzing the Power Amplifier

How Oscillograms Help to Indicate the Transient Voltages and Currents in the Circuits—A Radio Club of America Paper

By D. E. HARNETT

Engineering Dept., Pacent Electric Company

THE commercial need for high-quality reproduction has lately focused the attention, not only of engineers, but of the whole radio world, on the audio-frequency circuits of radio receivers. Selectivity and sensitivity for a number of years received much attention, but during that time, those engineers who realized how much better broadcast receiver reproduction could be, were trying to persuade the public to recognize good quality and to prefer it. Their efforts have finally met with success. The modern radio set has a much better amplifier than was the case a year and a half ago.

One of the lessons learned from the extensive experimenting on audio circuits is that it is necessary to have the loud speaker driven by a tube which can develop considerably more power than is required from the other tubes in the set. This means that the B-battery supply must furnish much more power to the output tube than was previously thought necessary. As a result, the B socket-power device, which operates from the a. c. house mains, has become very popular. The superiority of this type of socket-power device over the type which operates from some other source, such as a d. c. house-lighting circuit, is that it is possible to maintain the voltage by a suitable transformer at practically any desired value. The limiting factors are the safe operating voltage of the rectifier and the insulation in the device, particularly the insulation in the condensers. These factors are, of course, economic, for it is possible to build rectifying tubes for practically any voltages and to insulate properly for these voltages.

The device under discussion is the "Powerformer." It is a combination power amplifier and B socket-power device. The device was developed by a group of engineers under the direction of Mr. L. G. Pacent.

It is desirable to have all that wiring which connects with a high-voltage circuit (such as the plate circuit of the power amplifier tube) confined within a metal case, in order to eliminate danger of injury to the broadcast listener. The rectifier tube is capable of rectifying considerably more current than is required for the power tube. This excess current is supplied to a potentiometer from which the plate potentials for the different tubes in the receiver are drawn. These different plate potentials—of the order of 150 volts, or less—are brought out to binding posts, which connect to the plate circuit of the radio receiver. The audio circuit connects through the jacks. The schematic diagram is shown in Fig. 1.

The operation of the separate parts of this circuit has been studied by a good many engineers and reported before the Radio Club of America and before the Institute of Radio Engineers. When, however, these different units are combined into one circuit, certain complications arise. It has been found that the actual functioning of the different parts of this circuit is not generally understood.

The principal object of this device is to enable the broadcast listener to have good quality reproduction, with a fair amount of volume. In order to obtain this result, an amplifier tube must be employed which is capable of delivering about one watt without distortion. The audio transformers must be properly designed so that they will not distort the signal. This means that they must have a high primary inductance, a

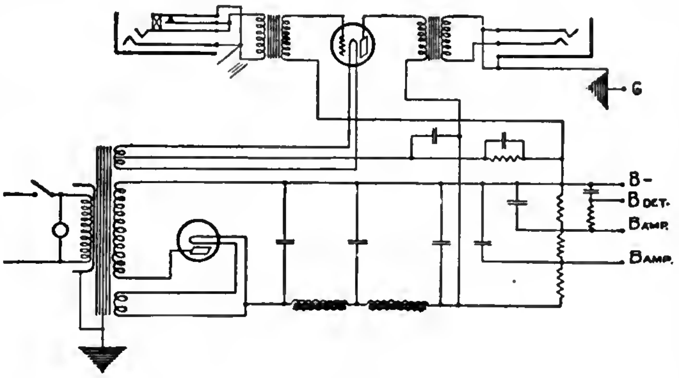


FIG. 1

high mutual impedance, and a ratio which is somewhat lower than was thought best three or four years ago. With the use of ordinary magnetic materials, this necessitates a large core and a winding employing from two to three times the copper used in the average transformer of the past.

Consider first the rectifier circuit—here a 60-cycle transformer is operated with the primary on a 110-volt lighting circuit. There are three other windings besides the primary. One of these operates the filament of the rectifier tube; the second, the filament of the amplifier tube; the third supplies the rectifier with high voltage, that is, it supplies the power for operating the plate circuits of the amplifier tube and those of the other tubes of the broadcast receiver. The current and voltages in the transformer are shown in Fig. 2. In Figs. 2 and 3, the arrow indicates the direction of travel in the film. In other words, the head of the arrow indicates an earlier time than the stem of the arrow. In the later photographs, the arrow indicates the direction of time; in other words, the meaning of the arrow is reversed. It will be noticed that the device is supplying the rectified current during approximately one third of the cycle; that is, instead of rectifying during all of the half cycle, which has the proper polarity for rectification, it is rectifying only during the portion of the cycle during which the transformer voltage exceeds the voltage across the first condenser in the filter circuit. Abrupt changes in the impedance of the transformer load introduce a large number of harmonics in the high-voltage winding which are reflected in the primary, giving the wave shape shown at the top of the photograph. Naturally, the direct-current component of this secondary current cannot be reflected through the transformer. This is shown by the fact that the area of the top half of the primary wave is equal to the area of the lower half. The power factor of this device is approximately 70 per cent.

$$\text{Power Factor} = \frac{\text{Power}}{EI}$$

The power is the product of primary voltage, the 60-cycle component of primary current, and the cosine of the angle between them. E is the primary voltage, and I is the r. m. s. value of primary current; that is, r. m. s. value of 60-cycle primary current and all of the harmonic currents. Thus there are two effects tending to decrease the power factor—the phase difference between the primary voltage and current, and the presence of the harmonics in the primary. The current in the other two secondary windings is a sine wave working into a resistive load, that is, into the tube filaments. Approximately two thirds of the power drawn from the transformer is supplied to the rectifying circuit; the remaining one third is used to light the tube filaments. Fig. 3 shows the effect of the rectifier winding on the primary current much more clearly than does Fig. 2. In Fig. 2, the presence of the harmonics appearing in the primary current wave is partially obscured by the presence of the power current which supplies the power to the tube filaments. In Fig. 3 the transformer was operated with the tube filament windings open-circuited, that is, the tube filaments were supplied by a separate transformer. Consequently, the primary current is the sum of the magnetiz-

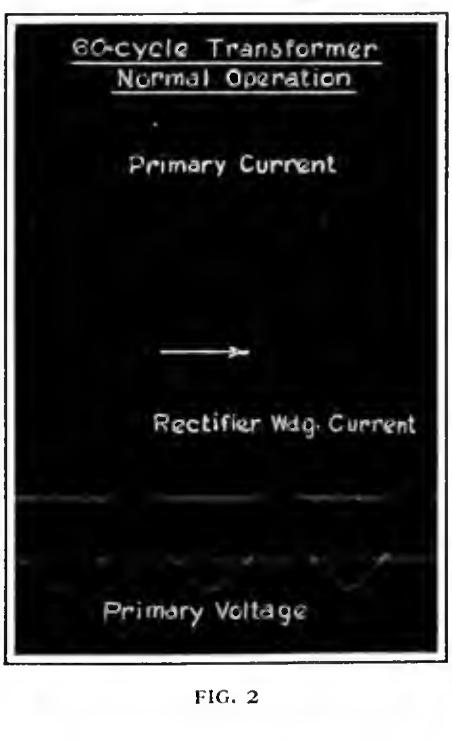


FIG. 2

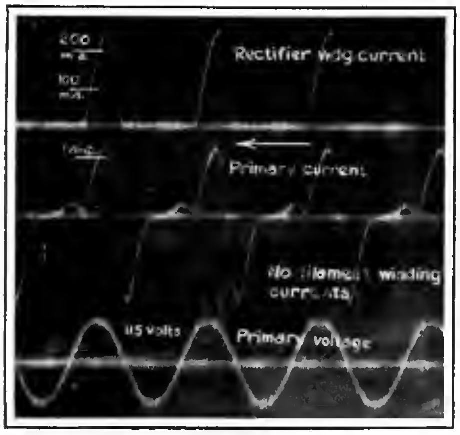


FIG. 3

ing current and the rectifier winding current reflected through the transformer.

THE FILTERING CIRCUIT

THE operation of the filtering circuit is shown in Fig. 4. The lower curve shows the current through the first condenser, and the upper curve shows the current through the first of the two chokes. It has been observed that the ratio of the r. m. s. value of the current of this first condenser to the direct-current rectified output is approximately constant, and lies between 1.8 and 2.2. for normal loads. It is practically independent of the capacity of this first condenser. The current through the second of the two chokes has very little ripple in it.

In a circuit such as this filter circuit, it might seem that the presence of the chokes and condensers would cause rather large transient voltages when the device is connected to or disconnected from the line. Actually, there are probably no transient increases and certainly none which exceed about ten per cent. of the normal voltage. The transient occurring when the switch was shut off is shown in Fig. 5. In this particular case, the switch was shut off during the time interval when the condenser was being charged. This is indicated by the fact that the last charging current peak is lower than the others. Oscillograms which were taken when the switch was turned off during the part of the cycle when the device was not rectifying, do not show this decrease in the last of the charging current peaks. It will be noticed that the current through the condenser drops to zero within approximately one fiftieth of a second after the switch is turned off. During the same time interval, the current through the first choke drops to zero. At the time that the current through this first choke has dropped to zero, there is still a charge on this first condenser. The choke current drops to zero, however, since the charge on the second condenser is still appreciable, and is sufficiently greater than the charge on the first condenser to stop the current. The current through the second choke starts to drop off at about the time when the current through the first choke is reduced to one third of its normal value. This current then drops to approximately zero at the time when the voltage on the third filter condenser is sufficiently greater than the voltage on the second to stop the current. By this time, the voltage on the second condenser is so low that the remaining charge on the first condenser proceeds to discharge through the choke, giving the slight current through the first choke that is shown in the illustration. A close inspection of the original film will show a slight current through the condenser at this instant. The reason it does not show up in the photograph is due to the fact that the current scale for the choke current is approximately four times that for the condenser current. A very short time after this discharge in current, the charge on the final condenser has been dissipated through the resistance and consequently the remaining charge on the second condenser discharges through the second choke, giving the slight rise shown. These steps in the discharge transient do not, of course, completely discharge the condensers, and very small current can be seen on the original film which repeats the first two slight rises in the choke currents that are plainly distinguished on this film. Several oscillograms of this transient were taken and all of them verify the results shown in this photograph. The right-hand portion of the middle curve on this line shows the amount of ripple in the second choke current before the switch is turned off. Practically all of this ripple is bypassed through the third of the filter condensers. Fig. 6 is another oscillogram taken under the same conditions. The condenser current is not faithfully recorded in this photograph because the oscillograph element was loose. The other two oscillograph elements were working properly, so that the choke currents are faithfully recorded.

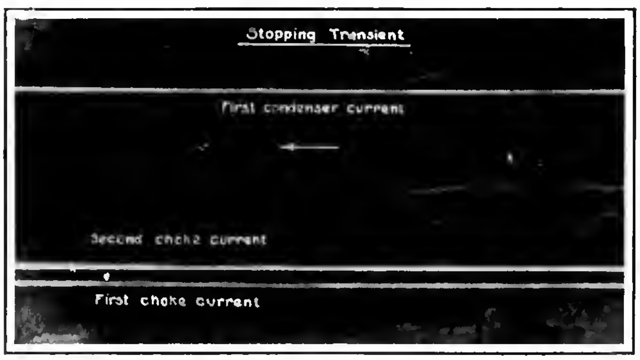


FIG. 5

In order to understand why the current drops to zero in pulses, consider the network as two separate circuits. The first is the circuit of the inductances, resistance, transformer, and rectifier in series. Assume the rectifier to act as a resistance. This is a reasonable assumption, since the direction of current flow is correct and the filament will remain hot for several cycles. The current in this circuit will decay logarithmically. The oscillatory discharge of the second circuit, inductances and condensers, will be superimposed on this discharge, giving the characteristics shown. This decay is shown even more clearly in Fig. 6.

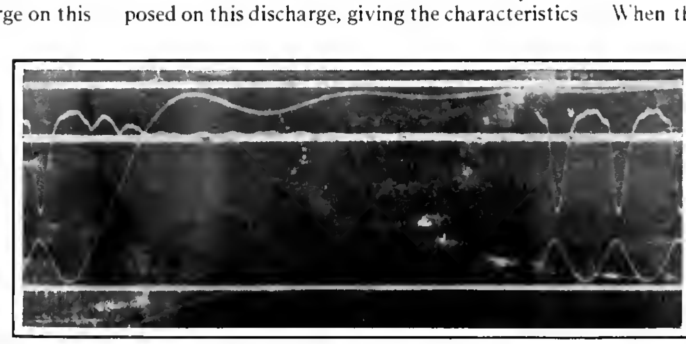


FIG. 6

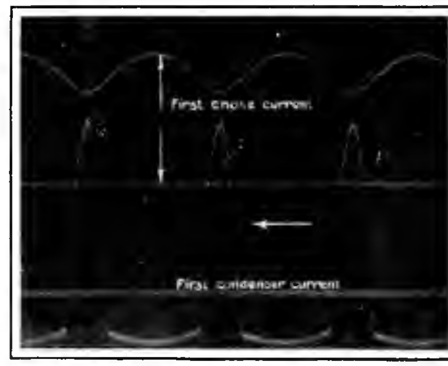


FIG. 4

In order that any considerable voltage will be built up across one of the condensers due to the switching transient, it would be necessary that the direction of the flow of energy in the steady state would be, for the moment, reversed. Since none of the photographs give any indication of the reversed current through the chokes, it follows that there can be no high voltage across any of the condensers during the discharging interval.

A moment's consideration of the energy stored in the filter circuit will show that it is very unlikely that a high-voltage transient across one of the condensers will occur. In this filter circuit we have two fifty-henry chokes in series with the high-voltage lead, with three 2-mfd. condensers connected across the line. See Fig. 7. Under normal conditions, the voltages across the condensers are 500, 375, and 350 volts respectively, 50 milliamperes of direct current flowing through each inductance. The energy stored in the first condenser will be $\frac{1}{2}$ CE^2, which is 0.25 joules. The other condensers store 0.14 and 0.112 joules. The energy stored in the chokes will be considerably less than this energy stored in the condensers. It is $\frac{1}{2}$ LI^2, or 0.0625 joules for each choke. The total stored energy in the circuit is then 0.637 joules. Thus we see that, even though the entire amount of this energy should by chance all pour into one of the condensers at once, the voltage across this condenser would be less than double the normal voltage across the first condenser. The solution is as follows:

$$\frac{1}{2} CE^2 = \frac{1}{2} \times 2 \times 10^{-6} \times E^2 = 0.637$$

Therefore, E=800 volts. But since the oscillogram shows that there is no reverse in the flow of energy, even this cannot occur, and there will be no increase in the voltage across any one of the condensers when the switch is turned off.

The starting transient is shown in Fig. 8. When the transformer is switched on to the line there may be a high secondary voltage transient if it is connected during a particular part of the cycle. In the device under consideration, this will have no effect except on the transformer itself. The reason is that the rectifier filament is cold, so the rectifier tube acts as an open circuit during the first few cycles, and therefore it separates the transformer from the filter. As the tube filament heats up, the tube rectifies and gradually builds up the necessary voltage to maintain the steady state. From the appearance of the oscillogram, it is evident that this voltage is built up gradually. If there were a transient voltage exceeding the normal, some of the charging current peaks would be slightly higher than the steady charging peaks. It will be noted that the area of the first few of these charging peaks is greater than the areas under the following discharging alternations of the condenser current. This is the interval during which the first condenser is accumulating its steady charge.

The drop in B voltage supplied by the "Powerformer" is directly proportional to the current drawn. The regulation curve for the high tap slopes down in a straight line from 175 volts, zero current, to zero volts, 37 milliamperes. The socket-power supply will give 20 milliamperes at 90 volts. The characteristic falls rapidly because it is impossible to use more than half the voltage at the output of the filter. The plate-circuit requirements of the power amplifier tube necessitate a high voltage at the filter output. The excess must be absorbed in a resistance. The scheme gives much poorer regulation than can be obtained from a good socket-power device where the voltage output of the filter is correct for the set. The power supply is ample for the usual two-step r. f. amplifier, detector, and one step audio amplifier. The second audio step is in the "Powerformer."

With the natural high impedance of socket-power devices, considerable trouble has been caused by the coupling between the audio plate circuits through the impedance of the socket device circuit. This trouble is entirely eliminated with this scheme. The detector plate circuit is completed through the 2-mfd. bypass condenser. The 30,000-ohm series resistance eliminates the coupling effects between the detector circuit and the two audio circuits.

The 7500-ohm sections of the potentiometer separate the two audio circuits so that each audio current goes through its proper bypassing condensers. Even at as low a frequency as 60 cycles, the condenser path for the audio component of the power amplifier plate current is only one thirtieth that of the potentiometer path.

THE AMPLIFIER

WE NOW consider the amplifier portion of the circuit. If we are to get fair reproduction, it is necessary that the current through the secondary of the output transformer, when connected to a normal load, will have the same wave shape as the signal voltage impressed across the primary of the input transformer. In other

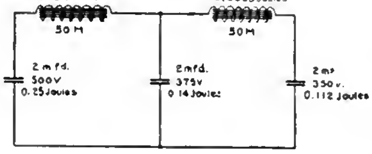


FIG. 7

words, the condition illustrated in Fig. 9 should obtain. The wave forms of the input voltage plate current and output transformer current are shown. The signal voltage is 4.22 volts r. m. s., corresponding to 6 volts peak signal or 18 on the grid through the 3:1 step-up transformer. The bottom curve represents the plate current of the tube. The zero of this current is above the curve

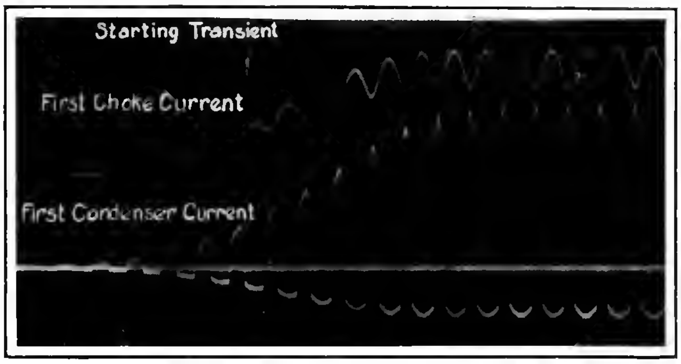


FIG. 8

shown. The center curve shows the current through the secondary of the output transformer working into a 5000-ohm resistive load used to simulate a loud speaker load. It will be noticed that the output current has about the same wave shape as the input signal voltage. The plate voltage was 390 volts; the grid bias 27 volts; the direct-current component of the plate current—34 milliamperes. This, and the succeeding oscillograms, were taken with a 60-cycle signal. The amplifier stage was connected to a more flexible battery supply than the rectifier and filter circuit we have been discussing. We used the separate battery supply so that it could be easily adjusted to illustrate the effect of having improper B and C voltages on the tubes. Fig. 10 shows the effect of using too small a C battery in this circuit. The signal voltage is still approximately $4\frac{1}{2}$ volts. The plate voltage is 400 volts. The C bias has been reduced to 10 volts, giving a plate current of 77 milliamperes. This condition obtains as the grid signal swings positive enough to draw current. The IZ drop of the current flowing through the high impedance of the transformer secondary will absorb practically all of the voltage induced in the secondary winding; consequently, the grid potential will remain approximately constant during the positive half of the grid signal, as shown in the photograph. When there is no alternating current in the plate circuit, the current through the output transformer secondary will, of course, fall off, just as any current decays when the potential across an inductance is removed and the inductance is discharged through a resistance. This gives the wave form shown in the center curve of the film. It will be noticed that the signal voltage shown at the top of the curve is no longer a sine wave. This is due to the fact that this particular curve was taken at 12:35 A. M. at Columbia University, using the United Service for the alternating current supply. It was noticed during that evening, as well as on other evenings, that the wave shape of the supply was much poorer after midnight than it was earlier in the evening. Fig. 11 is another curve representing approximately the same condition. The difference in this case is that another output transformer was substituted for the standard one. This output transformer has a large step-down ratio of the type which is adaptable to certain of the moving coil type loud speakers. In this case the signal voltage was considerably lower, that is, $\frac{3}{4}$ volt instead of $4\frac{1}{4}$ volts, accounting for the change in the plate current and the output transformer current. Since the output transformer secondary was much lower in inductance, the current decays more rapidly than in the other case.

The next oscillogram, Fig. 12, shows the amplifier tube operating with too large a C battery. The signal voltage in this case was $4\frac{1}{4}$ volts; B voltage—400 volts; the C voltage—44 volts; 14 milliamperes flowing in the plate circuit. This signal carried the grid so far negative that the curvature on the lower end of the tube characteristic distorted the signal. This distortion which appears both in the plate current curve (the top curve in the photograph), and the output transformer curve (the middle curve), is very similar to the distortion introduced when the grid swings too far positive, where the poor regulation of the high impedance grid circuit causes the peaks of the wave to be cut off. Fig. 13 illustrates the case where the signal voltage is too high, or the B voltage is too low. In this case, the signal voltage was $4\frac{1}{4}$ volts; the plate voltage—175 volts; the C bias—15 volts. This C bias was found to be about the best adjustment for 175 volts B voltage. The plate current was 14 milliamperes. It will be seen that this signal carried the grid down near the cut off point, giving distortion at the lower end, and also carried it sufficiently positive to cause

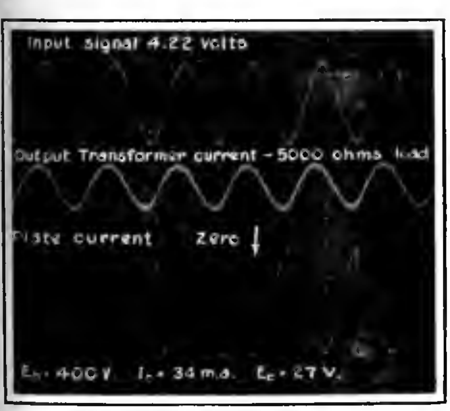


FIG. 9

FIG. 10

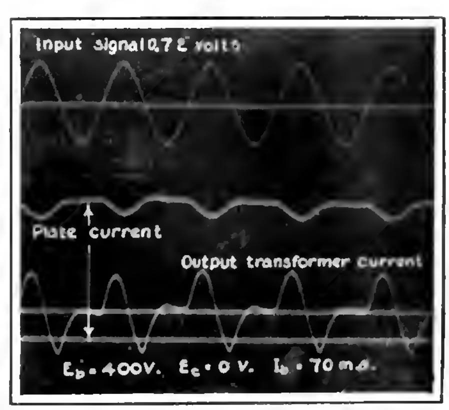


FIG. 11

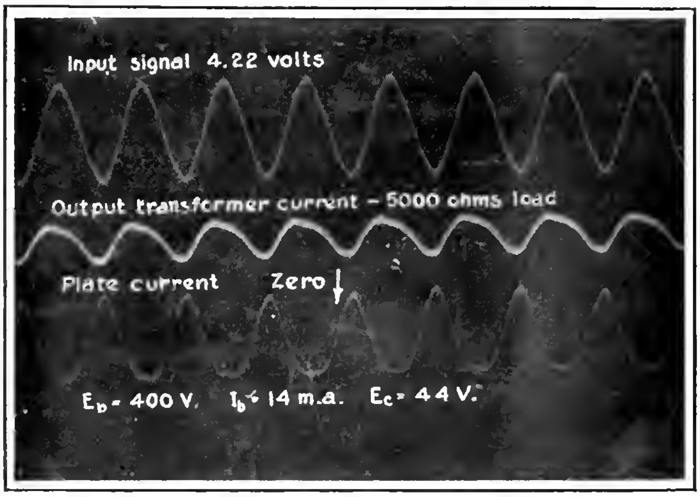


FIG. 12

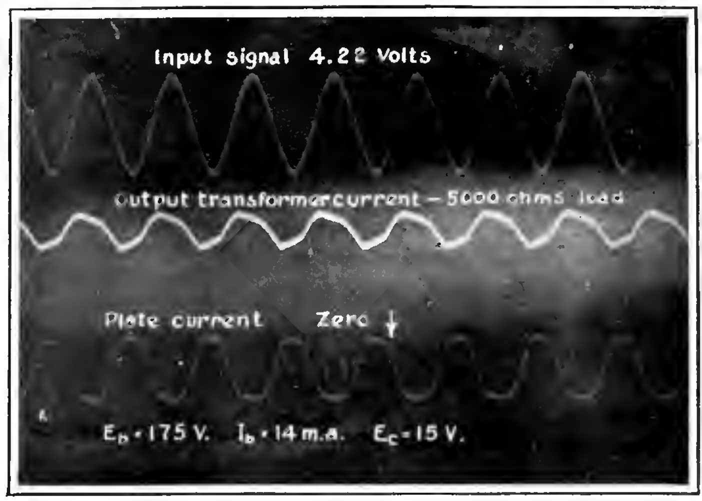


FIG. 13

similar distortion at the positive end of the cycle. This distortion appears in both the plate current curve and in the output transformer current curve.

Observations were made in several homes to find out how much signal voltage the average broadcast listener desires for what he would call normal volume. It was found that 6 volts peak audio-frequency voltage on the primary of the input transformer to the power stage was about the proper value. This corresponds to approximately 150 to 185 volts on the loud speaker. This value of 6 volts would of course be changed were a different transformer ratio to be used, or were a tube having a different amplification factor to be substituted. This power amplifier will take about 8 volts peak signal before the signal will suffer any distortion. It will take up to 12 volts on occasional peaks with such a small amount of distortion that the average broadcast listener will not notice it. If the plate voltage is reduced much below 300 volts, it will be found that the average broadcast listener will tune-in the signal so that there will be very objectionable tube overloading.

There is one other possible source of distortion, namely, the effect of the direct current flowing through the primary of the input transformer in saturating the core and so causing distortion. This form of distortion will not be encountered in the output transformer, since a small air gap is provided to prevent core saturation. There are two forms of distortion which might be expected from core saturation in the input transformer. One would be that form where the iron is operated so high up on the magnetization curve that the effect of the part of the signal cycle which would tend to carry it a little further up, would not be as effective in changing the flux as the part which tends to reduce the flux in the iron. This would give an unbalanced effect, destroying the symmetry between the two halves of the output voltage. This effect does not exist in the type of amplifier we are considering, for the reason that the signal voltage causes such an extremely small change in the flux density in the iron that the difference in the slope of the magnetization curve in different parts of the cycle is inappreciable. Fig. 14 shows this effect. The smaller of the two curves shows the signal current flowing through the secondary of the output transformer into a 5000-ohm resistive load when a sine wave is impressed on the primary of the first transformer. For the larger of the two curves, the same conditions were repeated with the change that 31 milliamperes of direct current were flowing through the primary of the input transformer. The change in magnitude of the wave is of no significance since it is due to a change in magnitude of the impressed signal voltage. It will be noted that this direct current, 31 milliamperes, is far in excess of any current that would flow through the primary of this transformer in a normal circuit. It will be noticed that the two wave forms are similar, showing that even this large direct current had no effect as far as introducing this particular type of distortion is concerned.

There is still another type of distortion to be considered. When the direct current is flowing through the primary, that is, when the iron is worked higher up on the magnetization curve, the impedance of the transformer primary will be reduced. This acts to reduce the amplification of low frequencies when the signal is impressed through a high series resistance, such as the plate circuit of the tube. Fig. 15 illustrates an exaggerated example of this effect. In the larger of the two curves, the 60-cycle voltage was impressed on the primary of the transformer through a 27,000 ohms. Under these circumstances, the transformer is operating under more unfavorable conditions than is usually the case. The departure from the sine wave is due to the better amplification of the harmonics of the signal than of the fundamental. The fluctuation in the height of the peaks of the same wave was due to the fluctuation in the B-potential supply. The smaller of the two curves shows the effect of 20 milliamperes flowing through the primary while the signal is impressed across the primary through a 27,000-ohm series resistance. It will be noticed that the magnitude of the output signal has decreased, due to the reduction in the primary impedance. The harmonics are also more pronounced than they are in the upper curve. The conclusion to be drawn from these two photographs is that the effect of the direct current flowing through the primary of the transformer is to tend to cut off the lower frequencies. From experimental data which were taken in addition to these two oscillograms, it seems that a current of 5 milliamperes has very little effect in reducing the effectiveness of the transformer at the lower frequencies.

In conclusion, I wish to thank Dr. S. L. Quimby for his assistance in taking the oscillograms, and for his helpful suggestions. I also wish to thank Mr. Goudy, Mr. Brown, Mr. Corbett, and Mr. Lundahl, of the Pacent Electric Company's engineering department, for making this paper possible.

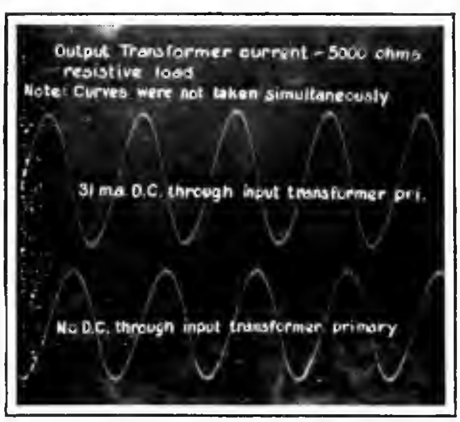


FIG. 14

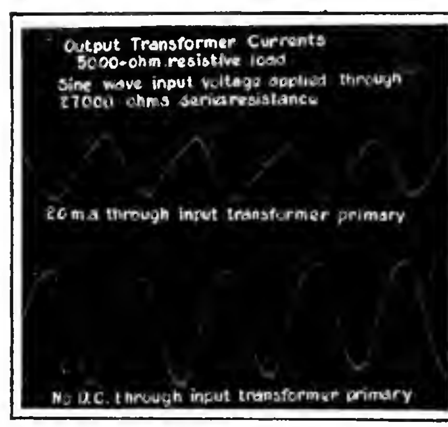


FIG. 15

¶ Radio Broadcast *is the official publication of the Radio Club of America, through whose courtesy, the foregoing paper has been printed here.* Radio Broadcast *does not, of course, assume responsibility for controversial statements made by authors of these papers. Other Radio Club papers will appear in subsequent numbers of this magazine*

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Raytheon BA
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Raytheon's leadership in the rectifier field is demonstrated again by the announcement of these sensational new rectifiers, worthy to take their places alongside Raytheon Types B and BH.

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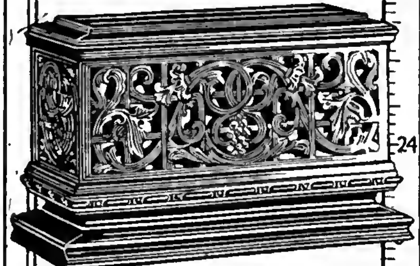

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AMPLION

The *Radio Broadcast* LABORATORY INFORMATION SHEETS

INQUIRIES sent to the Questions and Answers department of RADIO BROADCAST *were at one time answered either by letter or in "The Grid." The latter department has been discontinued, and all questions addressed to our technical service department are now answered by mail. In place of "The Grid," appears this series of Laboratory Information Sheets. These sheets contain much the same type of information as formerly appeared in "The Grid," but we believe that the change in the method of presentation and the wider scope of the information in the sheets, will make this section of* RADIO BROADCAST *of much greater interest to our readers.*

The Laboratory Information Sheets cover a wide range of information of value to the experimenter, and they are so arranged that they may be cut from the magazine and preserved for constant reference. We suggest that the series of Sheets appearing in each issue be cut out with a razor blade and pasted on 4" by 6" filing cards, or in a notebook. The cards should be arranged in numerical order. Several times during the year an index to all sheets previously printed will appear in this department. The first index appeared in November.

Those who wish to avail themselves of the service formerly supplied by "The Grid," are requested to send their questions to the Technical Information Service of the Laboratory, using the coupon which appears on page 127 of this issue. Some of the former issues of RADIO BROADCAST, *in which appeared the first sets of Laboratory Sheets, may still be obtained from the Subscription Department of Doubleday, Page & Company at Garden City, New York.*

No. 97 RADIO BROADCAST Laboratory Information Sheet June, 1927

Methods of Generating High-Frequency Energy

THE ARC

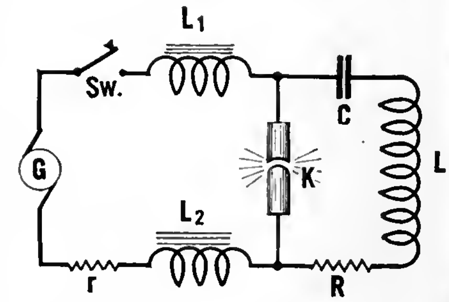
BEFORE the invention of the three-electrode tube, and its subsequent use as a source of large amounts of high-frequency energy, the arc was a common type of continuous-wave generator.

In the drawing on this Sheet is given the circuit diagram of a simple arc. The ordinary arc light used for street lighting might be used, but much more efficient operation is obtained from an especially designed arc. The elementary theory of the arc is given below.

The drawing indicates the simplest arrangement of the apparatus. "G" is a direct current generator, "r" is a resistance to control the current, L_1 and L_2 are two choke coils to keep the r. f. energy out of the generator and to keep the current practically constant, "K" is the arc, and "C," "L," and "R" are respectively, the capacity, inductance, and resistance of the oscillating circuit.

The arc, which consists of two electrodes, is different from ordinary electrical conductors in one important respect, which is that its resistance is not a constant quantity but a variable one, depending on the current flowing through it. At high current values the resistance is low and at low current the resistance is high. Consequently, an increase in current will produce a decrease in resistance.

Now, when the switch is closed, certain currents flow and the condenser begins to charge, and, therefore, part of the current is diverted from the arc. Since the current through the arc is decreased by this action, the voltage across the arc must rise, and it continues to rise as long as the condenser continues to charge. As soon as the condenser becomes fully charged, the arc voltage stops rising and the condenser begins to discharge itself through the arc.



When the discharge is complete, the cycle of charge and discharge repeats itself with a frequency determined by the constants of the inductance L and the capacity C. By carefully choosing these values, large amounts of high-frequency energy can be obtained.

No. 98 RADIO BROADCAST Laboratory Information Sheet June, 1927

Audio Amplifying Systems

RESISTANCE-COUPLED AMPLIFIERS

A VERY satisfactory method of audio amplification is that employing resistance coupling. The usual resistance-coupled amplifier requires three stages of amplification in order to obtain sufficient overall gain to satisfactorily operate a loud speaker. The introduction, however, of a new tube with a very high amplification constant, makes it possible in some cases to obtain sufficient amplification using only two stages. This new tube is known as the type 240 and data on it will appear on Laboratory Sheet No. 106 (July, 1927).

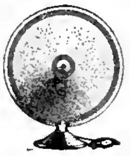
Several factors must be given attention if satisfactory results are to be obtained from a resistance-coupled amplifier. The mere fact that it is resistance coupled will not insure good quality. A poorly designed resistance-coupled amplifier is capable of creating as much distortion as can be obtained from a poorly designed amplifier of any other type. Some data regarding the constants of a resistance-coupled amplifier were given on Laboratory Sheet No. 74 (March, 1927). The constants given were for an ordinary tube for use in the resistance-coupled amplifier with an amplification constant of about 20. For the new type high-mu tube, however, with an amplification factor of about 30, it is necessary to use somewhat different values of resistance. See Laboratory Sheet No. 106.

The coupling condenser is a very important factor, and it is essential that this condenser have a very high insulation resistance, otherwise some of the B voltage will leak through the condenser to the grid circuit, and the amplifier will no longer function satisfactorily. In building up a resistance-coupled amplifier the best condensers should be used.

It is essential that high-quality plate and grid resistances be used to prevent noise in the amplifier. Also, the plate resistor should be capable of carrying the plate current of the tube without overheating.

Another important point is the amount of plate voltage used. It should be realized that most of the plate voltage supplied to the amplifier is lost in the resistance in series with the plate circuit of the tube. For this reason, it is necessary that fairly high voltages be available in order that there will be sufficient voltage left at the plate of the tube to obtain satisfactory operation. At least 135 volts should be used, and it should preferably be 180. The C-battery voltages should be kept as low as possible. It will generally be found that in an ordinary resistance-coupled amplifier a C-battery voltage of about 3 volts will be necessary on the grid of the tube preceding the last tube, if the latter is of the 171 type. The C voltage on the first tube of the ampifier need not be more than one volt.

Right down the scale!



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285-D (1 to 3)
285-H (1 to 6)
Price $6.00 each

1. Replace your old audio amplifier units by two General Radio Type 285 Transformers. A Type 285D (1 to 3) is recommended for the first stage, and a type 285H (1 to 6) for the second:

or, Substitute for your present amplifier a combination consisting of two stages of double impedance coupled and one stage of transformer coupled amplification. This combination requires two General Radio Type 373 Double Impedance Couplers and one Type 285D Transformer.

Type 373
Double Impedance Coupler
Price $6.50

2. Use a UX-171 or CX-371 tube in the last audio stage. This tube will effect an improvement in tone quality due to the greater volume it will produce without overloading. When this tube is used, however, a device such as the Type 367 output Transformer or Type 387A Speaker Filter is required to protect the loudspeaker from the flow of direct current.

Diagrams of the above mentioned amplifier circuits and folders fully describing the Type 285 Transformers, Type 373 Double Impedance Coupler, Type 367 Output Transformer, and Type 387A Speaker Filter will be sent upon request.

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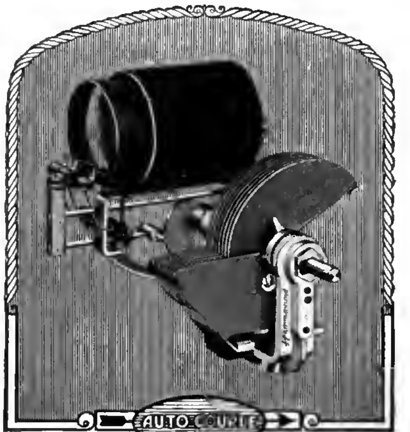

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No. 99 RADIO BROADCAST Laboratory Information Sheet June, 1927

Data on the "Universal" Receiver

PARTS REQUIRED

ON LABORATORY Sheet No. 100 is given the circuit diagram of the new "Universal" receiver which was described in the December, 1926, issue of RADIO BROADCAST. In constructing this receiver, the following parts are necessary:

L_1—Antenna coil consisting of 13 turns of No. 26 d. s. c. wire wound at one end of a 2¾-inch tube.

L_2—Secondary coil consisting of 50 turns of No. 26 d. s. c. wire wound on the same tube as L_1. The separation between L_1 and L_2 should be ⅛ inch.

L_3—Primary of interstage coil constructed in same manner as L_1 and tapped at the exact center.

L_4—Secondary winding constructed in same manner as L_2 and tapped at point No. 9, the 15th turn from that end of L_4 which is nearest to L_3

C_1, C_2—Two 0.0005-mfd. variable condensers.

C_3—Neutralizing condenser, variable, 0.000015 mfd.

C_4—Regeneration condenser, 0.00005 mfd.

L_5—R. F. choke coil, made by winding 400 turns of No. 28 wire on an ordinary spool.

T_1, T_2—Two audio-frequency transformers.

J_1—Interstage double-circuit jack.

J_2—Single-circuit filament-control jack.

R_1—30-ohm rheostat.

R_2—Fixed filament-control resistance for two 201-A tubes.

R_3—Fixed filament-control resistance for one power tube. One 0.00025 grid condenser with 3-megohm grid leak.

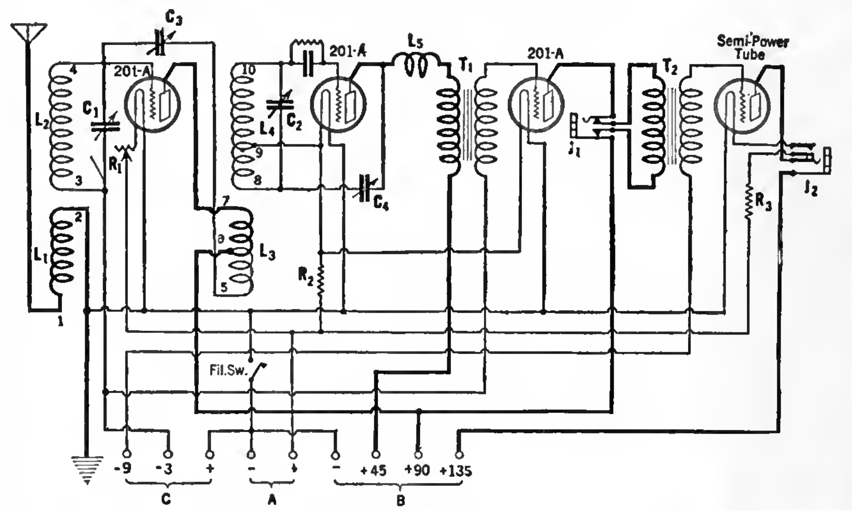
Four Sockets.

Eleven Binding posts.

In operation, condensers C_1 and C_2 will control the tuning, and C_4 will control the amount of regeneration. Various values of voltage should be tried on the plate of the detector tube, and that voltage used which gives smoothest regeneration. Frequently 22½ volts is more satisfactory than 45. Make certain that excessive C-battery voltage is not used on the grid of the r. f. tube, since the amplification obtained will be decreased considerably under such conditions. If there is any tendency toward regeneration or howling in the audio-frequency stages, reverse the connections to the primary of the transformer, T_2.

No. 100 RADIO BROADCAST Laboratory Information Sheet June, 1927

Circuit Diagram of the "Universal" Receiver



No. 101 RADIO BROADCAST Laboratory Information Sheet June, 1927

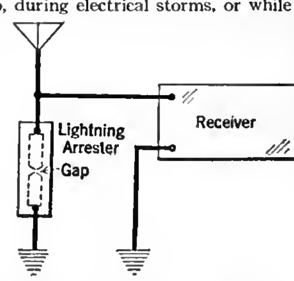
Lightning Arresters

HOW THEY WORK

AN ESSENTIAL part of any radio installation is the lightning arrester, which should be connected in the circuit as indicated in the diagram.

The arrester should preferably be located outside of the building at that point where the antenna lead-in enters the building. One terminal of the lightning arrester connects to the antenna and the other terminal connects to a good ground. A lightning arrester is a very simple device and actually consists of two metal electrodes which are spaced to within about five thousandths of an inch of each other. A radio-frequency current is too weak and too low in voltage to jump across these points which form the gap in the arrester and hence there is no path for the signal except that through the antenna to the receiver and thence to ground. The receiver is therefore actuated by this radio-frequency current and a signal is produced in the telephones, or the loud speaker, as the case may be. Suppose, however, that a high-potential atmospheric electrical discharge takes place near the antenna. Such discharges are always erratic in character and of high frequency. The antenna coil of the set therefore exerts a powerful choking action upon them even though the coil is quite small. For this reason, and also due to the very high voltage of the lightning discharge, it jumps across the small gap in the arrester and passes to ground without causing any more effect on the set than a loud static crash which will possibly drown out the signal for a moment.

Also, during electrical storms, or while they are



approaching, there is a considerable amount of static electricity present in the atmosphere which tends to accumulate on the antenna system until such time as the voltage is high enough to jump across the small gap in the arrester. This discharge voltage is generally about 500 volts.

No. 102 RADIO BROADCAST Laboratory Information Sheet June, 1927

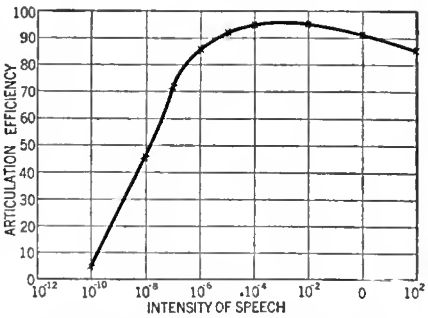
Efficiency of Amplifying Systems

ARTICULATION

IN AUDIO-amplifying systems, efficiency must be judged from two standards. One of the standards is, in the terminology of telephone engineers, the "volume efficiency" of the system, which tells us how much increase in loudness of sound is produced by the system. The other standard is known as "articulation efficiency." The "articulation efficiency" of any system is a measure of its effectiveness in the transmission of detached speech sounds. In these tests, sounds are grouped into meaningless monosyllables and the efficiency is measured by the percentage of sounds which are correctly received.

In actual tests on a system the monosyllables are spoken into the input of the system and listeners at the output record what sounds they think were spoken. In very high quality systems it is possible to obtain an articulation efficiency of almost 100 per cent.

The articulation efficiency depends upon the frequency distortion in the system, the amount of noise, and the volume efficiency. On this Sheet is an interesting curve the data for which were taken from a paper by Mr. R. L. Jones in the April, 1924, issue of the *A. I. E. E. Journal*, which shows how articulation varies with variations in intensity of sound. At the zero point the intensity of the received speech is equal to the intensity of the speech as it leaves the mouth and the articulation is about 91 per cent. With an intensity 100 times greater (10^2), the articulation falls to 87 per cent. If the intensity is decreased to a million times less than when it leaves the mouth, (10^6) the articulation is still very



good, being 85 per cent. These tests were made under quiet conditions and, of course, under noisy conditions the results would have been somewhat different.

No. 103 RADIO BROADCAST Laboratory Information Sheet June, 1927

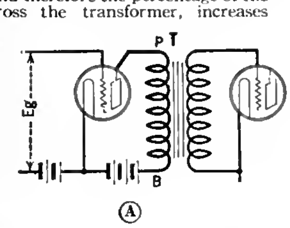
Audio Transformers

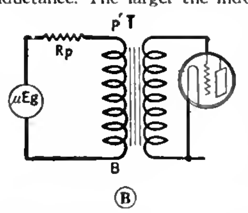
HIGH-IMPEDANCE PRIMARY NEEDED

THIS Sheet will explain why better quality is obtained from transformers with high-impedance primaries.

Drawing A shows how a transformer is connected in the plate circuit of a tube. Now, a voltage, Eg, on the grid of a tube is equivalent to a voltage of µEg (amplification constant times Eg) in the plate circuit of the tube. Also, the plate circuit of a tube acts like a resistance equal in value to the plate impedance of the tube (12,000 ohms for a 201-A type tube). These two facts were used in drawing the equivalent circuit diagram, B. In this diagram µEg indicates the voltage acting in the plate circuit and Rp represents the plate impedance of the tube. It is evident that the total voltage, µEg, available in the circuit, must divide itself between Rp and T, the transformer, and therefore the percentage of the total voltage across the transformer, increases with increased impedance in the transformer. Now, the impedance varies with the frequency, becoming greater as the frequency rises and decreasing as the frequency becomes lower. It is evident, then, that the percentage of the total voltage across the transformer will also vary with frequency, and if this variation is very great it will be a source of distortion. Practically, the result will be that, at the low frequencies where the transformer impedance is low, very little of the total voltage will be across the transformer, most of it being across the tube. As a result, the low frequencies will not receive as much amplification as do the moderate and high frequencies. The problem then is to so design the transformer that this variation of amplification with frequency is as small as possible consistent with economy of manufacture. The problem evidently comes down to one of designing a transformer to have as large an impedance as possible at the low frequencies for, since the impedance increases with frequency, there is no difficulty in obtaining high impedance at other than the low frequencies.

The impedance at low frequencies depends upon the inductance. The larger the inductance the greater the impedance. In order to get a large inductance, a large number of primary turns are required. It is also essential that the core of the transformer be very efficient so that the turns will have as much inductance as possible.





No. 104 RADIO BROADCAST Laboratory Information Sheet June, 1927

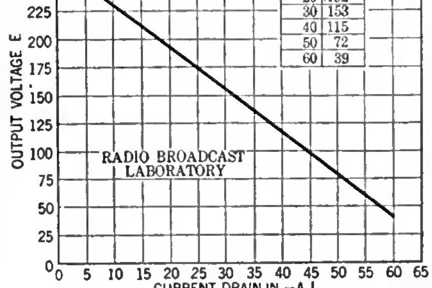
Socket Power Units

VOLTAGE OUTPUT CURVES

AT THE present time, it is common practice in rating B power units, to specify the voltages at various current drains which the unit will deliver from the high-voltage tap. These data are obtained by connecting a variable resistance, in series with a milliammeter, between the negative B and the terminal giving the highest voltage, and then measuring the output voltage with different values of current through the resistance. The data may be collected in the form of a table or a curve may be plotted. It is best to plot a curve for, from it, we can determine the voltage at any current drain. Also, the slope of the curve gives us visually an idea of how constant the voltage is.

If full benefit is to be obtained from such curves, it is essential that we thoroughly understand what they signify. We must first determine the total plate-current drain of our receiver. This information can be obtained by connecting a milliammeter in series with the negative B lead, where it will measure the total plate current. Suppose the reading to be 35 milliamperes. This value of current is now located on the curve and we find that the corresponding plate voltage is (in this particular case) 135 volts. This is the maximum voltage that the socket-power unit will supply at 35 milliamperes. If you require a maximum of 135 volts for your receiver, then the unit is satisfactory. If you cannot use as much as 135 volts and there is no adjustment on the device to lower this voltage, then the unit is not satisfactory; or you might want to use a 171 type tube with 180 volts and in this case also the unit will be unsatisfactory for it can only deliver 135 volts at the requisite current drain.

The curve tells us nothing concerning the voltages supplied by the other terminals on the power



unit. These other voltages are generally controlled by variable resistances so that any voltages from zero to maximum can be obtained.

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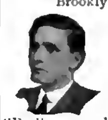

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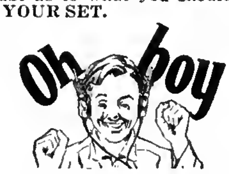

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Equipment for the Home-Constructor

How to Use Some of the New and Interesting Radio Equipment Which the Market Offers

By THE LABORATORY STAFF

MIDGET CONDENSERS

SMALL midget condensers of a capacity variable between about 15 and 150 mmfd. find many uses in the modern radio receiver. In Fig. 1 are shown several circuit positions where they might quite successfully be applied. For example, one may be connected in the antenna circuit to reduce the electrical length of the antenna without actually removing any wire, as shown at "A." "B" indicates the connection to be used to obtain vernier tuning—almost equivalent to a slow-motion dial—with an ordinary variable condenser. The midget is in this case shunted across its larger brother, and generally should have a maximum capacity of about 50 mmfd.

It should not be overlooked that the presence of a condenser in this latter position will upset somewhat the readings of the main dial so, if the receiver is to be logged accurately, the midget vernier condenser must always be set at approximately the same position before tuning is proceeded with. Midget condensers are frequently used with gang condensers in order to compensate any inequalities between the various stages.

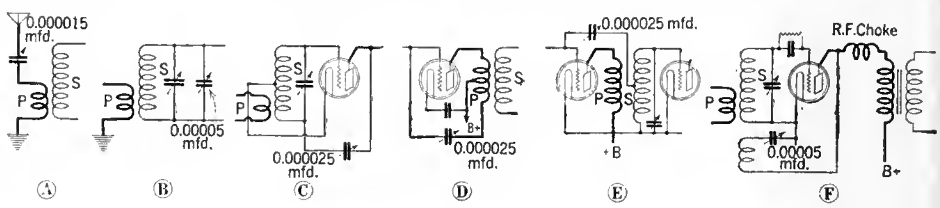


FIG. 1

In a circuit in which the tube capacity must be neutralized a small variable condenser connected in the proper way can be used for stabilization. Either a midget condenser of the type shown in Figs. 2 and 3, or a neutralizing condenser such as shown in Fig. 4, may be used. In the first two types of condenser, the capacity is readily variable by means of a knob, and may be, if desired, mounted on the panel. The latter type is usually mounted at the rear of the sub-panel, and capacity adjustments are made by means of a screw-driver. If the neutralizing condenser is of the midget type it may be used either as an oscillation control or to neutralize the tube capacity, at will. In the first case, the set may be made to regenerate over the full band of frequencies by simply adjusting the capacity so that more or less feedback is obtained. There are many different circuits making use of a small condenser to prevent oscillation (obtain neutralization). In Fig. 1, "C" shows the Rice system of neutralization, "D" the Roberts system, and "E" the Hazeltine method. For neutralization, the condenser is set at the proper value and left in that position.

The last drawing in Fig. 1, "F," shows one of several methods of regeneration control by means of a midget condenser. In this instance, the tickler coil is fixed in relation to the secondary, the amount of radio-frequency current going through it being controlled by the midget condenser.

Of the many possible circuit connections for these small variable condensers, the foregoing paragraphs list only a few of the most common.

The following are some of the manufacturers making midget condensers of capacities varying between 0.000015 and 0.00015 mfd: Hammarlund Manufacturing Company, New York City; Allen D. Cardwell Manufacturing Company, Brooklyn, New York; Silver-Marshall, Incorporated, Chicago, Illinois; Precise Manufacturing Company, Rochester, New York.

PICK-UP DEVICE

REALIZATION that the new phonographs employing electrical reproduction are far ahead of the old type ones using mechanical reproduction, has created a fertile market for equipment which makes possible the conversion of an old phonograph to one of the new type. Generally speaking, such devices consist of an electromagnetic pick-up, volume control, scratch filter, and often an adapter for plugging into the detector tube socket of a radio receiver; thus the audio amplifier of the receiver affords the necessary amplification of the electrical vibrations originating in the pick-up. These vibrations vary in electrical character depending upon the motion of the needle, which, in turn, relies for its minute movements upon the grooves in the rotating phonograph record.

The newest in the pick-up field is the Bosch "Recreator." Judging by the very satisfactory results obtained in our tests on this instrument, its somewhat belated appearance is due to a desire on the part of its manufacturers to produce a really first-rate piece of equipment. Fig. 5 is a diagram showing how the Bosch "Recreator" is used. In this diagram, "A" is the electromagnetic pick-up device; "B" is the swinging arm pivoted to the base "E" by a swivel arrange-

FIG. 2
Precise

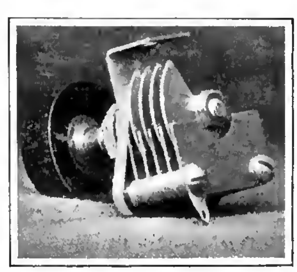


FIG. 3
Silver-Marshall

RADIO BROADCAST Photograph

FIG. 4
Hammarlund

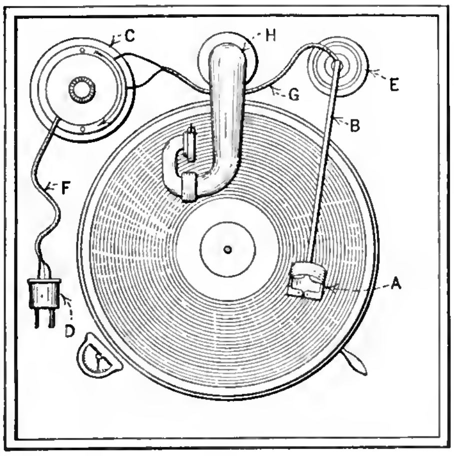


FIG. 5

ment; "G" is a flexible lead with pin jacks which are plugged into the volume control, "C"; "F" is another flexible lead between the volume control and the adapter "D," this latter, of course, being plugged into the detector tube socket of the receiver; "H" in the diagram is the regular tone arm and mechanical pick-up of the phonograph.

It is perhaps irrelevant to emphasize the necessity of employing a high-quality amplifier and loud speaker with this device. The advantages that accrue from the use of electrical reproduction will be forfeited if an amplifier system of satisfactory characteristics is not employed.

The volume obtainable from an outfit employing a Bosch pick-up necessarily depends upon the amplifier utilized. Although commercial electrical phonographs can deliver sufficient volume to make necessary the use of a 210 type tube, a two-stage transformer-coupled amplifier, or its equivalent, employing a 171 type output tube, will give satisfactory volume for average purposes.

Features of this device which are particularly commendable are as follows: (1) The arm between the pick-up and its base is adjustable in length; (2) the base, "D," is small yet sufficiently heavy for satisfactory balance; (3) the flexible leads, "G" and "F," are long, thus making it unnecessary to place the volume control close to the turntable, where generally there is inadequate room for it; (4) the volume control functions as a volume control should, *i. e.,* it satisfactorily and gradually reduces the music to a whisper, or vice versa, as desired; (5) the pick-up is very sensitive; (6) a clamp is supplied so that the electromagnetic pick-up may be permanently attached to the existing tone arm of the phonograph if desired, thus doing away with the arm and base supplied.

Manufactured by the American Bosch Magneto Corporation, Springfield, Massachusetts. Price $20.00, attractively boxed.

TRANSMITTING TUBE

A NEW transmitting tube, particularly adaptable to short-wave work, has recently made its appearance. This is the new UX-852, offered by the Radio Corporation of America.

The UX-852 is of the round bulb design, with three arms or extensions of the glass envelope. The largest or filament arm of the tube is provided with a standard UX base, suitable for use in either the UX or the UV type socket. The socket must be mounted so that the filament of the tube will be in a vertical position. Contrariwise, the horizontal grid and plate arms are not based. Instead, two heavy stranded leads, arranged in parallel, are brought from each of the widely separated stems for connection with grid and plate, respectively. Double grid and double plate leads serve greatly to increase the current-carrying capacity at exceptionally high frequencies, and both leads for each element should be employed at all times so as to carry safely the large circulating currents which flow at very high frequencies.

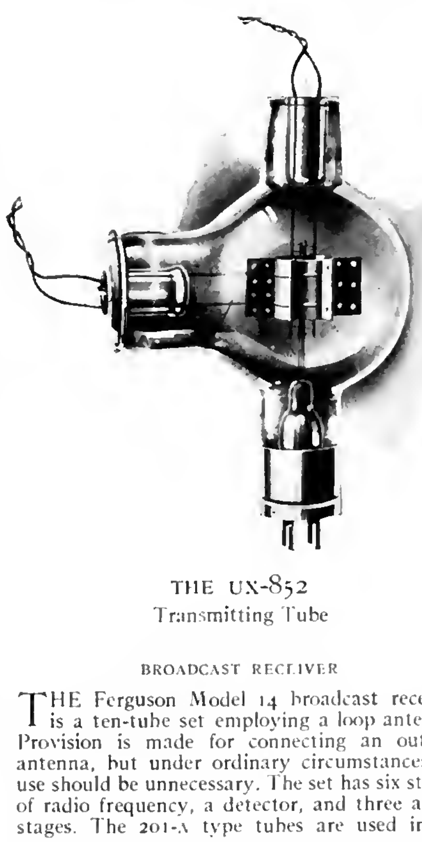
The fact that inter-electrode capacitance has been reduced to a minimum, permits of operating the UX-852 at wavelengths below 100 meters (3000 kc.). The tube provides excellent results on the popular 80-, 40-, and 20-meter channels (3750, 7500, and 15,000 kc.), and it has been successfully operated on wavelengths below 5 meters (60000 kc.) and even down to 77 centimeters (0.77 meters), or a frequency of 390,000 kilocycles, which is by no means the limit for the amateur who desires to explore the lowest wavelengths of short-wave radio.

The wiring of the ultra-short-wave transmitter is materially simplified when employing the UX-852 tube, since, with the grid and plate leads coming out of the bulb at different points, all connections do not have to be concentrated at the base, and the wiring can be made proportionately shorter and with wider spacing. The base, while of the UX type with four contact prongs, makes use of only two of the filament connections. Mounted upright in the usual UX push type or UV type socket, the tube has ample air circulation and operates much cooler than the 50-watt UX-203-A and other tubes. The ample cooling capacity is due in large part to the large area of the glass envelope. The new tube will handle plate voltages of 2000 normally, and even up to 3000 with proper precautions, without internal breakdown.

Alternating current should be used to operate the filament when possible. A center tap on the secondary of the filament transformer should be used for the grid and plate circuit returns. Rheostat control should be provided on the power supply side of the transformer. When it is necessary to use direct current to light the filament, the plate and grid return leads should be connected together and to the positive lead. Filament voltmeter leads should always be connected as closely as possible to the socket terminals.

The characteristics of the UX-852 tube are as follows:

Filament Voltage	10
Filament Current	3.25 amp.
Filament Power	32.5 watts
Filament Type	Thoriated Tungsten
Plate Voltage	2000 to 3000
Plate Current (Oscillating)	0.075 amp.
Input Power	150 watts
Maximum Safe Power Dissipation	100 watts
Amplification Constant	16
Nominal Output	75 watts
Plate Impedance (Eg=0)	8000 ohms.



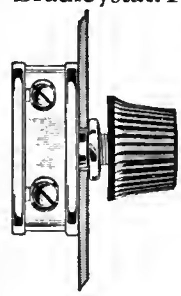
THE UX-852
Transmitting Tube

BROADCAST RECEIVER

THE Ferguson Model 14 broadcast receiver is a ten-tube set employing a loop antenna. Provision is made for connecting an outside antenna, but under ordinary circumstances its use should be unnecessary. The set has six stages of radio frequency, a detector, and three audio stages. The 201-A type tubes are used in all

Bradleystat
PERFECT FILAMENT CONTROL

For noiseless, smooth filament control and maximum range, ask your dealer for the Bradleystat. This well-known graphite disc rheostat can be used for ALL TUBES, without change of connections. The bakelite knob is removable, if desired. The one-hole mounting makes the Bradleystat easy to install.



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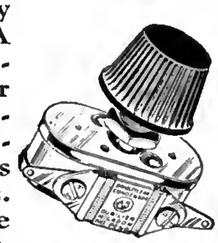
With a range from 1/4 to 10 megohms, the Bradleyleak offers a variation of adjustment that adapts it to any tube or any circuit. A small grid-condenser can be attached direct to its terminals. One-hole mounting.



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stages except the output, which is designed to take either the 112 or 171 type tube. C-battery connections are provided for use in the power stage. This receiver should not be operated without a power tube otherwise considerable distortion will result, due to overloading .

Only one dial is used for tuning, the condensers being arranged in gang formation. The dial is of the popular window type, and is illuminated from the rear by a small light operated by the battery supply. The dial is marked off directly in wavelengths and is graduated from 200 to 550 meters. During a test in the Laboratory the scale readings were found to check very closely with the wavelength of the stations logged. A volume control is placed directly beneath the tuning knob and consists of a small handle which regulates a rheostat in the filament circuit of the first, third, and fifth radio-frequency tubes. Throwing the lever as far as it will go in a counter clockwise direction turns off all the tubes. The dial is centered on a wooden panel 9 inches high and 20 inches long. The whole receiver is contained in a mahogany finished cabinet 12 inches high, 24 inches wide, and 16 inches deep. A battery cable runs through the cabinet to the rear and affords connections for A, B, and C batteries. The loud speaker jack is also in the rear, as are also the antenna and ground connections.

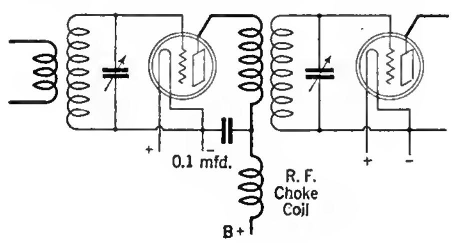


FIG. 6

In spite of the number of tubes employed in the receiver there is a drain of only 30 milliamperes from the B supply. Either heavy-duty dry cells or a socket-power device may be used to supply the B voltage. The A supply is obtained from a storage battery. A photograph of the receiver appears on this page. Manufactured by J. B. Ferguson, Incorporated, Long Island City New York. Price $235.00 without tubes or accessories.

PLATE POWER-SUPPLY RESISTOR

THIS resistor is used as standard equipment with the Amertran Power Supply Kit to provide the various voltages needed for the receiver. It can easily be applied to any type of plate supply device. The total resistance is 41,000 ohms, taps being taken at 32,000 ohms, 21,000 ohms, 16,500 ohms, 12,500 ohms, and 9000 ohms, as indicated in the accompanying diagram, Fig. 7. No definite values of voltage can be given for the different taps as this is dependent on the amount of current taken and the voltage of the rectifier element. The voltages across the resistances are not hard to calculate, however, and full instructions are given on Laboratory Information Sheet No. 63 (page 302, January, 1927, RADIO BROADCAST). In the diagram, the taps used in the Amertran device are indicated, together with the tubes they supply. A 210 type is used in the last stage with 400 volts on the plate. The resistors are connected in series and the resistance values are accurate within approximately two per cent. The current-carrying capacity of the unit is 30 milliamperes continuously, which is ample to take care of most of the conditions to which the resistor will be subject in actual service. The resistor is wire-wound and slightly inductive. There are no doubt many uses for this resistor. For instance, it may be used as a potentiometer or as a grid leak at low-power transmitting stations. Manufactured especially for the AmerTran Sales Company, Newark, New Jersey. Resistor type 400. Price $7.50.

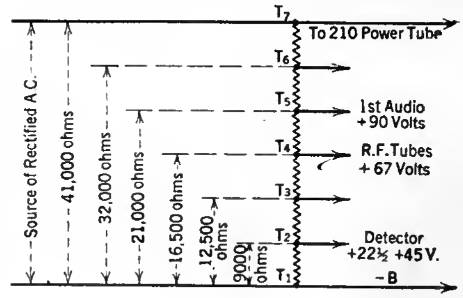
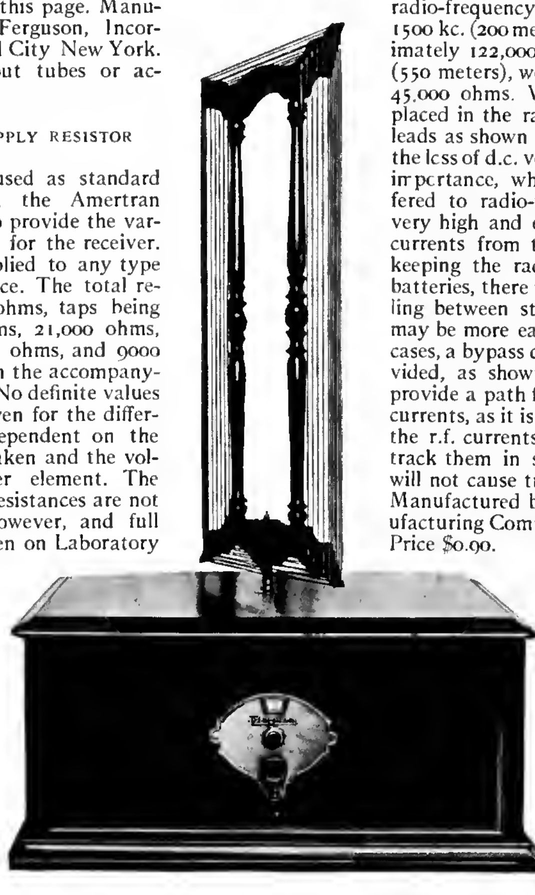


FIG. 7

RADIO-FREQUENCY CHOKE COIL

THE radio-frequency choke coil is a fairly recent addition to the family of parts which go to make up the refinements of modern receivers. There are many choke coils on the market and most are designed for a specific use, though they may be used by the experimenter in many different positions in the circuit. The inductance of the Bremer-Tully choke coil was found in the Laboratory to be 12.75 millihenries, and the direct current resistance, 83.7 ohms. This means that the voltage drop (d. c.) with a current of 2 mils. would be only about 0.0167 volts, or a figure which can be neglected. The impedance to a radio-frequency current, however, of 1500 kc. (200 meters) would be approximately 122,000 ohms, and at 545 kc. (550 meters), would be approximately 45,000 ohms. When such a choke is placed in the radio-frequency battery leads as shown in the diagram, Fig. 6, the loss of d.c. voltage is of no practical importance, while the impedance offered to radio-frequency currents is very high and effectually keeps these currents from the battery leads. By keeping the radio currents from the batteries, there is less chance for coupling between stages and the receiver may be more easily neutralized. In all cases, a bypass condenser must be provided, as shown in the diagram, to provide a path for the radio-frequency currents, as it is not the object to stop the r.f. currents entirely but to sidetrack them in such a way that they will not cause trouble in the receiver. Manufactured by Bremer-Tully Manufacturing Company, Chicago, Illinois. Price $0.90.



THE FERGUSON MODEL 14 RECEIVER

Manufacturers' Booklets

A Varied List of Books Pertaining to Radio and Allied Subjects Obtainable Free With the Accompanying Coupon

AS AN additional service to RADIO BROADCAST *readers, we print below a list of booklets on radio subjects issued by various manufacturers. The publications listed below cover a wide range of subjects, and offer interesting reading to the radio enthusiast. The manufacturers issuing these publications have made great effort to collect interesting and accurate information.* RADIO BROADCAST *hopes, by listing these publications regularly, to keep its readers in touch with what the manufacturers are doing. Every publication listed below is supplied free. In ordering, the coupon printed on page 124 must be used. Order by number only.*—THE EDITOR.

1. FILAMENT CONTROL—Problems of filament supply, voltage, regulation, and effect on various circuits. RADIALL COMPANY.

2. HARD RUBBER PANELS—Characteristics and properties of hard rubber as used in radio, with suggestions on how to "work" it. B. F. GOODRICH RUBBER COMPANY.

3. TRANSFORMERS—A booklet giving data on input and output transformers. PACENT ELECTRIC COMPANY.

4. RESISTANCE-COUPLED AMPLIFIERS—A general discussion of resistance coupling with curves and circuit diagrams. COLE RADIO MANUFACTURING COMPANY.

5. CARBORUNDUM IN RADIO—A book giving pertinent data on the crystal as used for detection, with hook-ups, and a section giving information on the use of resistors. THE CARBORUNDUM COMPANY.

6. B-ELIMINATOR CONSTRUCTION—Constructional data on how to build. AMERICAN ELECTRIC COMPANY.

7. TRANSFORMER AND CHOKE-COUPLED AMPLIFICATION—Circuit diagrams and discussion. ALL-AMERICAN RADIO CORPORATION.

8. RESISTANCE UNITS—A data sheet of resistance units and their application. WARD-LEONARD ELECTRIC COMPANY.

9. VOLUME CONTROL—A leaflet showing circuits for distortionless control of volume. CENTRAL RADIO LABORATORIES.

10. VARIABLE RESISTANCE—As used in various circuits. CENTRAL RADIO LABORATORIES.

11. RESISTANCE COUPLING—Resistors and their application to audio amplification, with circuit diagrams. DEJUR PRODUCTS COMPANY.

12. DISTORTION AND WHAT CAUSES IT—Hook-ups of resistance-coupled amplifiers with standard circuits. ALLEN-BRADLEY COMPANY.

15. B-ELIMINATOR AND POWER AMPLIFIER—Instructions for assembly and operation using Raytheon tube. GENERAL RADIO COMPANY.

15a. B-ELIMINATOR AND POWER AMPLIFIER—Instructions for assembly and operation using an R. C. A. rectifier. GENERAL RADIO COMPANY.

16. VARIABLE CONDENSERS—A description of the functions and characteristics of variable condensers with curves and specifications for their application to complete receivers. ALLEN D. CARDWELL MANUFACTURING COMPANY.

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20. AUDIO AMPLIFICATION—A booklet containing data on audio amplification together with hints for the constructor. ALL AMERICAN RADIO CORPORATION.

21. HIGH-FREQUENCY DRIVER AND SHORT-WAVE WAVEMETER—Constructional data and application. BURGESS BATTERY COMPANY.

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48. TRANSFORMER AND IMPEDANCE DATA—Tables giving the mechanical and electrical characteristics of transformers and impedances, together with a short description of their use in the circuit. SAMSON ELECTRIC COMPANY.

49. BYPASS CONDENSERS—A description of the manufacture of bypass and filter condensers. LESLIE F. MUTER COMPANY.

50. AUDIO MANUAL—Fifty questions which are often asked regarding audio amplification, and their answers. AMERTRAN SALES COMPANY, INCORPORATED

51. SHORT-WAVE RECEIVER—Constructional data on a receiver which, by the substitution of various coils, may be made to tune from a frequency of 16,660 kc. (18 meters) to 1999 kc. (150 meters). SILVER-MARSHALL, INCORPORATED.

52. AUDIO QUALITY—A booklet dealing with audio-frequency amplification of various kinds and the application to well-known circuits. SILVER-MARSHALL, INCORPORATED.

56. VARIABLE CONDENSERS—A bulletin giving an analysis of various condensers together with their characteristics. GENERAL RADIO COMPANY.

57. FILTER DATA—Facts about the filtering of direct current supplied by means of motor-generator outfits used with transmitters. ELECTRIC SPECIALTY COMPANY.

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62. RADIO-FREQUENCY AMPLIFICATION—Constructional details of a five-tube receiver using a special design of radio-frequency transformer. CAMFIELD RADIO MANUFACTURING COMPANY.

63. FIVE-TUBE RECEIVER—Constructional data on building a receiver. AERO PRODUCTS, INCORPORATED.

64. AMPLIFICATION WITHOUT DISTORTION—Data and curves illustrating the use of various methods of amplification. ACME APPARATUS COMPANY.

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66. SUPER-HETERODYNE—Constructional details of a seven-tube set. G. C. EVANS COMPANY.

70. IMPROVING THE AUDIO AMPLIFIER—Data on the characteristics of audio transformers, with a circuit diagram showing where chokes, resistors, and condensers can be used. AMERICAN TRANSFORMER COMPANY.

71. DISTORTIONLESS AMPLIFICATION—A discussion of the resistance-coupled amplifier used in conjunction with a transformer, impedance, or resistance input stage. Amplifier circuit diagrams and constants are given in detail for the constructor. AMSCO PRODUCTS INCORPORATED.

72. PLATE SUPPLY SYSTEM—A wiring diagram and layout plan for a plate supply system to be used with a power amplifier. Complete directions for wiring are given. AMERTRAN SALES COMPANY.

80. FIVE-TUBE RECEIVER—Data are given for the construction of a five-tube tuned radio-frequency receiver. Complete instructions, list of parts, circuit diagram, and template are given. ALL-AMERICAN RADIO CORPORATION.

81. BETTER TUNING—A booklet giving much general information on the subject of radio reception with specific illustrations. Primarily for the non-technical home constructor. BREMER-TULLY MANUFACTURING COMPANY.

82. SIX-TUBE RECEIVER—A booklet containing photographs, instructions, and diagrams for building a six-tube shielded receiver. SILVER-MARSHALL, INCORPORATED.

83. SOCKET POWER DEVICE—A list of parts, diagrams, and templates for the construction and assembly of socket power devices. JEFFERSON ELECTRIC MANUFACTURING COMPANY.

84. FIVE-TUBE EQUAMATIC—Panel layout, circuit diagrams, and instructions for building a five-tube receiver, together with data on the operation of tuned radio-frequency transformers of special design. KARAS ELECTRIC COMPANY.

85. FILTER—Data on a high-capacity electrolytic condenser used in filter circuits in connection with A socket power supply units, are given in a pamphlet. THE ABOX COMPANY.

86. SHORT-WAVE RECEIVER—A booklet containing data on a short-wave receiver as constructed for experimental purposes. THE ALLEN D. CARDWELL MANUFACTURING CORPORATION.

88. SUPER-HETERODYNE CONSTRUCTION—A booklet giving full instructions, together with a blue print and necessary data, for building an eight-tube receiver. THE GEORGE W. WALKER COMPANY.

89. SHORT-WAVE TRANSMITTER—Data and blue prints are given on the construction of a short-wave transmitter, together with operating instructions, methods of keying, and other pertinent data. RADIO ENGINEERING LABORATORIES.

90. IMPEDANCE AMPLIFICATION—The theory and practice of a special type of dual-impedance audio amplification are given. ALDEN MANUFACTURING COMPANY.

93. B-SOCKET POWER—A booklet giving constructional details of a socket-power device using either the BH or 313 type rectifier. NATIONAL COMPANY, INCORPORATED.

94. POWER AMPLIFIER—Constructional data and wiring diagrams of a power amplifier combined with a B-supply unit are given. NATIONAL COMPANY, INCORPORATED.

ACCESSORIES

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27. DRY-CELL BATTERY CAPACITIES FOR RADIO TRANSMITTERS—Characteristic curves and data on discharge tests. BURGESS BATTERY COMPANY.

28. B BATTERY LIFE—Battery life curves with general curves on tube characteristics. BURGESS BATTERY COMPANY.

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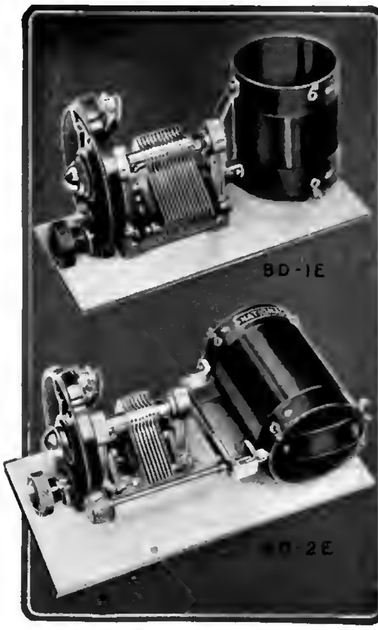
30. TUBE CHARACTERISTICS—A data sheet giving constants of tubes. C. E. MANUFACTURING COMPANY.

31. FUNCTIONS OF THE LOUD SPEAKER—A short, non-technical general article on loud speakers. AMPLION CORPORATION OF AMERICA.

32. METERS FOR RADIO—A catalogue of meters used in radio, with connecting diagrams. BURTON-ROGERS COMPANY.

33. SWITCHBOARD AND PORTABLE METERS—A booklet giving dimensions, specifications, and shunts used with various meters. BURTON-ROGERS COMPANY.

34. COST OF B BATTERIES—An interesting discussion of the relative merits of various sources of B supply. HARTFORD BATTERY MANUFACTURING COMPANY.



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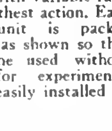

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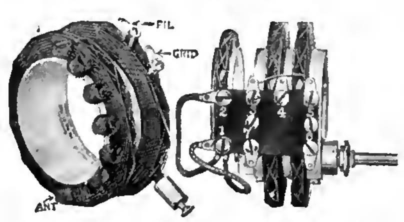

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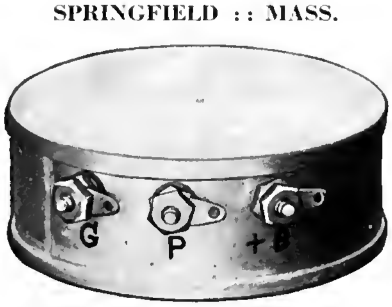

Shielded Tuned Radio Transformer, No.30

35. Storage Battery Operation—An illustrated booklet on the care and operation of the storage battery. General Lead Batteries Company.
36. Charging A and B Batteries—Various ways of connecting up batteries for charging purposes. Westinghouse Union Battery Company.
37. Choosing the Right Radio Battery—Advice on what dry cell battery to use; their application to radio, with wiring diagrams. National Carbon Company.
53. Tube Reactivator—Information on the care of vacuum tubes, with notes on how and when they should be reactivated. The Sterling Manufacturing Company.
54. Arresters—Mechanical details and principles of the vacuum type of arrester. National Electric Specialty Company.
55. Capacity Connector—Description of a new device for connecting up the various parts of a receiving set, and at the same time providing bypass condensers between the leads. Kurz-Kasch Company.
68. Chemical Rectifier—Details of assembly, with wiring diagrams, showing how to use a chemical rectifier for charging batteries. Cleveland Engineering Laboratories Company.
69. Vacuum Tubes—A booklet giving the characteristics of the various tube types with a short description of where they may be used in the circuit. Radio Corporation of America.
77. Tubes—A booklet for the beginner who is interested in vacuum tubes. A non-technical consideration of the various elements in the tube as well as their position in the receiver. Cleartron Vacuum Tube Company.
87. Tube Tester—A complete description of how to build and how to operate a tube tester. Burton-Rogers Company.
91. Vacuum Tubes—A booklet giving the characteristics and uses of various types of tubes. This booklet may be obtained in English, Spanish, or Portuguese. DeForest Radio Company.
92. Resistors for A. C. Operated Receivers—A booklet giving circuit suggestions for building a. c. operated receivers, together with a diagram of the circuit used with the new 400-millampere rectifier tube. Carter Radio Company.
97. High-Resistance Voltmeters—A folder giving information on how to use a high-resistance voltmeter, special consideration being given the voltage measurement of socket-power devices. Westinghouse Electric & Manufacturing Company.

Miscellaneous

38. Log Sheet—A list of broadcasting stations with columns for marking down dial settings. U. S. L. Radio, Incorporated.
41. Baby Radio Transmitter of 9xh-9ek—Description and circuit diagrams of dry-cell operated transmitter. Burgess Battery Company.
42. Arctic Radio Equipment—Description and circuit details of short-wave receiver and transmitter used in Arctic exploration. Burgess Battery Company.
43. Short-Wave Receiver of 9xh-9ek—Complete directions for assembly and operation of the receiver. Burgess Battery Company.
44. Aluminum for Radio—A booklet containing much radio information with hook-ups of basic circuits, with inductance-capacity tables and other pertinent data. Aluminum Company of America.
45. Shielding—A discussion of the application of shielding in radio circuits with special data on aluminum shields. Aluminum Company of America.
58. How to Select a Receiver—A commonsense booklet describing what a radio set is, and what you should expect from it, in language that any one can understand. Day-Fan Electric Company.
67. Weather for Radio—A very interesting booklet on the relationship between weather and radio reception, with maps and data on forecasting the probable results. Taylor Instrument Companies.
73. Radio Simplified—A non-technical booklet giving pertinent data on various radio subjects. Of especial interest to the beginner and set owner. Crosley Radio Corporation.
74. The Experimenter—A monthly publication which gives technical facts, valuable tables, and pertinent information on various radio subjects. Interesting to the experimenter and to the technical radio man. General Radio Company.
75. For the Listener—General suggestions for the selecting, and the care of radio receivers. Valley Electric Company.
76. Radio Instruments—A description of various meters used in radio and electrical circuits together with a short discussion of their uses. Jewell Electrical Instrument Company.
78. Electrical Troubles—A pamphlet describing the use of electrical testing instruments in automotive work combined with a description of the cadmium test for storage batteries. Of interest to the owner of storage batteries. Burton Rogers Company.
95. Resistance Data—Successive bulletins regarding the use of resistors in various parts of the radio circuit. International Resistance Company.
96. Vacuum Tube Testing—A booklet giving pertinent data on how to test vacuum tubes with special reference to a tube testing unit. Jewell Electrical Instrument Company.

What Kit Shall I Buy?

The list of kits herewith is printed as an extension of the scope of the Service Department of Radio Broadcast. *It is our purpose to list here the technical data about kits on which information is available. In some cases, the kit can be purchased from your dealer complete; in others, the descriptive booklet is supplied for a small charge and the parts can be purchased as the buyer likes. The Service Department will not undertake to*

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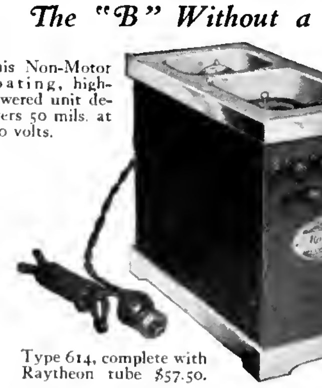
The "B" Without a Buzz



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Type 614, complete with Raytheon tube $57.50.

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MODEL "N"—Capacity range 1.8 to 20 micro-micro farads. Micrometer adjustment assures correct oscillation control in all tuned radio frequency circuits, Neutrodyne, Roberts 2-tube, Browning-Drake, Silver's Knockout, Interflex circuit, Quadroformer, World's Record Super-9, B. T. Power-6, R. B. Lab. Circuit, etc. Price, $1.00.

MODEL "G"—For Cockaday, Oliver Lodge N, Loftin-White, Nankin Ultra-5 circuits, filter and intermediate frequency tuning in super-heterodyne and positive grid bias in all sets. Capacity range, Model G-1 .00002 to .0001 Mfd. Model G-5 .0001 to .0005 Mfd. Model G-10 .0003 to .001 Mfd. Price each with grid leak clips, $1.50.

X-L PUSH POST—Push it down with your thumb, insert wire, remove pressure, wire is firmly held. Vibrations will not loosen, releases instantly. Price, 15c. Also in strip of 7 on black panel marked in white. Price, $1.50.

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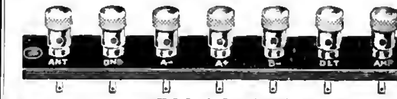

X-L Push Post Panel

handle cash remittances for parts, but when the coupon on page 126 is filled out, all the information requested will be forwarded.

201. SC Four-Tube Receiver—Single control. One stage of tuned radio frequency, regenerative detector, and two stages of transformer-coupled audio amplification. Regeneration control is accomplished by means of a variable resistor across the tickler coil. Standard parts; cost approximately $58.85.

202. SC-II Five-Tube Receiver—Two stages of tuned radio frequency, detector, and two stages of transformer-coupled audio. Two tuning controls. Volume control consists of potentiometer grid bias on r.f. tubes. Standard parts cost approximately $60.35.

203. "HI-Q" Kit—A five-tube tuned radio-frequency set having two radio stages, a detector, and two transformer-coupled audio stages. A special method of coupling in the r.f. stages tends to make the amplification more nearly equal over the entire band. Price $63.05 without cabinet.

204. R. G. S. Kit—A four-tube inverse reflex circuit, having the equivalent of two tuned radio-frequency stages, detector, and three audio stages. Two controls. Price $69.70 without cabinet.

205. Pierce Airo Kit—A six-tube single-dial receiver; two stages of radio-frequency amplification, detector, and three stages of resistance-coupled audio. Volume control accomplished by variation of filament brilliancy of r.f. tubes or by adjusting compensating condensers. Complete chassis assembled but not wired costs $42.50.

206. H & H-T. r. f. Assembly—A five-tube set; three tuning dials, two steps of radio frequency, detector, and 2 transfo.mer-coupled audio stages. Complete except for baseboard, panel, screws, wires, and accessories. Price $35.00.

207. Premier Five-Tube Ensemble—Two stages of tuned radio frequency, detector, and two steps of transformer-coupled audio. Three dials. Parts assembled but not wired. Price complete, except for cabinet, $35.00.

208. "Quaoraformer VI"—A six-tube set with two tuning controls. Two stages of tuned radio frequency using specially designed shielded coils, a detector, one stage of transformer-coupled audio, and two stages of resistance-coupled audio. Gain control by means of tapped primaries on the r.f. transformers. Essential kit consists of three shielded double-range "Quadraformer" coils, a selectivity control, and an "Ampitrol," price $17.50. Complete parts $70.15.

209. Gen-Ral Five-Ture Set—Two stages of tuned radio frequency, detector, and two transformer-coupled audio stages. Volume is controlled by a resistor in the plate circuit of the r.f. tubes. Uses a special r.f. coil ("Duo-Former") with figure eight winding. Parts mounted but not wired, price $37.50.

210. Bremer-Tully Power-Six—A six-tube, dual-control set; three stages of neutralized tuned radio frequency, detector, and two transformer-coupled audio stages. Resistances in the grid circuit together with a phase shifting arrangement are used to prevent oscillation. Volume control accomplished by variation of B potential on r.f. tube. Essential kit consists of four r.f. transformers, two dual condensers, three small condensers, three choke coils, one 500,000-ohm resistor, three 1500-ohm resistors, and a set of color charts and diagrams. Price $41.50.

211. Bruno Drum Control Receivers—How to apply a drum tuning unit to such circuits as the three-tube regenerative receiver, four-tube Browning-Drake, five-tube Diamond-of-the-Air, and the "Grand" 6.

212. Infradyne Amplifier—A three-tube intermediate-frequency amplifier for the super-heterodyne and other special receivers, tuned to 3400 kc. (86 meters). Price $25.00.

213. Radio Broadcast "Lab" Receiver—A four-tube dual-control receiver with one stage of Rice neutralized tuned-radio frequency, regenerative detector (capacity controlled), and two stages of transformer-coupled audio. Approximate price, $78.15.

214. LC-27—A five-tube set with two stages of tuned-radio frequency, a detector, and two stages of transformer-coupled audio. Special coils and special means of neutralizing are employed. Output device. Price $85.20 without cabinet.

215. Loftin-White—A five-tube set with two stages of radio frequency, especially designed to give equal amplification at all frequencies, a detector, and two stages of transformer-coupled audio. Two controls. Output device. Price $85.10.

216. K.H.-27—A six-tube receiver with two stages of neutralized tuned radio frequency, a detector, three stages of choke-coupled audio, and an output device. Two controls. Price $86.00 without cabinet.

217. Aero Short-Wave Kit—Three plug-in coils designed to operate with a regenerative detector circuit and having 2 frequency range of from 19,990 to 2306 kc. (15 to 130 meters). Coils and plug only, price $12.50.

218. Diamond-of-the-Air—A five-tube set having one stage of tuned-radio frequency, a regenerative detector, one stage of transformer-coupled audio, and two stages of resistance-coupled audio. Volume control through regeneration. Two tuning dials.

219. Norden-Hauck Super 10—Ten tubes; five stages of tuned radio frequency, detector, and four stages of choke- and transformer-coupled audio frequency. Two controls. Price $291.40.

220. Browning-Drake—Five tubes; one stage tuned radio frequency (Rice neutralization), regenerative detector (tickler control), three stages of audio (special combination of resistance- and impedance-coupled audio). Two controls.

221. LR4 Ultradyne—Nine-tube super-heterodyne; one stage of tuned radio frequency, one modulator, one oscillator, three intermediate-frequency stages, detector, and two transformer-coupled audio stages.

222. Greiff Multiplex—Four tubes (equivalent to six tubes); one stage of tuned radio frequency, one stage of transformer-coupled radio frequency, crystal detector, two stages of transformer-coupled audio, and one stage of impedance-coupled audio. Two controls. Price complete parts, $50.00.

223. Phonograph Amplifier—A five-tube amplifier device having an oscillator, a detector, one stage of transformer-coupled audio, and two stages of impedance-coupled audio. The phonograph signal is made to modulate the oscillator in much the same manner as an incoming signal from an antenna.

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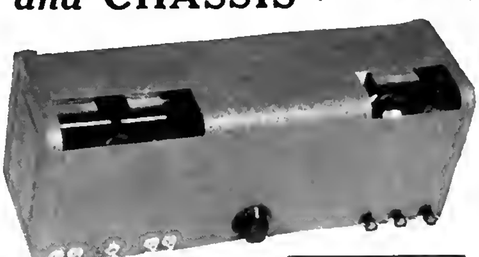
$6.00 for the complete unit. Includes insulation bushings, washers and all necessary hardware and accessories



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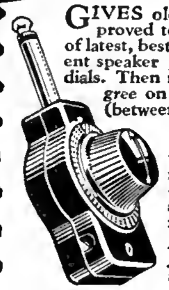

GIVES old receivers the improved tone volume control of latest, best sets. Replaces present speaker plug. Tune in with dials. Then modulate *to any degree* on Modu Plug alone (between speaker and set). Reduces interfering noises. Attaches without tools. Nothing else like it. Cord or Jack Type, $2.50 at dealers', or mailed C. O. D.

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A KEY TO RECENT RADIO ARTICLES

By E. G. SHALKHAUSER

THIS is the twentieth installment of references to articles which have appeared recently in various radio periodicals. Each separate reference should be cut out and pasted on 4" x 6" cards for filing, or pasted in a scrap book either alphabetically or numerically. An outline of the Dewey Decimal System (employed here) appeared last in the January RADIO BROADCAST.

R582. TRANSMISSION OF PHOTOGRAPHS. PHOTOGRAPH TRANSMISSION.
Radio. Feb., 1927. Pp. 18-ff.
"Radio Photography and Television," Dr. E. F. W. Alexanderson.
The writer gives a brief survey of the problems of telephotography and television, the developments made to date, the research being carried on in the laboratory, and the difficulties that will have to be overcome in order to make television practical.

R342.6. RADIO-FREQUENCY AMPLIFIERS. AMPLIFIER, *Infradyne.*
Radio. Feb., 1927. Pp. 20-ff.
"Infradyning R. F. Receivers," E. M. Sargent.
Wiring diagrams and data are presented showing how the Infradyne amplifying principle may be adapted to four well-known circuits, namely, the Browning-Drake, the Hammarlund "Hi-Q," the Bremer-Tully Counterphase, and the Silver-Six.

R334. FOUR-ELECTRODE TUBES. VACUUM TUBES, *Four-Electrode.*
Radio. Feb., 1927. Pp. 23-24.
"A Four-Electrode Tube and Circuit," H. de A. Donisthorpe.
Several uses to which four-electrode tubes may be put are outlined. Circuits are given for rectification, for combined radio-frequency amplification, for detection, and for audio-frequency amplification. A circuit is also given where rectification and radio-frequency amplification are accomplished with the use of only one tube.

R007.1. UNITED STATES LAWS AND REGULATIONS. LAWS AND REGULATIONS.
Public No. 632–69th Congress. H. R. 9971. Feb. 23, 1927.
"An Act for the Regulation of Radio Communication, and for Other Purposes."
The new radio law of 1927, enacted by the Senate and the House of Representatives, and signed by the President on the 23rd of February, 1927, is printed in this copy, which may be obtained from the Superintendent of Documents, Government Printing Office, at 5 cents per copy. Other acts and resolutions, previously in effect, are repealed by this act placing all control under the new law.

R582. TRANSMISSION OF PHOTOGRAPHS. PHOTOGRAPH TRANSMISSION.
RADIO BROADCAST. March, 1927. Pp. 459-462.
"Television: Europe or America First?" E. H. Felix.
An account is given of the theoretical and experimental work carried on by Dr. E. F. W. Alexanderson of the General Electric Company, in the field of television and radio photography. The apparatus consists of a source of light, a lens, and a revolving drum carrying a number of reflecting mirrors. It is stated that, in order to make television a success by the method outlined, it will be necessary to transmit something like 300,000 pictures per second, a feat very difficult, if not impossible, to accomplish, unless other major difficulties are first overcome.

R343.7. ALTERNATING CURRENT SUPPLY. ELIMINATORS, *B-Battery.*
RADIO BROADCAST. March, 1927. Pp. 477-479.
"What You Should Know About B Power-Supply Devices," E. H. Felix.
A general discussion of B battery eliminators is given. The essential elements in such a unit consist of a transformer which steps up the line voltage to an amount determined by the requirements, a rectifier element, a system of inductances and filters to smooth out the pulsating output, and a potentiometer output device to obtain various voltages.
Tests made on a dozen different power-supply devices are shown in graph form. The operation, maintenance, and the causes of trouble are outlined in detail.

R343. Electron-Tube Receiving Sets. RECEIVER, *Reflex.*
RADIO BROADCAST. March, 1927. Pp. 480-482.
"Building the R. G. S. Inverse-Duplex Receiver. Part. 3," D. Grimes.
This is the third of a series of articles describing the new Inverse-Duplex system of reception, and presents the constructional details for the adaptation of the previously outlined developments to the R. G. S. receiver. Wiring diagrams, a list of parts required, and data on winding the special coils used, are given.

R342.5. POWER AMPLIFIER. AMPLIFIER, *Power*
RADIO BROADCAST. March, 1927. Pp. 489-492.
"Constructing an Amplifier-Power Supply Device," James Millen.
Detailed information is given on the construction of a three-stage resistance-coupled power amplifier operated directly from an a.c. source. The data include the winding of the power transformer, choke coils, and output impedance.

R343. ELECTRON-TUBE RECEIVING SET. RECEIVER, *Model EA Gorod.*
RADIO BROADCAST. March, 1927. Pp. 495-497.
"A. C. as a Filament-Supply Source," B. F. Miessner.
Data are given on the operation of a receiver deriving all of its power from the lighting mains. Three 112 type tubes, one 199 type tube for detector, and one 210 type tube for the last stage of power amplification are used in this set. A description of the power conversion unit is given.

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Radio Panels

Black, Mahogany and Walnut.
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Machine easier and are better electrically than any other material in common use.
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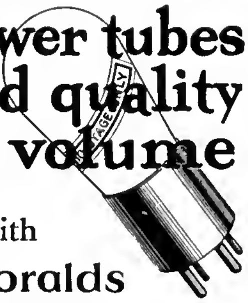

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For UX 171 and UX 112 Tubes, Na-Ald 112 Connectoralds are recommended for maximum volume with storage battery sets. These tubes will deliver without distortion several times the volume of the regular 201A.. Price $1.50

For UX 120 Tubes in UV 201A sockets, the Na-Ald No. 120 Connectorald should be used. To convert a storage battery set to dry batteries with ample loud speaker volume, use a UX 120 tube in the last audio stage with the 120 Connectorald and UX 199 tubes with 419X Adapters in the other sockets. Price $1 25.

For the UX 120 Tube in UV 199 sockets, ample loud speaker volume without distortion is obtainable from any set equipped for UV 199 tubes by means of the UX 120 or equivalent tube with the Na-Ald No. 920 Connectorald. The tube is raised slightly, but provides for its use in most sets with limited headroom. Price $1.25.

For UX 120 tubes in the UV 199 sockets of the Radiola Superheterodyne Semi-Portable, and Radiola Super VIII. These excellent Superheterodynes will deliver ample volume for loud speaker operation when equipped with the UX 120 used with the Na-Ald No. 420 Connectorald. Price $1.25.

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Dept. B-26 Springfield, Mass.

U. S. Patent, Oct. 12, 1926

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Ask your radio dealer
FANSTEEL PRODUCTS CO., INC.
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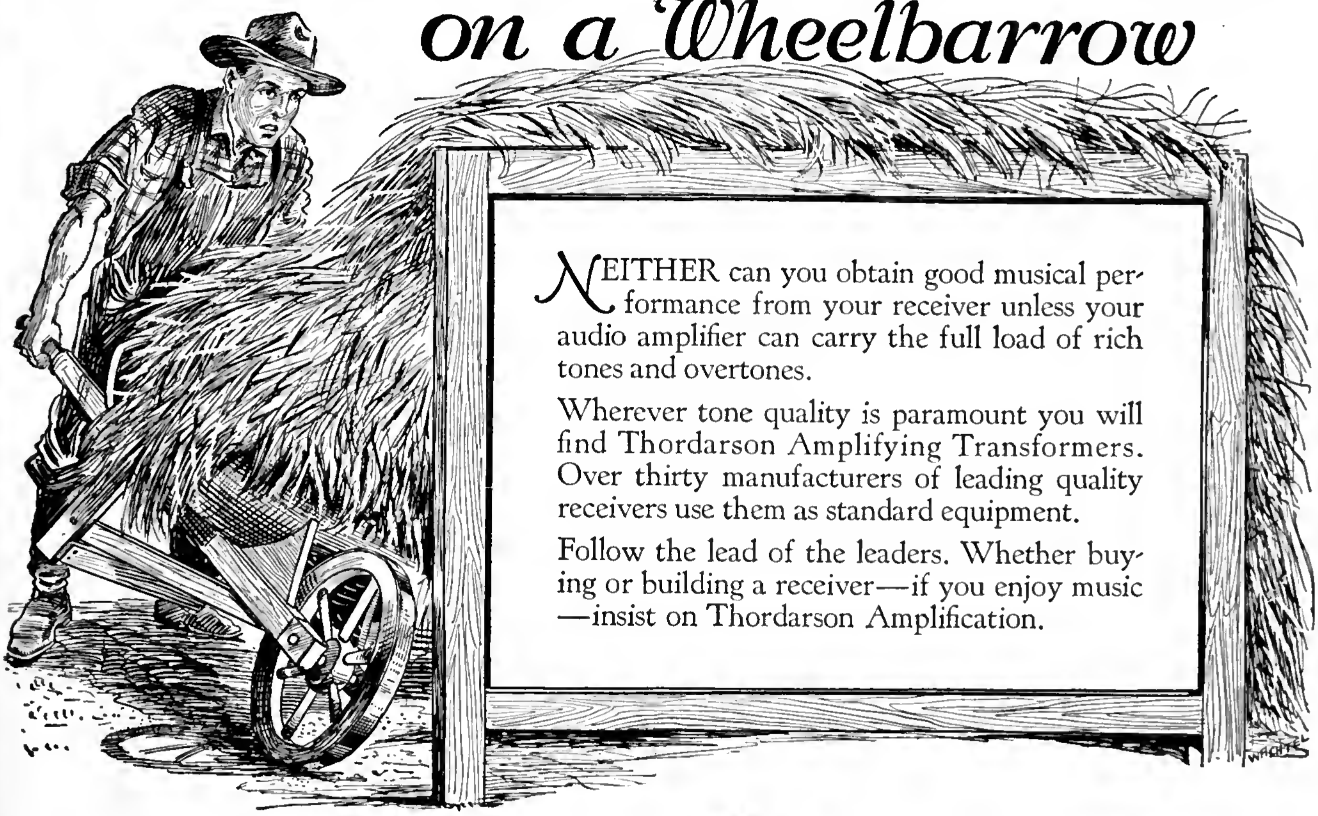

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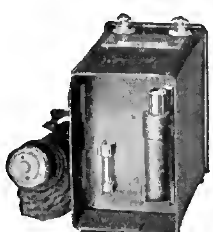

DRY—As dry as they make them. In fact the rectifying element is contained in a moisture-proof cartridge.

SILENT—No vibrating parts. Current is rectified through a patented electro-chemical process.

SAFE—There is no hazard to rugs or woodwork for there is no acid to spill. The tubes of the set are safe, even if turned on when the charger is in operation.

COMPACT—Fits into battery compartment easily. Only 2¾" wide, 5¾" long and 4¾" high, overall.

EFFICIENT—This charger is always ready for service. No overhauling required. Rectifying element is held in spring clips and can be replaced in thirty seconds.

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CHARGING RATE—2 amperes.

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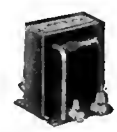
Type R-171, $15.00
Type R-210, 20.00



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A transformer designed for the musical epicure. The large core of finest silicon steel and the high inductance primary winding combine to give this instrument the most perfect transformer reproduction obtainable. Has a remarkably wide range of amplification. Ideal for use with cone type speakers. Designed for both first and second stage amplification. Weight, 2 lbs.

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RADIO BROADCAST

WILLIS KINGSLEY WING, Editor

JULY, 1927

KEITH HENNEY, Director of the Laboratory — EDGAR H. FELIX, Contributing Editor

Vol. XI, No. 3

CONTENTS

Cover Design . . . . . *From a Design by Harvey Hopkins Dunn*

Frontispiece
In the Radio Cabin of an England-Egypt-India Airplane 134

The Aurora and Fading . . . . *Austin G. Cooley* 135

The March of Radio . . . . . . *An Editorial Interpretation* 138

- What the Radio Commission Is Accomplishing
- Radio Freedom of Speech Impossible
- What Stations Shall Be Eliminated?
- Unnecessary Duplication of Radio Standards
- Why Important Events Can't Always Be Broadcast
- Radio Reception Is No Longer Seasonal
- Radio Control Unsettled in Australia
- Where Are the Listeners' Organizations?
- Misuse of the Word "Broadcasting"
- Probable Progress of Television
- Two Announcements by the Westinghouse Company
- The Patent Situation
- The Month in Radio

A Low-Cost Battery Charger . . . . *James Millen* 143

"Strays" from the Laboratory 146

- Measuring Audio Amplifiers
- A Fine British Magazine
- Batteryless Receivers
- Articulation Curves
- New Equipment

How to Build a 36-inch Cone . . . . . *Warren T. Mithoff* 148

Something About Single Control . . . . . *Edgar H. Felix* 151

A Lamp Socket A, B, C Device . . . . *Gilbert Edgar* 153

An A, B, C Power-Supply Unit for 201-A Type Tubes
Roland F. Beers 155

Receiver Design for A. C. Operation . . . *Howard E. Rhodes* 157

The Listeners' Point of View . . . . *John Wallace* 159

- Sunday Broadcasting Is Five Years Behind the Times
- How It Feels to Face a Microphone For the First Time
- British Listeners Want Lighter Broadcast Fare
- Thumb Nail Reviews
- Microphone Miscellany
- Communications

A Combined Push-Pull Power Amplifier and Socket B Device
The Laboratory Staff 163

A Portable Long-Wave Receiver . . . . . . *Keith Henney* 165

As the Broadcaster Sees It . . . . *Carl Dreher* 167

- The Place of Television in the Progress of Science
- What the Broadcast Technician Should Read
- Technical Problem for Broadcasters, No. 2
- Technical Problem for Broadcasters, No. 3
- Thirteen Years Ago
- Radio Revolutionized Again
- Solution to Technical Problem No. 2
- Solution to Technical Problem No. 3

Description of a Short-Wave Station . . . *C. R. Runyon, Jr.* 171

"Radio Broadcast's" Laboratory Information Sheets 176

- No. 105 Measuring R. F. Resistance of a Coil
- No. 106 The UX-240 Type Tube
- No. 107 Neutralization
- No. 108 High-Voltage Supply for 210 Type Tube
- No. 109 The Threshold of Hearing and Feeling in the Ear
- No. 110 Dry-Cell Tubes
- No. 111 Index
- No. 112 Index

Equipment for the Home Constructor 182

Manufacturers' Booklets Available 186

What Kit Shall I Buy? 190

AMONG OTHER THINGS. . .

THIS issue of RADIO BROADCAST is almost an A.C. current supply number, for there is a wealth of information on the new methods for running vacuum tube filaments and supplying B and C potentials too. Although the four articles concerned do not total a great number of pages, they are the result of a great deal of laboratory work, and they contain plenty of information to aid the home constructor. Both the Raytheon and the Q. R. S. high-current rectifier units have been carefully tested for many weeks in the RADIO BROADCAST Laboratory under Howard Rhodes's direction and applied to receivers of various sorts. Much interest will also attach to James Millen's descriptions of the remarkable A battery charger tube developed in the Raytheon laboratory.

THOSE of a theoretical turn of mind will find Austin Cooley's story dealing with the aurora and radio fading, as observed on the last MacMillan Arctic expedition, of considerable interest. Mr. Cooley's deductions are ingenious and perhaps will cast considerable light on some of the problems of radio transmission. Neither RADIO BROADCAST, nor indeed, Mr. Cooley, regard the theory as more than an entering wedge. We hope other investigators may be encouraged to make actual long-time measurements which will give us a better basis for conclusion.

RADIO men, traditionally, are argumentative souls and those who have turned their attention to the economics of the current supply of radio receivers will find some interesting figures on page 146 of this number. Our position is neutral, but discussion is interesting.

OUR correspondents are constantly asking us for lists of radio reading matter, text book and periodical. A very helpful list of recent works is found on page 168 of this issue. There are, of course, many other standard books of value, many of which have in the past been reviewed in this magazine.

RADIO BROADCAST for September will contain the first of an usually complete series of articles on the elimination of interference. These articles are practical and definite and should help many a puzzled citizen to improve local reception. A shielded neutrodyne which can be built from standard parts will be described in the same issue. It was designed by H. G. Reich, a member of the physics department at Cornell University. A beautiful 80-meter code and phone transmitter will be described, also, and it will delight the heart of all of us who are interested in a compact efficient transmitter for this wave-band.

MANY features of RADIO BROADCAST, as our readers have discovered and generously appreciated, are designed to supply regularly concise information which is not to be found elsewhere. The Laboratory Data Sheets were the first of these features of this nature, then "The Best in Current Radio Periodicals," the "Manufacturers' Booklets Available," and, with the June issue, we began a listing of kits for building receivers, together with a brief technical summary of each. Information about kits can be secured through the Service Department of RADIO BROADCAST by exactly the same procedure that so many of our readers have followed with the manufacturers' booklets.

—WILLIS KINGSLEY WING.

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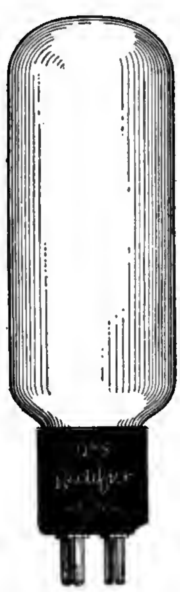

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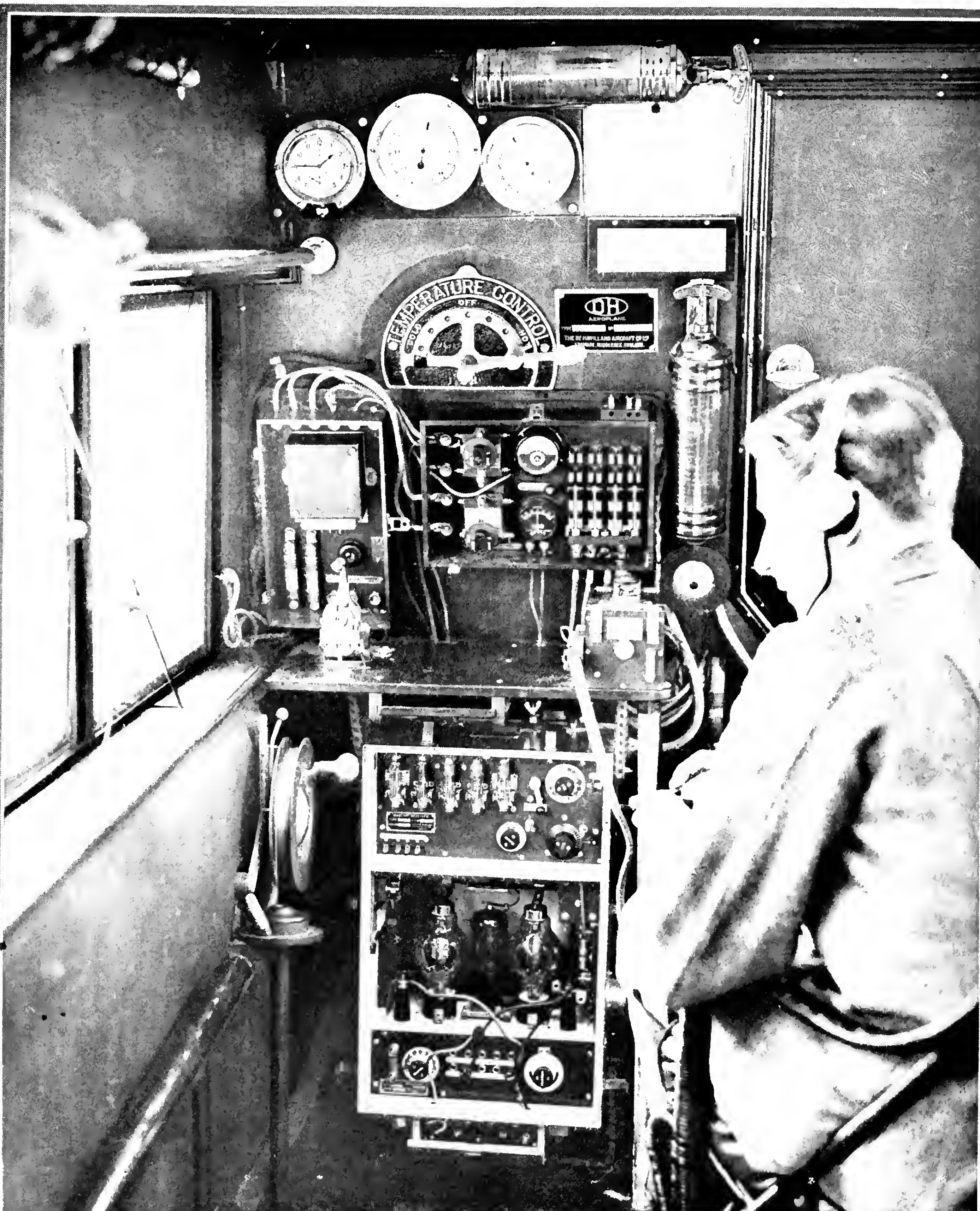


IN THE RADIO CABIN OF AN ENGLAND-EGYPT-INDIA AIRPLANE

Under the new international air regulations, a radio operator and mechanic is carried aboard passenger air liners. Previously the wireless apparatus was operated by the pilot and fitted in the cockpit. The 150-watt apparatus shown is aboard a De Haviland 66 Hercules multiple-engined machine on the England-Egypt-India air route. The reel for lowering the antenna is at the left

RADIO BROADCAST

VOLUME XI | NUMBER 3

JULY, 1927

The Aurora and Fading

A Report of Some Observations on the Relation Between Radio Signals and the Aurora Made During the Last MacMillan Arctic Expedition to Greenland and Labrador

By AUSTIN G. COOLEY

THE mystery of fading and freak radio conditions has been one of the most prominent problems in the science of radio since its earliest days. It has been observed in a general way that some relation exists between radio fading and other phenomena such as air pressure, temperature, humidity, auro[illegible]tc., but no generally accepted hypothes[illegible]idence has been advanced for considera[illegible]t definitely ties these phenomena together.

Besides the studies made during the 1926 Rawson MacMillan Sub-Arctic expedition for the Field Museum of Chicago, were the efforts made by the writer to find a relation between the aurora and fading. As will be remembered, the *Sachem* (one of the two boats on the Expedition) was outfitted with radio equipment designed in the Laboratory of RADIO BROADCAST. The writer was the operator chosen to make the trip, and was thus able to make the studies which are outlined in this article.

Every effort was made to collect information that would prove valuable in determining what relation, if any, existed between aurora and radio fading. Owing to the lack of time and the limited amount of apparatus available, it was possible to collect only a fraction of the information that might be useful in the study, but sufficient was observed to point out a possible solution to one of the mysteries of radio fading.

During an early part of the Expedition, while on the coast of Labrador, mirages of ice and land caused considerable attention and comment. Commander MacMillan spent an evening telling of his experiences and observations on mirages to the members of the crew of the *Sachem*. He said that, if conditions were right, it would be possible to see mirages of objects half way around the world. This suggested the possible relation of mirages to short-wave radio transmission because radio and light waves are the same except for length. The shorter radio waves, which have a closer relation to light, seem to behave in very much the same way as light in that they can be reflected or refracted so as to reach far distant parts of the globe.

A radio communication from the Expedition to RADIO BROADCAST commenting on this possible relationship, and telling of the mirages on the Labrador Coast, brought the following reply:

> Greatly interested in your reflection idea. New York *Times* July 15 quotes Captain Rose of Steamer *President Adams* at 8 P. M. July 15 in Mediterranean Sea bound for Port Said quote Saw large field of floating ice cakes suspended above horizon and presently a number of small pieces drifted into view followed by a large one. The latter was so clear that we could see blue and green veins in the ice unquote Nearest ice field was 8000 miles away.

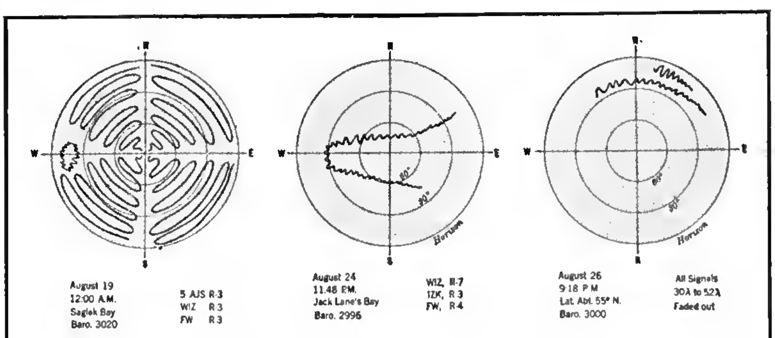
This news gave one member of the Expedition courage enough to tell a story he had heard about people in an Alaskan town seeing a mirage of an European city.

The mirages seen off the Labrador Coast formed very slowly. As a rough guess, the time averaged around five to fifteen minutes. They generally remained in position for a number of hours. Because of this slow action, we did not suspect that there might be a connection with radio fading, but observations taken about a month later indicated that the occurence of mirages was an important factor to be considered.

Except for the last few days, no unusual radio conditions prevailed while the Expedition was off the Greenland coast. Reception on short waves seemed to be excellent regardless of position with respect to surrounding land or mountains. During the last three or four nights, however, it was very difficult to establish communication with any of the amateur stations in the States. For long periods, practically no amateur signals came through. The weather conditions at first were such that it could not be determined whether aurora existed at the time or not, but the weather cleared up enough the night of sailing west from Sukkertoppen, Greenland, to allow us good vision of the skies. Strong displays of aurora were observed but no time was then available to make any studies. While crossing Davis Straits to Baffin Land, fading on short waves made communication very difficult as the signals generally faded in and out in cycles varying in length from five to fifteen minutes. Again, thick weather prevented thorough investigation.

It was not until the Expedition arrived at Saglek Bay, Labrador, that anything definite could be determined regarding the aurora. Fortunately the displays at Saglek Bay were unusually strong and the weather perfectly clear.

Here it was soon found that some association existed between the aurora and fading yet there were times when the signals were absolutely unaffected during strong displays. The problem resulted into one of determining just when and how the signals were affected in relation to the aurora. Having no information that would suggest what to look for, it was difficult to determine just what observations should be made. After watching the aurora and signals for a little over an hour, there appeared to be some



HOW THE AURORA WAS LOGGED

The observer is supposed to be situated at the center of the circle and if some aurora is noted in the northern sky at an angle of somewhat less than 30° with the horizon, then some lines to indicate it are roughly drawn on the sketch between the horizon and the 30° circle. Such conditions existed when the right-hand sketch was made, the effect on radio signals being noted below the drawing. The center sketch shows aurora of a somewhat different form while the left-hand sketch indicates that the sky was, at this particular time, completely covered with bands of aurora, while a small cluster was also seen in the west relation between the location of the aurora and strength of signals but it was all very puzzling. At times the sky would be completely covered with aurora yet the signals came through nicely, while at other times, the signals faded out completely when only a very small amount of aurora was visible.

While at sea the night after this display at Saglek Bay, further observations were taken but under quite different conditions. The aurora formation was entirely different in that it formed in long bands on the northern horizon then moved across the skies to the zenith—at times the bands traveled on to the south until they reached within thirty degrees of the southern horizon before they faded out. The relation of the aurora bands to radio fading appeared very definite. When the bands were between ten and thirty degrees above the horizon, the signals coming from the opposite direction to the aurora faded out completely. When the bands were more than forty-five degrees above the horizon, the signals were not sufficiently affected that any difference could be determined between reception then and under normal conditions. The actual intensity of the aurora seemed to have little or no effect on the signals.

The magnetic storm accompanying the aurora display was observed by taking bearings on islands and then watching the compass. As the streamers passed overhead, the compass was observed to swing about eight degrees, but when the streamers were close to the horizon, no effect on the compass was observed. This information appears to be interesting in that the radio fading did not occur during those periods when the magnetic swing was the strongest.

The district in northern Labrador where these studies were made is known as the zone of maximum amount of aurora. Consequently, the opportunities for making investigations on terrestrial magnetism and radio fading are great in these regions. For good work, a complete line of apparatus is necessary, the most essential thing being some device for scaring away the mosquitoes. Labrador is also the zone of maximum amount of flies and mosquitoes! Preparations were made to measure intensity and direction of earth currents during an aurora display near Nain, Labrador, but it was not possible to stay ashore for longer than ten minutes at a time on account of the flies, despite the fact that head nets and oils were used for protection.

The magnetic storms continued and the weather remained clear for a number of days, so it was possible to observe the aurora at leisure. All the information we gathered checked nicely with that obtained during the first two nights.

Fading was watched on two wave bands; one from twenty to one hundred meters (15,000 to 3000 kc.) and the other from two thousand to eighteen thousand meters (150 to 16 kc.). Because of familiarity with reception between thirty-two and forty-eight meters, this particular band was given the most attention. While at Saglek Bay, a broadcast receiver was set up ashore for the purpose of receiving a special program being broadcast from WJAZ, Chicago, but it was not possible to hear any of the broadcast stations. Under normal conditions, the broadcast stations could be heard reasonably well, even in Greenland.

Before trying to account for the fading during certain phases of the aurora displays, it probably would be interesting to consider a few of the definite cases. It was found that the European commercial short-wave stations were the last to fade out, their direction being a little south of east. Generally, when they were received weakly, it was found that they were sending test signals or sending traffic slowly and each word twice, this indicating that they were also experiencing the fading effects. Station KEL, near San Francisco, generally came through even when all the other stations on short waves had faded out completely. This station was operating on a wave of about thirty meters and its direction bore about thirty degrees south of west. At no time was it noticed that KEL was having difficulty getting his signals through to his receiving station which was in a westerly direction.

The schooner *Morrissey* of the Putnam Expedition, which was about a thousand miles to the north of us, operated without difficulty in communicating with a station near Chicago. The *Morrissey's* signals were received with normal intensity on the Labrador Coast when the aurora was very strong in his direction but his signals faded out when the aurora was confined chiefly to the southern horizon.

No fading effects were noticed on wavelengths above two thousand meters. No static noises were noticed at all during any of the aurora displays and all was quiet except for noises caused locally aboard the ship.

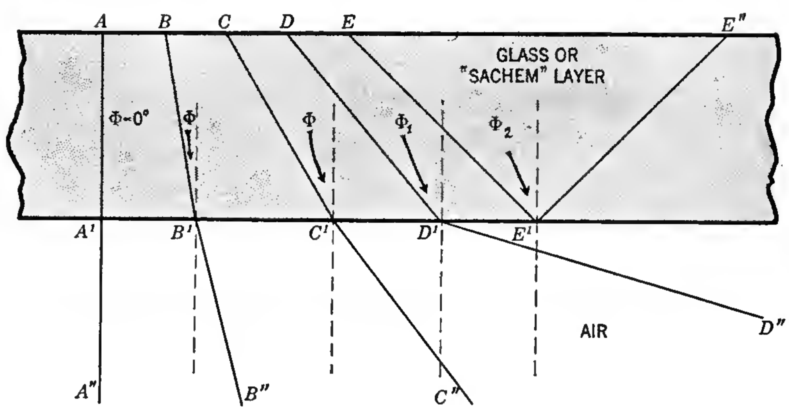


FIG. 1

THEORIES INVOLVED

THE physics of light seems to play an important part in the phenomena of radio wave propagation. In trying to account for radio fading it is best to consider first a few of the simple laws of reflection and refraction of light beams. When a light beam passes through one medium, e.g., glass, into another, e.g., air, the beam is bent or refracted. The amount of bending is a factor of the difference in speed with which the light travels through the two different mediums. The relative speeds of light in mediums are designated by their "index of refraction." The index of refraction of a vacuum is taken as unity. Glass has an index of refraction of about 1.6, and diamonds about 2.4. The "index of refraction" also varies with the wavelength. In the light and heat spectrum, the index decreases with the increase of wavelength. This has also been found to be true in the radio wave spectrum.

Fig. 1 shows how a light beam is refracted when passing through glass into air. The letters A, B, C, D, E, represent the sources of light beams. As the angle of incidence, ϕ, increases, a point will be reached where the ray will not pass into the air but will be totally reflected. The smallest angle at which total reflection occurs is known as the "critical angle," and in Fig. 1 is some value between that of ϕ_1 and ϕ_2.

Considering that radio waves are the same as light waves except for the difference in length, we may expect them to behave similarly. With mirrors it can be definitely shown that short radio waves may be reflected in the same manner as light waves. It has also been demonstrated that radio waves may be refracted as light waves are when passed through a prism or lens. The amount of refraction for radio and light waves is almost the same in some prisms.

A radio wave is known to follow two paths, one along the surface of the earth and another into the higher atmospheres. Some of the waves taking the latter course appear to be reflected back to earth after they reach a certain height. The medium which causes this reflection is known as the Kennelly-Heaviside Layer and its height has been determined through the efforts of Dr. A. Hoyt Taylor and Doctor Hulburt to vary from 100 to 500 miles, depending upon the time of day and the season. The theory of reflection from the Kennelly-Heaviside Layer is generally accepted, so there is no need of considering it here in detail.

If a medium is placed over a receiving station so that the radio waves coming down from the Kennelly-Heaviside Layer are reflected, the receiving station will be completely shielded except for that portion of the radio waves which travels over the surface of the earth. Assuming that such a shielding medium does exist under certain conditions, let us consider just what effects may be expected. Referring again to Fig. 1, assume that the ray E-E[1] is a radio wave and the medium, instead of being glass, is the lower shielding layer or reflecting medium just referred to as existing between the station and the Heaviside Layer. This reflecting layer may for the sake of convenience, be called the "Sachem" Layer. If the radio wave strikes so that ϕ is more than or equal to the critical angle, the wave will be totally reflected. In Fig. 2 it is seen that, if the lower surface of the layer is cut at an angle, the same wave will pass on through to the receiving station.

If the lower surface is cut so as to incline the opposite way, Fig. 3, the waves C and D will strike at an angle more than the critical angle and will not pass on to the receiver.

If such a layer as suggested above does exist, it is most likely that its surface will be irregular and probably appears as waves that continually move due to slight disturbances. Any such layer then would cause radio fading which would be somewhat in proportion to the index of refraction of this layer, since the critical angle is dependent upon the refractive index.

Before referring any more to the observations made on the Expedition, it is best to consider the theoretical possibilities of any such layer. The requirements are that the index of refraction of the layer be greater than that of the atmosphere below if we are to obtain the reflections shown in the diagrams. It is also necessary to prove that the Heaviside Layer is above the Sachem Layer and that the two do not coincide and are not the same thing. There is not enough data available really to prove either of these two points; the best we can do is to attempt to draw reasonable conclusions from what information we have to work with.

In regard to relative heights of the two layers, the writer is guided by the work of Doctor Taylor and Doctor Hulburt and the studies made on the height of the aurora. The work of these two scientists appears to indicate that the Heaviside Layer at night on the Labrador Coast would be considerably over a hundred miles above the earth's surface. As will be mentioned later, it appears that the aurora occurs on the surface of the Sachem Layer. The aurora has been found to average about sixty miles in altitude.

The changes of refractive index at different altitudes cause light waves to be reflected and bent so objects at a distance may be seen. The images are known as mirages. The causes for the changes in refractive indices are variations in air pressure and temperature, but it stands to reason that the air pressure decreases with increase of height so we cannot expect to find in the upper atmospheres a layer having a higher refractive index than the air below unless some other factor than pressure has a control. From studies made with light it is found that the refractive index increases as the air gets colder. If there is a sudden drop in temperature in the upper atmosphere, we can plainly see that we will have the proper conditions for a reflecting medium that would reflect all waves striking at less than the critical angle.

At the irregular boundary line between the cold and warm air, the light waves are bent, or refracted, so as to give the wave appearance. With the air pressure as high as it is at the earth's surface, only a small change in temperature is necessary to produce these visible waves but, where the air pressure is less, a considerable change in temperature would be necessary to produce an appreciable effect. It was noticed that the fading effects that might be attributed to the Sachem Layer, only occurred when the air pressure was high. An increase of pressure at the line where the temperature drops would increase the possibilities of the existence of the Sachem Layer.

It is also to be considered that the surface of such a layer would be sharp since large temperature changes can occur in a very short distance. One often notices the sudden temperature changes in the air when driving in an automobile.

CHECKING UP THE HYPOTHESIS

THE investigations made on the Expedition appear to connect closely with the above hypothesis of the Sachem Layer in remarkable detail. Mirages and aurora appeared only as associated phenomena and not the direct cause of fading. From studies made, it appears that the aurora followed along the crest or high part of the Sachem waves. Because the waves were marked by the aurora, it was possible to tell just when signals would come through and when they would suffer reflection.

When the waves were very flat, the aurora appeared to fall from their crests into the troughs. This resulted in the entire sky being covered with aurora but, because the waves were rather flat, the radio waves were not subject to as much total reflection. Fig. 1 represents the case of a flat wave.

Since the inertia of the body of the Sachem Layer is very little, it is possible for the waves to travel at a very high speed. Judging from observations made in Labrador, it appeared that the waves traveled from five to thirty miles per minute. The major waves would undoubtedly be surfaced with smaller waves, as is the case with ocean waves. The smaller, or minor Sachem waves, can cause additional fading that would appear more rapid.

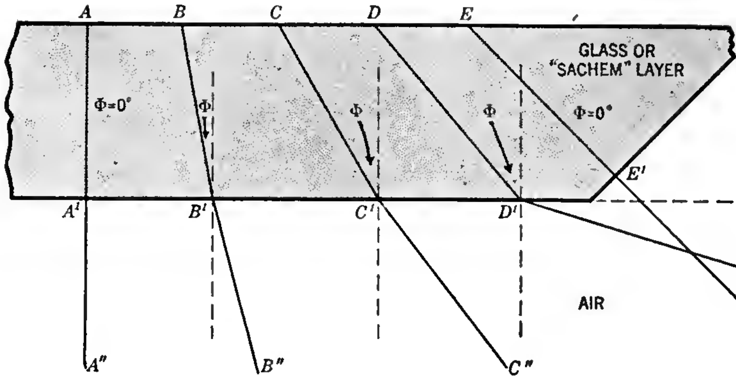


FIG. 2

It is to be noted that this Sachem wave hypothesis of fading takes into account the relation of temperature and humidity to the fading. When the temperature is high in the earth's atmosphere, a greater and sharper index of refraction will occur at the Sachem Layer. This will cause a larger portion of radio signals to be reflected so they will not reach the earth's surface. If the temperature is low, the change of index of refraction at the Sachem Layer may not be enough to cause any reflection even though the pressure may be high.

The humidity increases the index of refraction so fading would occur in a higher degree when the humidity is high. The effects of humidity on radio fading were given considerable study by Frank Conrad (8 XK, Pittsburgh) and James C. Ramsey (1 XA, Boston) when carrying on the first short-wave radiophone tests in 1922 on the sixty-meter band. They were thoroughly convinced that humidity affected fading.

It is also interesting to note that radio communication is chiefly affected in the north and south directions during aurora displays while land wire and cable communications are affected in the east and west directions, due to potentials generated in the earth probably by the swinging magnetic fields.

Vaudeville artists have been unable to determine whether the hen or the egg came first. With our present information it is difficult to say whether the aurora causes the Sachem Layer and waves or whether the Sachem Layer and waves cause the aurora. Probably neither is correct, but it seems certain that they occur at the same time and are dependent upon each other. The heavy air pressure on the surface of the earth has a direct relation to the Sachem Layer and may be the cause of it. The Sachem Layer may produce the proper conditions so that, by means of the magnetic field revolving with the earth, high enough potentials may be produced to cause an electrical discharge along the Layer in places where the proper pressure or "critical pressure" exists. Such an electrical discharge would tend to put a load on the earth's magnetic field and distort it. This may be the answer to the swinging of the compass as the aurora bands pass overhead.

It appears that only a slight change of index of refraction is enough to refract a radio wave considerably. This may be accounted for by reflection of polarized waves but, to avoid confusion, a discussion on this point will be omitted.

As mentioned before, a change of pressure or temperature will cause the index change. The index also varies with different gases. A possibility exists that the change at the Sachem Layer may be due to a gas change. If this should be true, it is quite likely the gas responsible is nitrous oxide.

In 1912, Mount Katmai in Alaska erupted. A large amount of sulphur dioxide gas escaped and was so strong at Cordova, Alaska, about 400 miles away, that enough dissolved in the rain to bleach cloth. Radio communication was impossible for a number of days, even over a distance of a few miles. Apparently even the earth waves suffered such reflection that they were unable to travel any distance from the transmitter.

Another case of the apparent effect of gases was noticed by the writer when operating two receiving sets, one from a loop and the other from an antenna subjected to smoke from a chimney. Considerable fading from a local station was noticed on the set operating from the antenna while the loop set operated without any noticeable change in signal strength.

It is hoped that the information and hypothesis advanced in this article will encourage other investigators to work along lines to prove or disprove all that is claimed here, so that, by a process of substitution and elimination, more of the factors influencing radio fading will soon be known.

The writer wishes to thank Dr. J. H. C. Martens, geologist of the expedition, for his help in obtaining information on the atmospheric conditions; Commander MacMillan for his helpful suggestions; and Commodore Rowe B. Metcalf who built and financed the schooner *Sachem*.

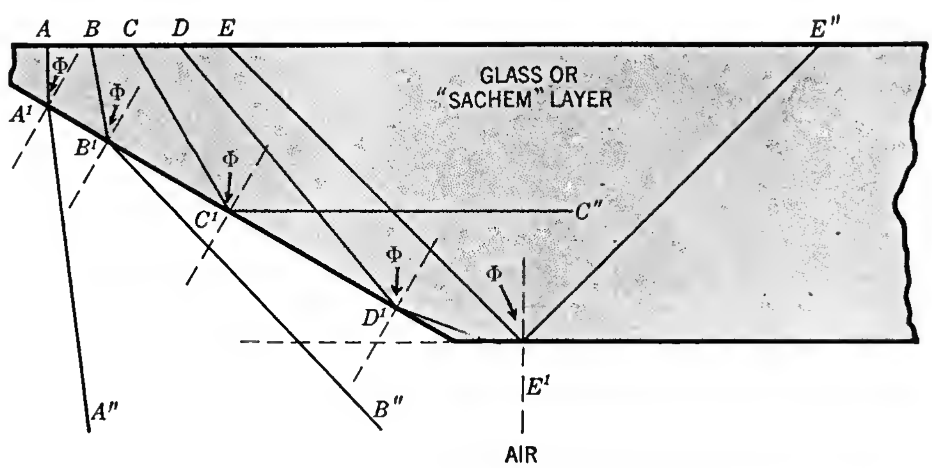


FIG. 3

The March of Radio

News and Interpretation of Current Radio Events

What the Radio Commission Is Accomplishing

THE Federal Radio Commission has proceeded to its labors with caution and moderation. Its first step was to clear of American pirates, the six usurped Canadian channels. Next it cleared the various channels of those stations which elected to occupy two broadcasting channels rather than one, by restricting allocations to channels exactly ten kc. apart. It definitely decided against broadening of the broadcast band. It opened up the lower frequency end of the amateur band for experimental purposes. It adopted a policy of temporary licensing of broadcasting stations, reserving the option to change the assigned frequency or power of any station at any time or to revoke its license at will. This permits the Commission to arrive at the ultimate lineup of stations by a careful process of evolution rather than by a dangerous upheaval.

The Commission has made a start in cleaning up the New York and Chicago situations by assigning all stations to channels at least twenty kc. apart, thereby minimizing heterodyning and cross talk between stations in the same area. Some incomprehensible broadcasters had actually been using channels only five, three, and two kc. apart from other stations in the same area, thereby successfully eliminating all listeners from both channels. The ultimate plan is to require at least a fifty-kc. separation between stations, allowing the simultaneous operation of twenty stations in the same area.

Fifty-kc. separation, although a vast improvement, still means a nearly complete air blanket by local stations in New York and Chicago for all but the most expensive radio sets. It is far from the ideal broadcasting situation. The next step should be to eliminate a few more excess ether polluters, of which there are many in New York and Chicago, whose demise will be loudly applauded by all listeners. For example, there is a group of anaemic New York stations, comprising the last word in program mediocrity, which are linked up in a chain, thus inflicting their hopeless hours upon the listener at three places on the dial instead of one. There is no excuse for a chain of stations serving the same area except when the combination is a temporary one, linked only for program events of transcendant importance, such as presidential addresses or national election returns.

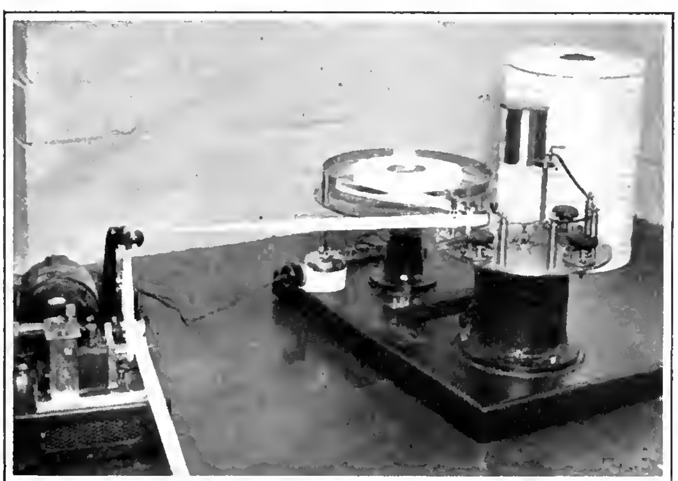
A further reduction in the number of channels required by New York and Chicago can be effected by requiring the splitting of time on the part of stations so limited in their ability to serve the public that they can afford to broadcast only during the prize hours of the evening. A station broadcasting only in the evening is not entitled to an exclusive channel. It should be limited to perhaps two evening programs a week. That would help to cut down the unpopular small fry.

Radio Freedom of Speech Impossible

IF WE omit those who make a profitable profession of agitating for freedom of speech, the radio audience is little exercised about this subject. We have examined several hundred replies to the questionnaire published in the May issue which, at this writing, are still being received from our readers in great numbers daily. Those who answered the questionnaire—and they are from all over the country—were emphatic and practically unanimous in their disapproval of the religious stations. In the Chicago district, another marked trend is indicated by the many requests for the elimination of WCFL and WJAZ. The feeling against WJAZ is particularly strong. Apparently undermining the Department of Commerce's legal status has caused distinct reaction. Other parts of the central west take particular delight in urging the immediate extinction of KFNF, KMA, and KTNT because of their blatant direct advertising. We regret that a few of our readers have even suggested diabolical forms of punishment for the owners of these stations, apparently a subconscious influence of previous incarnations, many being reminiscent of the Spanish Inquisition. A host of lesser stations come in for their share of blackballing, but the expressions toward them are not nearly as consistent or as emphatic as those directed against religious, direct advertising, and propaganda stations.

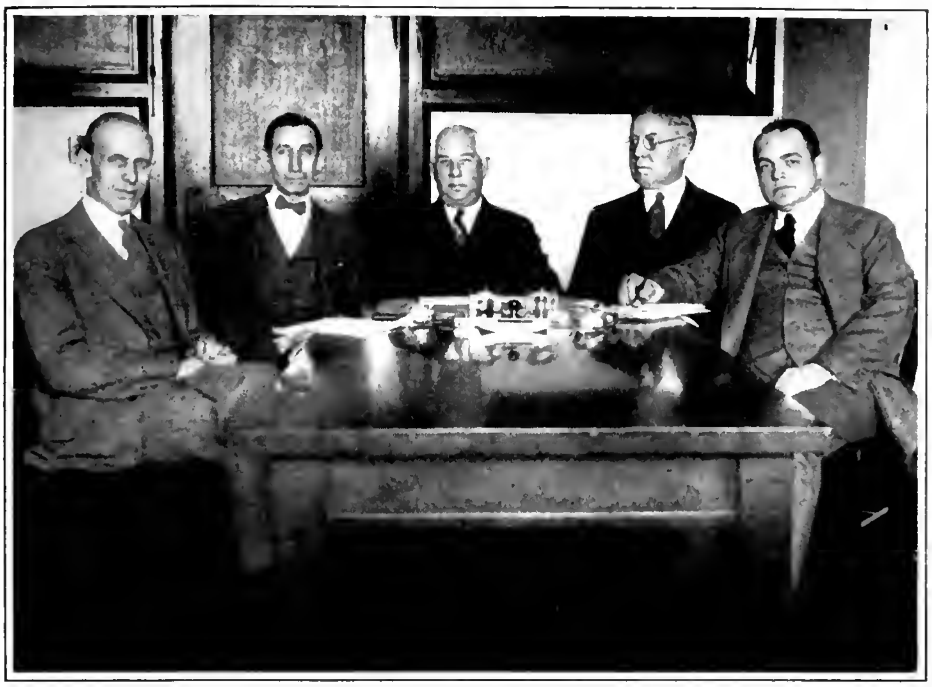
The old established stations, both of the chain and, we are glad to say, the better independents, rank highest among those stations which listeners wish retained. In our question, "What distant stations do you wish retained?" the percentage within range of KDKA putting that station first, is striking. The regularity with which KDKA, WEAF, WGY, and WJZ appear in that order is also remarkably consistent, while KYW, WGN, KPO, and KFI are strong in the approval of listeners within their respective ranges.

For making this statement of fact, we shall, no doubt, receive one or two letters from rabid demagogues, inquiring how much we were paid by the R. C. A. or the N. B. C. for mentioning the obvious superiority of some of their affiliated stations.



"BEAM" WIRELESS SERVICE DIRECT FROM ENGLAND TO AUSTRALIA

Messages are now sent at an average rate of 100 words per minute between London and Melbourne. The English receiver at Skegness uses the Marconi UG2 high-speed automatic syphon recorder shown in the illustration. An automatic tape puller is at the left



THE GOVERNORS OF THE UNITED STATES ETHER

The Radio Act of 1927 became law on February 24th. Its provisions did not go into force until two months later. From the time the Commission was appointed, it has been very active. In March, public hearings were held in Washington, giving a reliable cross section of opinion and suggestion for dealing with the broadcasting problem. The Commission has cleared the Canadian channels, reduced power of stations in residential districts to 500 watts, reënforced the 10-kc. separation between stations, and already reduced the total number of broadcasters from 732 to approximately 660. From left to right: H. A. Bellows, E. O. Sykes, W. H. G. Bullard, J. F. Dillon, O. H. Caldwell

In response, we regret to advise that, to date, we have not been rewarded in any way. We would like particularly to publish in full a scurrilous letter along these lines, sent us by a certain Mr. O'Hara of Nebraska, because it is representative of the type of letter which sometimes follows favorable mention of the pioneer broadcasting stations. The ratio of letters, endorsing our stand for a drastic cut in the number of stations, to these rabid letters, accusing us of being bribed by the monopoly, is far better than two hundred to one. Mr. O'Hara's occasional profanity and excessive wordiness make it impossible to quote him in full, but these few words indicate his trend of thought:

> You want to see 500 stations eliminated and these 500 are to be the ones you New Yorkers and the chain don't own fine business for you, then you and your pals can get $4500.00 per for the use of your stations for advertising and you will have no competition so you can put your price up and make 'em pay it because there won't be any other stations. Well old dear lets see you put that over and get away with it. The half has never been told in this radio game yet and the dear public are going to be told a few things during the next few months that may make some of you fellows think this is a cruel old world. You know that is what Donahue and Sinclair both think this miserable U. S. Govt. has just treated them terrible. You fellows are not kidding the dear publick as much as you think you are. You and your gang want to hog the radio broadcasting, not because you are so interested in giving the dear people high class programmes and by the way just what do you mean by high class programmes? Some cigarette smoking female Dago or Russian warbling in upper C till they drive all the dogs in the neighborhood crazy. If that is your idea of a high class programme and judging from the programmes we hear over WEAF it is just keep them in the cultured and protected east will you.

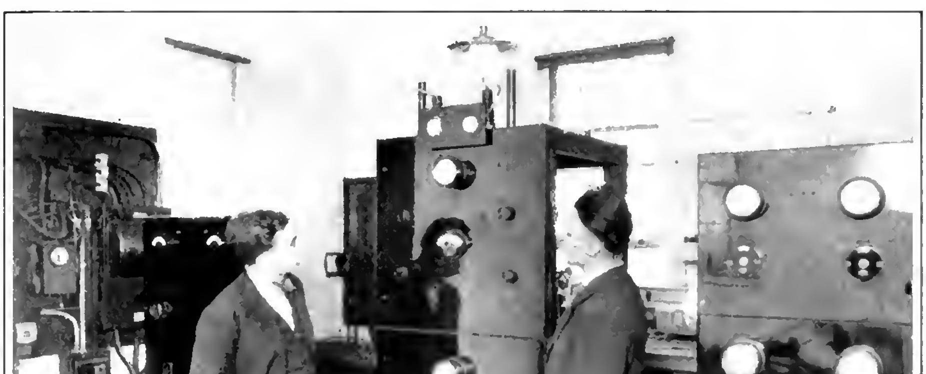
We inflict this twaddle on our readers to make certain that few, if any, agree with our correspondont. The suggestion that these columns are subsidized is silly; what we endeavor to do is to promote the good of radio as a whole. We are using what influence we have to bring about the conditions which the majority of listeners want and should have. Only by following such a course can we hope to continue our stready growth. We welcome expressions of opinion of our editorial stand and hereby take the opportunity to thank publicly the hundreds of readers who have written us favorably during the last few weeks.

We continue unhesitatingly to urge further reduction in the number of stations until the total falls to 225 or 250 powerful and capable broadcasters in simultaneous operation. We hope for a spirited competition in program attractiveness among independent, well organized, and well financed broadcasting stations. We are in favor of eliminating a great number of small stations so that we may have more great stations. This is our stand because it is sound common sense and because it is the expressed wish of a majority of our readers.

What Stations Shall Be Eliminated?

THERE is no excuse for the existence of a station which serves only a special and limited interest —to the exclusion of general educational and entertainment services to which the broadcasting band should be devoted. Since broadcasting facilities are limited because there is room for only so many stations on the air, some form of selection must be applied. That may be censorship; call it what you will. "Freedom" of the air is impossible because more wish to broadcast at the same time than the ether will accommodate. That means restriction and restriction is not freedom.

The first stations which must go are the



THE CROSLEY SHORT-WAVE BROADCASTING UNIT AT CINCINNATI

All the WLW programs radiated on the standard broadcast frequency of 710 kc. (422.3 meters) are now also simultaneously broadcast on 5760 kc. (52.02 meters). The power is 250 watts. On the left is Russell Blair, the Crosley engineer, who built the set. On his right is Joe Whitehouse, chief engineer of WLW direct advertisers because the public vigorously resents their existence. A broadcaster serving the private purposes of a harness maker or a seed salesman is not serving the public.

The next group which must go consists of stations representing perfectly legitimate special interests, but using the entire time of a private broadcasting channel for the benefit of only a fraction of the audience and for only a small part of the total hours of the day. Labor groups, sectarian religious appeals, socialism, Mormonism, atheism, vegetarianism, and spiritualism may require the use of microphones, but they do not require exclusive channels. If goodwill advertisers were as narrow minded as the religious and "ism" interests, they would demand separate and private channels also. Within a few evenings, we recently heard the LaSalle, the Willys Overland, and the Studebaker concerns broadcast through the same high-grade station. But suggest to a religious or educational group that they use a single station coöperatively with others of a different creed or line of thought and they wail that you discriminate against their interests.

There is need for a more generous spirit on the part of the smaller broadcasters, leading toward a healthy and desirable combination of stations with consequent increase of audiences, improvement of reception, reduced maintenance cost, and better program standards. There is no shortage of microphones to present any worthy cause. Broadcasters, accused of the most sordid commercialism, do not refuse the gentlemen of the clergy and educators free use of their broadcasting facilities. If the Radio Commission will let solely the interest of the listeners, rather than the private desires of the broadcasting station operators, determine their ultimate solution of the broadcasting problem, there will be a continued decrease in the number of stations on the air until they are less than 300.

It is unfair to condemn small broadcasters as a whole because here and there are one or two fine exceptions which have shown a far-sighted spirit of coöperation. We spoke to the owner of a small station in Newark which did not increase power or change wavelength through the radio dark ages, in spite of the fact that two pirates completely hedged in its programs. After such maltreatment, however, the station's owner expressed a willingness for the good of radio to discontinue broadcasting if all small broadcasters were to be treated in the same way. Another example for small broadcasters is that set by G. S. Corpe, who has been in radio since 1909, and who wrote us recently as follows:

The writer owned KUY, one of the first three or four stations on this Coast. It was a popular station, too, back in 1922; but two weeks after the Los Angeles *Times*—KHJ—installed a real Western Electric set, we discontinued KUY. Why? Because we felt that with inferior home-made equipment and a limited amount of talent in a small town, we were hurting radio by continuing rather than helping it. Apparently, there are some hundreds of broadcasters in the last year who have not been suffering from any such modest and retiring attitude.

But the majority of small broadcasters feel that self-elimination or combination is unthinkable. In the last analysis, there is but one choice. Broadcasting may remain stationary in comparative mediocrity and the radio industry will be thereby practically paralyzed, or the radio listener may be served by substantially reducing the number of stations, encouraging capital to spend huge sums on improved broadcasting by reason of the greater audiences of the remaining stations. The axe must be applied either to the broadcasting stations or to the radio industry, and the Radio Commission is choosing between the two. Happily, it is bending its efforts toward station reduction, a saving grace for the radio industry; our only fear is that it will not go nearly far enough in the right direction.

A RADIO BEACON FOR SHIPS

Operating directly off the ship's a. c. mains. It has two $7\frac{1}{2}$-watt tubes in parallel tuned to 352.7 kc. (850 meters). The signal—i. c. w.—is a series of one-second dashes for thirty seconds, followed by a silent period of thirty seconds. A single-wire antenna about 50 feet long is used, independent of the ship's antenna system. The beacon on shipboard enables ships using a radio compass to exchange radio bearings over a distance up to twelve miles. Naval radio compass stations on both coasts and on the Great Lakes now provide bearings to ships at sea on 374.8 kc. (800 meters)

Unnecessary Duplication of Radio Standards

EXPENSIVE trouble is being stirred up in the radio industry by the toleration of two separate organizations busily engaged in setting up standards. Standardization is vital but the establishment of two sets of standards is figurative suicide. We cannot be concerned with the respective claims or purposes of the organizations involved. Both groups are meritorious and well intentioned. In a previous issue, we stated that the radio industry was shortsighted in tolerating two sets of standards and were taken to task by one of these organizations for so doing. Its spokesman claimed to speak for the only representative organization. Whether his statement is true or not, the fact remains that two sets of standards are being drawn. We repeat that this is folly which in the end will be very costly. The rival organizations may differ entirely in purpose, membership, policies and what-not, but in the preparation of standards at least they should function as one organization.

Why Important Events Can't Always Be Broadcast

AN EDITORIAL in the New York *Evening Post*, entitled, "Radio and the Press," points to a serious evil of the broadcasting system, unavoidable under its present economic structure. The Butler-Borah debate, it pointed out, although of great public interest, could be heard only through two small New England stations, both of which were surrounded by interference from stations who had jumped their wavelength. None of the big broadcasting stations, because of commercial commitments, were in a position to offer their audiences this desirable event. The newspapers, on the other hand, were in a position to give the report of the debate plenty of space, hampered by no limitations as to cost of printing and paper, reportorial representation, and wire transmission; nor did the publication of this news require the sponsorship and capitalization of a commercial organization.

While the commercial broadcasting rate of even the best stations is necessarily limited at this stage of the game, a large proportion of their time must be given to commercial features which cannot, for very vital reasons of revenue, be set aside whenever an interesting broadcasting event heaves into sight. If the individual audience of stations be tenfolded, however, the increased revenue thereby gained would make it possible to set aside revenue producing features more freely in favor of such desirable news features.

Radio Reception Is No Longer Seasonal

A STATEMENT by the National Broadcasting Company to the effect that there is no summer seasonal slump in broadcasting program quality is supported by a list of regular weekly features which continue throughout the summer. The program fare of the listener is remarkably well sustained throughout this period and it is a pity that the tremendous prejudice against summer reception has been built up. This prejudice is a heritage of the days of headphone reception when even slight static impressed directly upon the ear drums of the listener caused acute discomfort. With modern pick-ups by loops or very small antennas, and up to date sound radiation through power loud speakers, reception from near-by and local stations is entirely satisfactory twelve months of the year. The seasonal usefulness of a good radio set is no less than that of a closed automobile which is out of service only for blizzard or hurricane for a few hours each year. Radio must make way only for thunderstorms. The only static eliminator required is the encouragement of the use of small pick-up devices, either loops or small antennas, rather than the all-too-long antenna frequently employed.

Radio Control Unsettled in Australia

AUSTRALIA is in the midst of an argument about the regulation of broadcasting. The Naval Board desires to shift the broadcast band from its present 300 to 400 meters area (1000 to 750 kc. area) up to the 800-meter (375-kc.) region. Any attempt to regulate broadcasting from any constricted point of view always works hardship on the listening audience. The Australian Naval Board's proposition means that special receiving sets of higher cost will have to be made and these sets will not be able to pick up foreign broadcasting which may some day be within their range.

Where Are the Listeners' Organizations?

OUR comments in a recent issue regarding the general ineffectiveness of most broadcast listener societies caused a number of irate "executive" secretaries to uncover the bushel which hid their feeble light. Some of these accused us most petulantly of going out of our way to disregard their frantic efforts to form a broadcasting listener organization. We are not, however, guilty of any prejudice or oversight, since none of them have, through public statements or by public attention gained through constructive activities, come to our notice previously. We hope that the spirit of service to the listener, which should animate the proponents of any listener organization, will be sufficiently obvious to cause large numbers of radio folk to flock to their standards so that at least one of them will ultimately become a powerful and influential organization. The policies of bona fide societies should be actually shaped by the membership itself and not by the dictation of their handful of founders. Too often, however, are new organizations the figment of the imagination of a professional executive secretary who sees in them a great opportunity for profit. Whether this is the case is easily determined by examining the method by which the officers are elected and by determining to what degree the individual member has a real voice in shaping the policies.

The most promising organization from which we heard was the United States Radio Society, claiming 5000 members in and about Cincinnati, Ohio. Fred G. Gruen, President of the Gruen Watch Guild, is the principal source of encouragement and funds for this organization, and he is putting much effort into building up something which is to give form to the listeners' desires in an unmistakable and influential way. We have not had opportunity to examine the constitution of the organization but do know, in the person of Mr. Gruen, that it has intelligent and unselfish leadership to commend it.

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THE LATE IRVING BARDSHAR CRANDALL

Irving Bardshar Crandall, a member of the technical staff of the Bell Telephone Laboratories and an authority on the telephonic transmission of speech and methods of recording it, died on April 22, 1927, at the age of 36, in New York. He was graduated from the University of Wisconsin in 1909 with the degree of Bachelor of Arts and received the degree of Master of Arts from Princeton. In 1916, three years after he had become associated with the Bell Telephone Laboratories, Princeton made him a Doctor of Philosophy. At the time of his death, Doctor Crandall was engaged on important experiments. He recently published a book, *Vibrating Systems and Sound*, and he had previously written many monographs on the scientific aspects of speech, analyses of its mechanisms, and methods for its transmission and recording. He was a Fellow of the American Physical Society and the American Institute of Graphic Arts

The Frequent Misuse of the Word "Broadcasting"

THE word "broadcasting" is frequently used in newspaper reports in referring to the dissemination of information through the regular radio telegraph channels. For example, it was recently announced that the Navy Department and the Weather Bureau in coöperation are broadcasting special weather information to aviators at 10:30 A. M. and 10:30 P. M. daily. The frequency employed is 8030 and 12045 kilocycles (37.24 and 34.89 meters). Eleven naval short-wave stations, well located, are used for the purpose. Obviously this is broadcasting in the sense that it is sent out in all directions by radio. However, the use of the term "broadcasting" should be confined to programs radiated in the broadcasting band. By so limiting the scope of the word "broadcasting," much confusion in the meaning of newspaper stories will be avoided.

PROBABLE PROGRESS OF TELEVISION

THE stimulation of inventions due indirectly to the growth of broadcasting appears to be rapid. The first important contribution of scientific progress engendered by broadcasting is the application of vacuum-tube amplification to phonograph recording and reproduction. Now comes high-grade loud speaker entertainment to accompany motion pictures, a decidedly important contribution, particularly for small communities which have had to content themselves with second rate mechanical accompaniment or quite incompetent musical groups. The educational possibilities of the combination of loud speaker and motion picture are perhaps even more important although less spectacular than the entertainment aspects. The next step is to link the motion picture with radio transmission to give us television, a process already hatched in the laboratory incubator. Most people imagine television as a means of enabling them to see the radio artists perform in the studio, a privilege, we are frank to say, often of doubtful value. More than likely, the visual program broadcast for general reception will lean heavily upon the motion picture studio for its source. The improvement of the phonograph and the loud speaker at the moving picture theatre is accomplished by the use of radio developments with but slight adaptations. Television, on the other hand, will need much research before it is within range of home use. Considering the speed with which our laboratories work, stupendous as the problems yet to be overcome are, it may be a matter of only two or three years before you will be buying television receivers as a part of your radio equipment.

TWO ANNOUNCEMENTS BY THE WESTINGHOUSE COMPANY

THE transmission of power by radio has frequently been made the subject of public demonstration during the last few years. The most recent announcement comes from Dr. Philips Thomas of the Westinghouse Company. He utilizes a high-frequency transmitter, a straight Hertzian antenna, and a metal screen to obtain the beam effect. The radio-frequency output is approximately thirty-five watts and, by its means, lamps are lighted from a distance of ten to fifteen feet. It seems that the transmission of power must await some important new dis-

L. S. BAKER

New York

Executive Vice President Radio Manufacturers' Association. A special statement for RADIO BROADCAST:

"The question of whether or not the listener keeps his set in operation, tuned to his favorite station, is the keystone of the entire radio industry. Without trustworthy sets, good broadcasting is of no avail; without good broadcasting, the best set made is nothing more than junk.

"In recognition of this phase of public opinion which joins the two gigantic divisions of the radio industry and makes what are otherwise totally independent divisions entirely interdependent one upon the other, the National Association of Broadcasters and the Radio Manufacturers Association have joined hands by consolidating personnel, in an effort to keep all phases of the industry in constant liaison with each other."

coveries before we get beyond the technique of the average amateur "glow" wavemeter.

At about the same time, another Westinghouse engineer, D. D. Knowles, demonstrated his light-sensitive vacuum tube relay which does with light and shadow what our radio tubes do with radio-frequency currents. One billionth of a watt of input light energy is sufficient to start a current as high as twenty-five milliamperes flowing through the tube which can, in turn, be magnified sufficiently to control an electric power system of any size. Thus it is quite possible by the use of this relay for a passing shadow to turn on the lights of a city, start or stop a railroad train, or move a battleship. The automatic turning on and off of street lamps at sunset and during dark storms is a valuable service which, accomplished automatically, may result in the saving of millions of horsepower annually.

THE PATENT SITUATION

THE patent examiner rejected claims of an interference under design patent 72,261, issued to M. C. Hopkins. Hopkins contended that the Atlas loud speaker was an infringement of his design patent. The patent examiner stated that merely to place a cone unit in the base "would not require an exercise of the inventive faculties. It would be regarded as a mere assembling of the elements which are old in the art of making radio loud speakers."

The Patent Office reports the following suits and decisions: Patent No. 1,589,308, J. A. Victoreen vs the Radio Art Company, decree pro confesso and injunction granted; 1,616,207, J. W. Wardell vs. Utah Radio Products, suit filed February 28.

The Latour Corporation has begun suit against the Charles Freshman Company of New York and the Zenith Radio Corporation of Chicago. The latter company has been licensed by the Radio Corporation and consequently the suit represents a test to determine the relative strength of the R. C. A., Hazeltine, and Latour patent groups.

The Splitdorf Bethlehem Electric Company, the American Transformer Company, and the Crosley Radio Corporation, have joined the growing group which is licensed under the Radio Corporation patents.

A recent decision in the Exchequer Court of Canada respecting the Alexanderson radio-frequency tuning patent and the neutrodyne system, was favorable to the former. The contenders were the Canadian General Electric Co. and the Fada Radio Corp. Ltd. of Canada.

The Month In Radio

THE Hudson River Navigation Corporation is replacing its orchestras aboard the night boats, plying between New York, Albany, and Troy, with the highest grade of power radio equipment. The principal problem has been to obtain receiving sets sufficiently sensitive to overcome the dead spots created by ore deposits in the Catskills. This apparently has been achieved by three existing radio equipments, while an additional factor of safety will be provided by the fact that the amplifier system may be actuated by a high grade phonograph equipment to alternate with the radio programs.

A COMPANY has been formed in Africa to take over the bankrupt South African stations under the protection of a government monopoly for a period of five years. Stock will be offered to the public. The interests backing the plan are in control of the most important South African theatres and they promise better programs which should discourage the extensive evasion of license payments, the reef on which the original broadcasting plan was wrecked.

DR. A. HOYT TAYLOR, of the Naval Research Laboratory, states that station 2XS of the Radio Corporation of America, which theoretically should be inaudible at distances between two hundred and six hundred miles because of the skip distance effect, is nevertheless clearly heard in this so called area. Oddly, the much talked of skip distance influence does not, in this instance, follow any of the prohibitions laid upon it by radio observers.

THE Radio Corporation of America announces an improvement in its photographic reproduction system which accomplishes a ninefold enlargement of the picture received by radio through a new and ingenious method of printing the radio picture. Instead of putting a light beam on the surface of the sensitive paper, a special photographic paper is used upon which heat rays have the same influence that light waves have on the ordinary photographic paper. A jet of hot air is blown on the newly developed paper, making a black mark. A second jet of cold air, controlled by the radio signal, intercepts the hot air wave. The result is a more rapidly produced, clear print, nine times as large as one made by light rays. It is such ingenuity that encourages us to predict practical television somewhat sooner than the scientists, steeped in the details of the problem, are willing to grant as a possibility. Incidentally, the transmission of photographs by wire has recently been supplemented by three-color service.

C. P. EDWARDS

Ottawa

Director of Radio, Dominion of Canada:

"Broadcasting in Canada is indirectly paid for by the broadcast listener himself through the Canadian licensing system, whereby the owner of every radio receiving set must take out a license, for which he pays an annual fee of $1. For the fiscal year ended March 31, 1926, the proceeds from broadcasting license fees of all classes amounted to $139,742.40.

"In only one case is any of these funds used to assist in the support of a broadcasting station. Station CKY, Winnipeg, owned and operated by the Provincial Government of Manitoba, has entered into an arrangement with the Dominion Government whereby it enjoys a virtual monopoly of broadcasting in that Province, and fifty cents out of each dollar license fee collected from residents of the Province is paid to the Provincial Government to assist in maintaining the station."

OBSERVERS at the recent demonstration of television at the Bell System Laboratory in New York stated that they sometimes observed two or three images reproduced in the background which appeared much as do the ghostly figures in spirit photographs. The engineers state that these "ghosts," which have only a fraction of the intensity of the main picture, are caused by signals which take a longer path through the atmosphere than the main incoming signal. In the reception of music, we have similar lag which expresses itself to the senses as indefinable distortion. Television may pay its debt to radio development by the spectacular way in which it will reveal the hidden causes of distortion in radio reception.

A DEPARTMENT of Commerce report states that there are 49.5 radio sets per thousand inhabitants in England. Sweden is the second European Country with 40.1, Austria, third, 37.8; Denmark 25.3, Germany 22, Norway 15.5, Czechoslovakia 12.9, Switzerland 12.8, Netherlands 7, Belgium 3.14, and Finland 3.1. No figures for France and Italy were reported.

A Low-Cost Battery Charger

Something About a New Raytheon Rectifier Tube Which Is Remarkably Efficient—A Home-Made and Compact 2½-Ampere Charger

By JAMES MILLEN

COMPACT AND RUGGED

This is the full-wave charger unit manufactured by the National Company, Cambridge, Massachusetts, and which employs two of the new "A" tubes described in this article. The circuit diagram of this charger is shown in Fig. 6

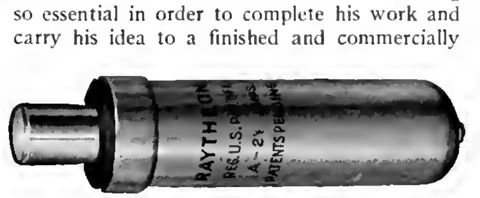
STORAGE batteries, the source of direct current for lighting the filaments of the tubes in a radio receiver, are just what their name implies; they have the property of storing up electrical energy in a chemical form within their cells, and when called upon to do work, discharge this energy by virtue of a chemical action which takes place inside the battery. As the current is drawn out of the battery, the nature of the plates and electrolyte which go to make up the cells of the battery, change their chemical character, and finally reach a point where it is not wise to make further current demands upon them. In this state, the battery is said to be discharged and it becomes necessary then to reverse the chemical action so that the plates are restored to their original state of usefulness.

This requires that a direct current be passed back through the storage cells, and our most convenient source of supply for this work is the energy to be derived from the house lighting circuit. However, in most cases, this energy is in the nature of alternating current and as such is unsuited for *immediate* use. The reason for this is that the current flows first in one direction and then in another direction, these changes occurring, in the case of a 60-cycle current, 120 times per second.

The job, therefore, is to employ a device which will make use of these alternations and provide a series of pulsations delivering current all in one direction. This device is termed a rectifier, and may be obtained in many different forms. Some, such as the electrolytic, depend for their operation upon chemical action. Others, such as the vibrator or magnetic type, depend upon a set of mechanical contacts which shift every time the alternating current reverses. Still others, such as the Tungar, depend upon the unidirectional conduction of the stream of electrons emitted by an incandescent filament in vacuo. All have their advantages and disadvantages.

Perhaps the ideal rectifier would consist of a piece of low-resistance wire with the property of conduction in one direction only. The recent perfection of a rectifier which approaches somewhat closely this ideal is what brings us to the main topic of this article.

Working under great handicap in his small laboratory just outside of Paris, a French physicist, M. Henri André, developed the forerunner of a new rectifier "tube," one of which is shown in a photograph on this page. But what could he do with his device? He did not have the facilities or financial backing so essential in order to complete his work and carry his idea to a finished and commercially



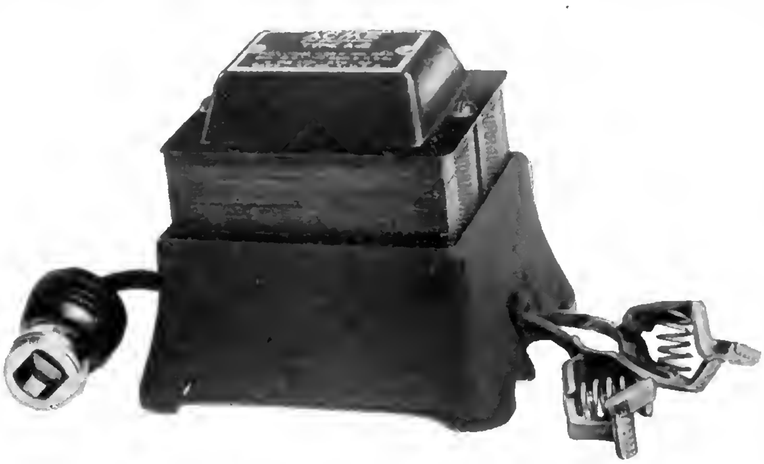
THE NEW 2½-AMP. "A" TUBE

practical state. Then radio stepped in, in the form of the research department of the Raytheon Company, specializing in the development and manufacture of rectifying devices for radio use. M. André came to America where with most complete laboratory facilities at his command and with several physicists and engineers to aid him, it took but a year to reach the long sought goal. A highly efficient, inexpensive, rugged, compact, and long-lived rectifier element, encased in a small steel tube hardly three inches long and less than an inch in diameter, was the fruit of his long labors.

As this new rectifier cartridge is now on the market, it is the purpose of this article to give a brief description of its theory of operation, together with some data on the design and use of a battery charger in which the tube is employed as the rectifying medium.

A rectifier as we understand it, is a device which offers great resistance, or opposition, to the flow of current in one direction and little or no opposition to the flow of current in an opposite direction. The more completely the rectifying device prevents current from passing in the one direction, and the more easily it permits current to flow in the opposite direction, the more desirable is its use as a rectifier. This new rectifier very admirably fits in with these requirements, for it involves a metallic conducting path with an oriented junction at one point which exerts very little effect when current flows one way, but which effectively opens the circuit when current attempts to pass in the opposite direction.

There is much yet to be learned in regard to metallic conduction, and the behavior of electrons in solids is not at all clearly understood. Hence a clear explanation of the exact nature of this oriented condition is indeed difficult. However, we may quote from a report by Dr. V. Bush, of the Massachusetts Institute of Technology, as follows: "All materials contain electrons distributed in orbits about the nucleii of atoms. When conditions are such that electrons may with ease pass from an orbit about one nucleus to an orbit about an adjacent nucleus a motion of electrons through the material is readily produced and we have an electrical conductor. Metals have this property in large degree and are hence good conductors. When two metals are in contact a similar interchange of electrons ordinarily takes place between the adjacent atoms of the two metals, and conduction readily occurs in the two directions. A proper choice of metals in the presence of a suitable agent, however, may set up a condition in which this property is oriented or unilateral. Briefly this occurs when electron excursions of one metal are much extended in the presence of the agent, while the excursions of the other are inhibited. In this condition the far extending electrons readily pass to the opposed metal and conduction occurs, while for a potential in the other direction



EMPLOYS THE NEW "A" TUBE

A commercially made charger employing the new tube described in this article. It is a product of the Acme Apparatus Company, Cambridge, Massachusetts there is no overlap of orbits, and the device insulates."

In the new "A" rectifier, as this new development is called there are two metals—an anode of pure silver connected to the casing, and a cathode of a porous alloy connected to the central projection, brought into contact on the inside. The porous cathode contains in its interstices a non-conducting agent which has free access to the junction between the metals. The presence of this agent preserves the junction in an oriented condition, but the actual conduction is through the metals themselves. It not only creates the oriented condition, but preserves this function despite much abuse in the form of rough handling and usage.

Due to the fact that the conduction is metallic, the internal electrical resistance of the rectifier cell, and the power, or I^2 R losses in the cell are exceedingly low, and thus its efficiency is quite high. As will be seen from Fig. 1, the efficiency of a charger employing the new tube is in the neighborhood of 60 per cent. When compared with existing types of chargers, this, as charger efficiencies go, is unusually high. Aside from the saving in power consumed, which may amount to as much as from $6.00 to $10.00 a year, the higher efficiency of a charger of this type permits it to be constructed from exceedingly compact, and in this case, less expensive parts.

Only the tube, fuse, and transformer, as indicated in Fig. 2, are required in the charger circuit. As no energy worth mentioning is wasted in the tube, it may be made quite small itself, and as the transformer does not have to supply a great deal of useless energy, its core need not be any larger than those of some of the new high-quality audio transformers.

RATE OF CHARGE

THE new "A" tube lends itself to either full-wave or half-wave rectification When used as a half-wave rectifier, the maximum charging rate consistent with long life is 2½ amperes. By means of suitable ballast resistors of ¼ ohm each, several "A" tubes may be operated in parallel for higher currents. In full-wave rectification, the charging rate may be double that for one "A" tube. While the tube

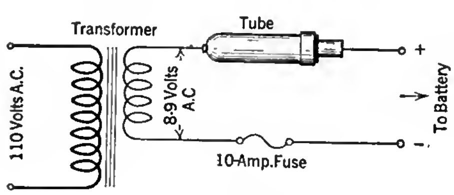


FIG. 2

will have a longer life when used as a trickle charger than when used as a comparatively high-rate charger, its use as a trickle charger is not recommended, due to the necessity for a tremendously long life for rectifiers suitable for such use.

But is trickle-charging so desirable after all? As an answer to the demand made by the public for an A power unit and the elimination of the A battery and charger, many manufacturers brought out trickle chargers and circulated much information regarding the advantages of such a method of charging.

Both systems have their merits. The outstanding advantage of trickle charging is convenience.

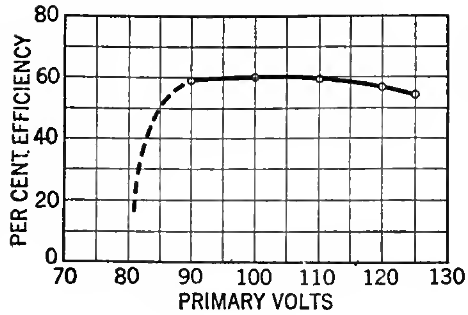
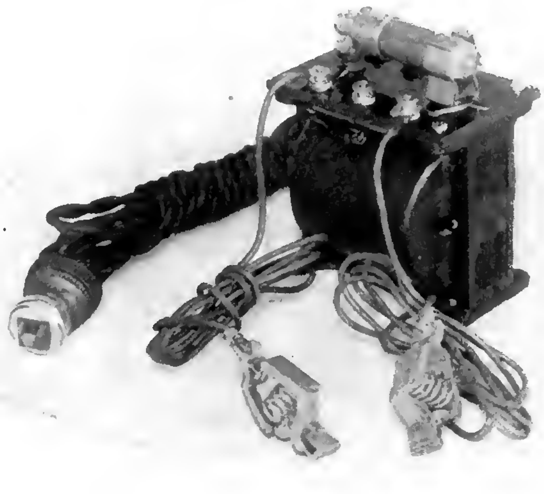


FIG. 1

There is no need to remember to turn on the charger for an overnight run each week, and if the charging rate is properly adjusted, there is never the inconvenience of a run-down battery.



ANOTHER COMMERCIAL UNIT

This one is manufactured by the Mayolian Company, of New York, It is a half-wave charger

But against the advantage of convenience must be placed lower electrical efficiency (which means greater operating costs), the difficulty of determining and then obtaining the optimum charging rate, and, finally, shorter battery life.

The storage battery manufacturers tell us that, as far as the life of the battery itself is concerned, the ideal charging system would consist of a high-rate initial charge, to remove any sulphate formation on the plates, and greatly reduce the time required for the complete charge, followed by a gradually decreasing rate of charge in order to prevent excessive gassing and thus slow disintegration of the positive plates as the charge nears completion.

In good battery service stations, charging batteries at a high rate which gradually tapers off is accomplished by manually regulating the charging rate, as the state of the battery changes, by means of field rheostats on the motor-generators employed for charging.

In some types of chargers, where the secondary voltage is from 20 to 30 volts, the rise in back-voltage as the battery reaches its fully charged condition is only a small percentage of the total impressed or secondary voltage. Since the current flow is governed by the difference between the impressed voltage and the back voltage of the battery on charge, no great change in current flow will take place and there is not the advantage to be gained of a tapered charge.

Because of the high efficiency of the charger discussed here which permits of low secondary voltage, the variation in battery back voltage, as it approaches its fully charged condition, is a large percentage of the total effective voltage of the circuit, thus resulting in a very decided decrease in current flow, and thereby automatically producing a condition of tapered charge which is so beneficial in battery charging.

The curves given in Fig. 3 show this phenomenon clearly at various charging rates.

Fig. 4 shows the wave form of the output of the Raytheon "A" tube as indicated by an oscillograph. An oscillograph gives a visual indication of the variation of voltage or current, as the case may be, in an electrical circuit over a period of time. Thus, from Fig. 4, it will be seen that the current increases in a positive direction with time until a maximum is reached and then falls off to zero. Instead of then continuing to build up in a negative direction, as in the case of an alternating current, Fig. 5, the rectifier tube effectively opens the electrical circuit and the current remains zero until such time as the alternating line voltage has passed through another half cycle ($\frac{1}{120}$ of a second in the case of a 60-cycle supply) at which time the rectifier tube closes the circuit and permits the current to build

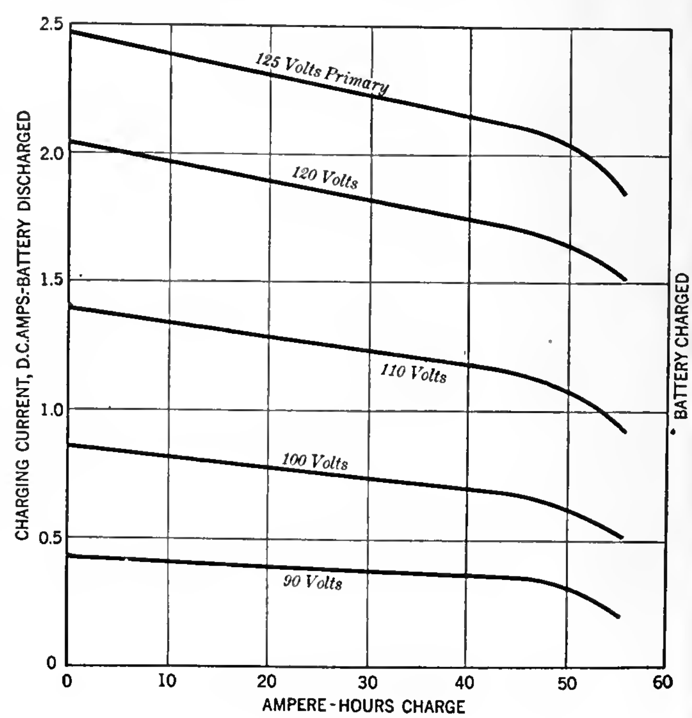


FIG. 3

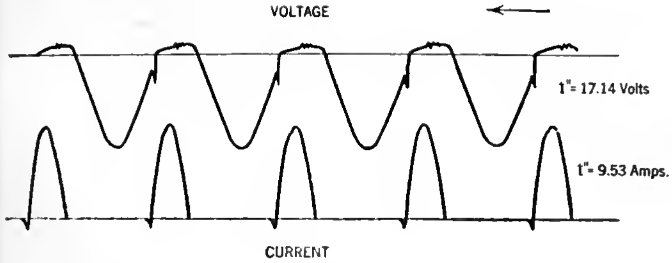


FIG. 4

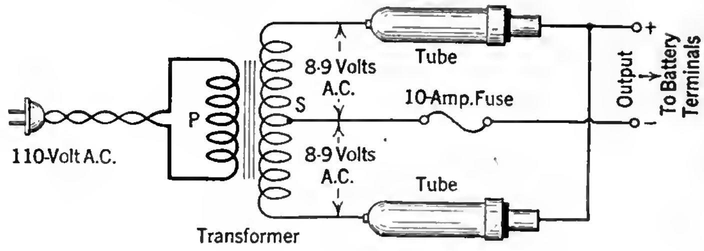


FIG. 6

up again in the same direction as the first half cycle.

One of the purposes of making oscillograms of the operation of the rectifier tube is to ascertain just how completely it prevents current flow in the wrong direction during the half cycle when it should prevent current flow. A perfect rectifier would let no current through in a negative direction.

"A" TUBE CHARGER DESIGN

A NUMBER of prominent manufacturers, such as National, Thordarson, and Mayolian offer for sale complete chargers using this new tube. For those who wish to construct a charger at home using the new rectifier tube, details for the transformer are given in Fig. 7, and a photograph of the equipment appears on this page.

Consider the circuit diagram for the single-wave unit shown in Fig. 2.

Any well made transformer of about 20 watts capacity and with a low-resistance secondary having an open circuit voltage of between 8 and 9 volts may be used. It is preferable to mount the rectifier tube with the small end up. The fuse clips should be used, one making contact with the body of the tube and the other with the small cylinder projecting from the top.

The small cylinder (cathode) should be connected to the positive output circuit while the body of the rectifier (anode) should be connected through the transformer to the negative.

A fuse of not over 10 amperes capacity must be connected in the charging circuit to prevent damage should the output of the charger become short-circuited or the battery be connected in the reverse manner. Small automobile cartridge fuses are excellent for this purpose.

Perhaps it may occur to some readers that a charger with variable rate may be readily constructed from a transformer with a higher secondary voltage than that described, by inserting a rheostat in series with the tube. Such is not the case. The maximum back voltage that the tube will withstand without injury is 22 volts. As there is no current flowing during the half cycle in which the battery is not charging, IR drops become zero and the back voltage becomes equal to the peak a. c. secondary voltage plus the battery voltage. Thus, for long tube life, transformer voltages must be limited to 8

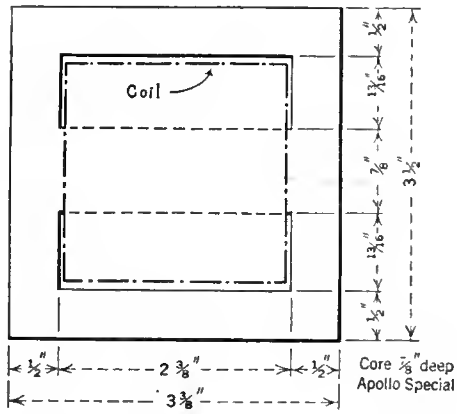


FIG. 7

Here are the specifications for the construction of a transformer suitable for use in a home-made charger using the new "A" tube. The transformer should be of the customary shell type with a core having dimensions equivalent to those given here. The primary of the transformer consists of 750 turns of No. 24 enameled copper wire, while the secondary consists of 53 turns of No. 14 single cotton-covered enameled copper wire. The transformer coil should be layer wound with the secondary coil next to the core. The usual insulation between layers, between core and secondary, and between primary and secondary, should of course also be provided

or 9 volts at no load. (Peak A. C. voltage = RMS $\times \sqrt{2}$).

The National charger shown in the photograph on page 143 and diagramatically in Fig. 6 is so designed as to be used either as a half- or full-wave charger. As a half-wave charger, only one rectifier tube is plugged in, while as a full-wave outfit both tubes are employed. The charging rate with one tube is approximately 2½ amperes and with both tubes 5 amperes. The manufacturer's price is $10.00 without tubes; the tubes are $4.50 each.

The Mayolian Charger, which is shown in a photograph on page 144 lists for $10.00, and the Thordarson charger lists for $12.50 complete.

The new rectifier unit is already being applied to A elimination and at least two manufacturers have complete A-units ready for the market at present.

There are many tricks to the successful design of such devices however, and the development of suitable filter circuits has been exceedingly difficult. The present commercial units employ several chokes with quite low inductance and exceedingly low d.c. resistance. Instead of ordinary condensers, special dry cells, offering a very high d.c., and at the same time extremely low a.c. path are employed.

Some of these units or cells are based on the principle of the electrolytic condenser, but use a paste electrolyte rather than a liquid.

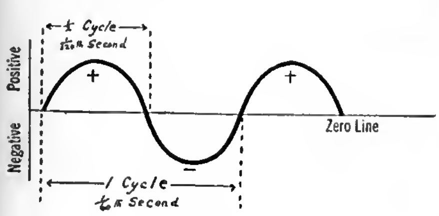


FIG. 5

THE HOME-MADE UNIT

Fig. 6 is the schematic diagram that should be followed in building this full-wave 5-amp. charger

"Strays" from the Laboratory

Measuring Audio Amplifiers

AS HAS already been mentioned in these pages, progress of standardization in the radio industry is encouragingly sponsored and aided by two organizations —the Radio Manufacturers Association and the radio section of the National Electrical Manu-Manufacturers Association. Considerable effort has been made by both organizations to standardize not only mechanical and electrical constants of radio apparatus but methods of measurement as well.

In the booklet giving the NEMA radio standards there can be found a method of testing audio-frequency coupling devices—transformers, resistance-condenser, and choke-condenser couplers. The problem of output devices has not, as yet, been included. The method of measuring transformers is not new, nor, in the opinion of many engineers, is it correct, in that it does not give a true picture of what the transformer will do under actual working conditions.

The circuit diagram of the test equipment is shown in Fig. 1. Briefly it consists of an oscillator whose frequency range is 30 to 7000 cycles and whose "percentage of harmonics present in the output shall be not more than 5 per cent." Current from this oscillator is passed through a potential divider and is read on a thermo-couple-milliammeter. A portion of the output voltage is impressed on the primary of the coupling device under test in series with a fixed resistance to simulate the plate impedance of the tube out of which, in normal practice, the coupling unit works. Arrangements are made for direct current to flow through the primary.

A given deflection on a vacuum-tube voltmeter is obtained by placing its terminals across the secondary or output side of the coupling device. Then the same deflection is obtained by impressing the oscillator output voltage directly on the tube voltmeter by means of a slider on the potential divider. Since the resistance through which the coupling device is fed is fixed, the ratio of these resistances gives the voltage gain of the coupling device.

Criticism leveled at this method arises from the fact that the input characteristics of the vacuum-tube voltmeter differ from those of a tube with an inductive load in the plate circuit—such as would normally work out of the coupling device. The frequency characteristic of the transformer depends upon what is shunted across its secondary or output terminals. In the Laboratory, and elsewhere, it has been found that the curve obtained in this way may have very little in common with that obtained from a complete amplifier, or even from a single coupling unit plus one amplifier tube.

The question naturally arises as to what is the best method of measuring a coupling device or an amplifier. Shall the curve obtained by the NEMA method be taken as standard; shall the overall characteristic of two or more coupling devices with their associated tubes be preferred; and if so, how shall the output be measured? That is, with what is the amplifier to be terminated; if a resistance, of what value? Are we interested in the amplifier as a power amplifying device; shall the output power be measured, or is it sufficient to measure the voltage appearing across, say, the primary of an output transformer and to divide it by the input voltage to the amplifier to obtain the overall voltage gain?

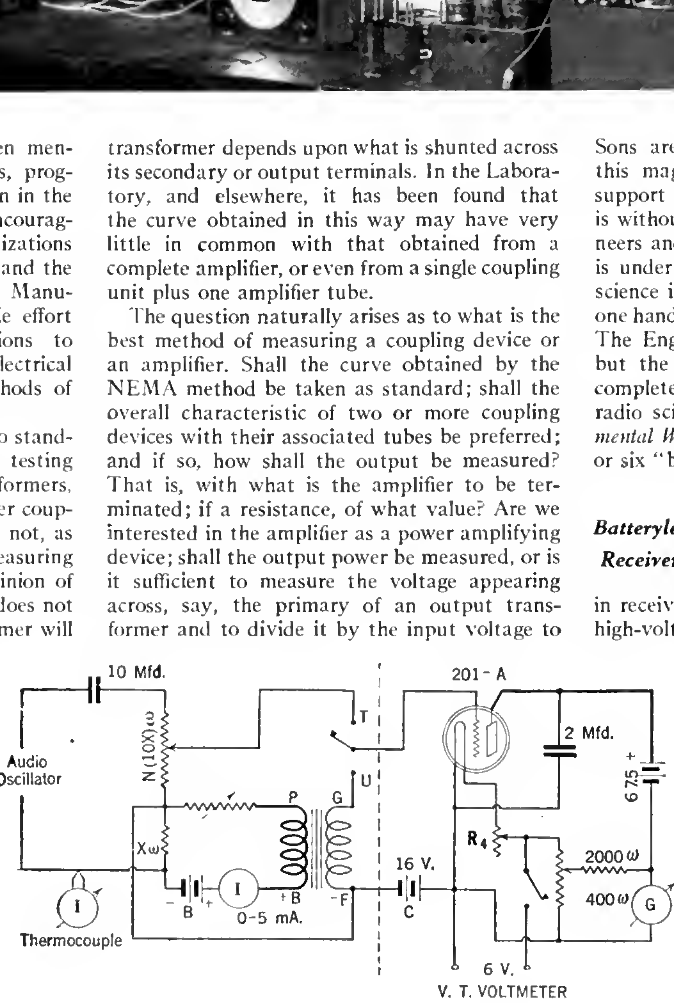


FIG. 1

These questions have occurred in letters from laboratory experimenters who would use standard test methods if such could be agreed upon. It is possible that they have occurred to members of the standardization committee of the RMA and the NEMA too, and it is probable that readers who have suggestions will find willing ears.

A Fine British Magazine

IT IS disappointing to note that one of the best British technical journals, *Experimental Wireless and the Wireless Engineer*, published in London by Iliffe and Sons, has been compelled to raise its subscription price to two shillings and sixpence per copy on account of "lack of support by English advertisers." Without a doubt if Iliffe and Sons are compelled to pass the hat to keep this magazine going, they will receive strong support from American engineers, for this paper is without a peer as an organ for serious engineers and experimenters. In England a research is undertaken, it seems, with the love of pure science in the investigator's heart and not with one hand tied by production department threats. The English may pursue roundabout methods, but the end point is final and the answer is complete. No American deeply interested in radio science can afford to be without *Experimental Wireless*, even were the price raised to five or six "bob" per month.

Batteryless Receivers

THE Laboratory has witnessed the demonstration of two radically different systems of battery elimination in receivers within a month, one employing the high-voltage high-current rectifier tubes, the uses of which are outlined elsewhere in this issue of RADIO BROADCAST, and the other a method made possible by the so-called Miessner tube.

The Raytheon, QRS, and similar rectifier tubes, are designed to rectify enough current so that 201-A tubes can be wired in series and 250 milliamperes passed through them. The rectifier system must furnish five volts for each tube filament and also the high plate and grid bias voltages of the power output tube whose filament is heated from raw a. c. A five-tube set using four 201-A's and a 171 will require 20 volts for the filaments, 40 volts C grid bias, and 180 volts for the 171 plate; since the filament voltage is also available for the plate voltage of the last tube, the total will be 220 volts.

The Miessner tube is the high-current low-voltage valve predicted in the February and March RADIO BROADCAST and mentioned again in May of this year. The thermal inertia of the tube is so high, about sixteen times that of 112, and the voltage drop across the tube so low, that it is possible to place raw a. c. on the filament without introducing appreciable a. c. hum into the output. In fact, the ripple in the output, produced by incomplete filtering, can be made to serve a useful purpose. Since the plate current produces a ripple in the C bias which, is opposite in phase with that in the plate circuit, the a. c. hum which would otherwise emanate from the loud speaker is automatically reduced.

And now that it is possible to throw away one's batteries, is it worth while? What are the advantages either way?

For the Raytheon and QRS outfits it must be conceded that the power problem indeed seems simplified. There are no acids or liquids, and it is possible to supply the high plate voltage of the final audio tube economically and continuously. There are no chargers constantly and sometimes inefficiently dissipating power; no batteries to fill with water, and few replacements.

On the side of the battery the advantages are also manifold. Battery voltages are pure unadulterated d. c. This means that a high-quality battery-operated amplifier and loud speaker will be quiet until a signal comes in and it will be possible to use headphones after a two-stage amplifier; this is frequently impossible with distance reception on account of the a.c hum

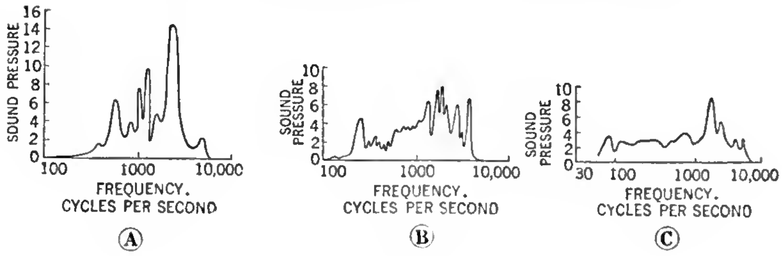


FIG. 2

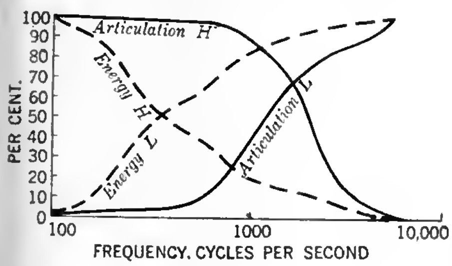


FIG. 3

which is more annoying in headphones than in a loud speaker. There is no a. c. hum whatsoever in the case of battery-operated sets, and there are no voltages higher than that necessary for the last tube. B batteries have a practically perfect regulation curve, i.e., they are of very low resistance when new. There is no heat to be dissipated. Either a. c. or d. c. may be used to charge the A battery, and the charging process may be made almost automatic.

The honors seem about even. Now let us look at the economics of the problem. Suppose the first cost of a battery and a charger is $30 while it costs $60 to equip one's set with a QRS or Raytheon A, B, C, supply. Further, suppose it costs $30 a year to run the power operated receiver and that batteries cost, for a year, about $50. This latter figure includes B batteries and charging the A battery.

At the end of the first year the power set has cost $90 compared to $80 for the battery receiver. At the end of the second year the respective total costs are $120 against $130. Thus, from the standpoint of economics, at the end of two years, there is little gained or lost by one method or the other. Figures on the Miessner system are not yet available.

Articulation Curves

THERE are few independent laboratories that have the equipment to measure the effectiveness of a receiver from input radio-frequency voltage to output sound pressure from the loud speaker. For this reason, some data presented at a meeting of the Radio Manufacturers Association, held in New York on March 23, 1927, by Dr. John P. Minton and his associate, I. G. Maloff, are more than interesting.

Fig. 2 shows the frequency response of three loud speakers, curve A being a representative horn speaker, curve B an average cone speaker, and curve C "one of the best cone speakers that has been produced." It may be seen that the horn has an effective range of from 450 to about 3000 cycles, the average commercial cone covers from 200 to about 3600 with several severe "ups and downs," while the third curve is good from about 60 to 6000 cycles.

These curves of Dr. Minton's by themselves are nothing more than interesting, but when looked at with other data collected by such authorities as Dr. Harvey Fletcher and Dr. Minton himself, they become illuminating. For example, the curves shown in Fig. 3 give an idea of what happens when frequencies above any desired frequency are not reproduced, "L", and conversely "H" shows when only the high frequencies are passed through the receiver and loud speaker. From the standpoint of intelligibility or articulation the low frequencies are not so important, but if no frequencies below 500 cycles are reproduced, there will be but 40 per cent. of the speech energy present in the loud speaker output. On the other hand, the high frequencies carry little energy but are important from the standpoint of intelligibility. If all over 1000 cycles are cut off, 80 per cent. of the energy remains but only 40 per cent. of the articulation or intelligibility. From this consideration and others it seems certain that frequencies between about 75 and 5000 should be reproduced equally for faithful reproduction of music.

Fig 4 gives the comparison of sound pressures at various frequencies occurring in organ music, which explains why a poor loud speaker or poor amplifier makes organ music sound like anything but organ music.

Fig. 5 gives the overall radio amplification against wavelength of several common types of receivers. Curve S is for a super-heterodyne;

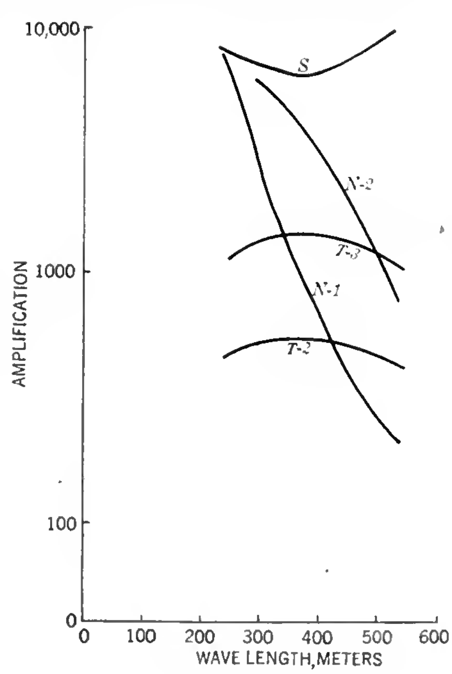


FIG. 5

curve N-2 is for a dual-control neutralized receiver of commercial make, while curve N-1 represents a single-control receiver of the same type; T-2 and T-3 are representative two- and three-stage resistance neutralized receivers.

Mr. Maloff makes several interesting and significant statements, of which the following are of special interest:

"For some unknown reason the importance of adequate audio amplifiers was overlooked by many manufacturers. Many sets on the market have very good r. f. circuits but very few of them have audio circuits of the same grade."

"In a certain commercial set the transformer form of coupling is used, the transformers being of high ratio and insufficient primary impedance. This set is very quiet even with the worst kind of battery eliminator, but responds only to the frequencies in the middle range, which means

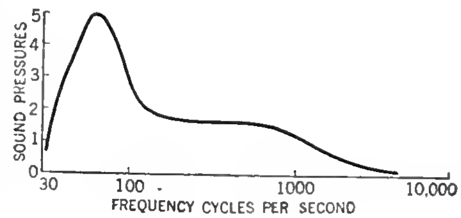


FIG. 4

lack of depth and lack of brilliancy of the reproduced sound."

New Equipment

TWO instruments that deserve more than ordinary attention have recently been received by the Laboratory. One of these is the Taylor resonance tester, which consists of a small radio-frequency oscillator and a vacuum-tube voltmeter, all in one cabinet. It is for use in "lining up" two or more radio-frequency stages that are to be controlled by one dial. The second instrument is the Weston set tester, comprising a milliammeter with several shunt and series resistances and a multiple switch so that the meter can be used to measure plate current, and filament, grid, and plate voltages, as well as to test for opens, etc. Further interesting equipment received is as follows:

The Elkon dry rectifier, recently described by R. S. Kruse in *QST*; the Sprague tone control, for use between the amplifier and loud speaker; grid leaks and resistors made from Carborundum; electron relay tubes which will open or close a circuit through the influence of a distant signal; the Crosley AC-7 receiver, which operates without batteries; another automatic radio power relay, known as the Liberty 712S; a grand assortment of Fahnestock clips; tapped heavy-duty resistors from Mountford; a little vest pocket receiver by Flash, that actually receives signals from Manhattan, twenty miles away; experimental four-element tubes from Clearton and Van Horne; condensers for various uses from National and Wireless Specialty; output devices by Centralab, Muter, and Silver-Marshall; the new high-quality General Radio audio transformer, type 285 N; Carter's radio kit No. 400, comprising the necessary resistors for use in an A, B, C, device employing the new QRS 400-mil. tube; resistors from Cresradio; the Davy Vertrex Autocharger; new Paragon double-impedance units; Browning-Drake and Loftin-White receiver kits.

Complete Constructional Data for Converting a Popular 19-Inch Cone Loud Speaker Into a Three-Foot One—Cone Kits Available

By
WARREN T. MITHOFF

A THREE-FOOT CONE
It is a fairly simple matter for the fan interested to make himself a three-foot cone, and obtain superior reproduction of music. The one illustrated to the left is described by the author and makes use of a Western Electric 540-AW unit

How to Build a 36-inch Cone

THE true dyed-in-the-wool radio fan is never content with his equipment, however excellent it may be. The constant urge is for improvement, advancement, and change. Hence, manufacturers are able to market with considerable success such items as super-sensitive detector tubes, $10 transformers, and improved loud speakers.

Thanks, in large measure, to the inquisitiveness of the aforementioned fan, radio has advanced more rapidly than most other sciences of a similarly complex nature. Take loud speakers, for instance. The moderate-sized cone of to-day is vastly superior to the tinny-sounding horn of five years ago; yet there looms on the horizon a much enlarged edition of the cone, costing nearly three times as much, and giving noticeably better quality. In theory, and in practice as well, perfect reproduction requires a large diaphragm—within reasonable limits, the larger the better. Therefore, the three-foot cone sets itself up as a contender for highest honors in the struggle for better radio music.

Many fans have doubtless wished for one of these giant cones, but for various reason have foregone the pleasure and pride of possession. For the owner of a Western Electric 540-AW loud speaker, however, there is a short cut to ownership without having to pay the penalty of excessive transportation and handling charges which attaches to the manufactured three-foot cone. He can build the cone himself, and install in it the excellent 540-AW driving unit, or any one of a number of other good units now obtainable, thereby gaining every advantage of the large cone at a minimum of expense. Where the 540-AW unit is removed from the cone for this purpose it does not necessarily follow that the smaller cone is permanently useless. The actuating unit is retained intact, so that on occasion it can be put back in the smaller cone should a more portable loud speaker be desired.

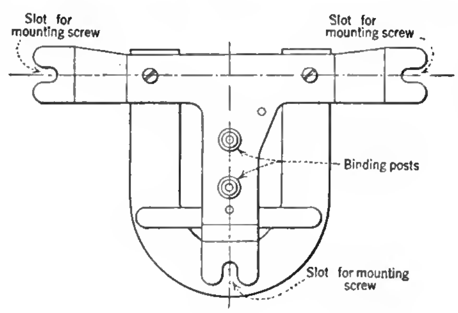


FIG. 1

MOUNTING THE UNIT

IT IS the purpose of this article to describe the process necessary in building a giant cone and the 540-AW unit will be employed for the purpose although practically the same procedure will have to be followed where other units are used. First, we must gain access to this 540-AW unit. The five screws holding the perforated bronze screen are removed, and the screen taken out. The rear of the unit proper is then disclosed; in appearance, it is somewhat like Fig. 1. Now, the set screw at the tip of the cone is loosened, and the three mounting screws holding the unit to the circular frame are removed. The unit is then drawn out, care being exercised to see that the driving pin is not bent. For the large cone it is desirable first to mount the unit on a flat surface. A piece of hard wood, such as oak or maple, serves admirably, and it is easily worked. This should be at least ¾ inch thick, and should be a heavy close-grained wood. Weight is needed back of the unit to preclude the possibility of the unit vibrating instead of the paper cone.

This mounting base is planed smooth, cut to size, and drilled as indicated in Fig. 2. The ½-inch holes near the center are simply to clear the binding posts on the unit, which project somewhat beyond the plane of the three slotted mounting feet.

The next step is the preparation of the supporting arm, Fig. 3. This may be of soft wood, and should, at the start, be made about 4½ inches long. The exact distance from tip to back of the three-foot cone may vary a little in individual cases, and it is easier to cut off than to add on.

The mounting base is now fastened to the supporting arm by means of three flat-head wood screws, fairly heavy, and about 1¾ inches long. The arm is placed at the top of the base, in the exact center, and the three screws are passed through the countersunk holes and tightened.

Fig. 4 shows the details of the cross piece which supports the entire assembly inside the cone. It may be made of soft wood, drilled as indicated,

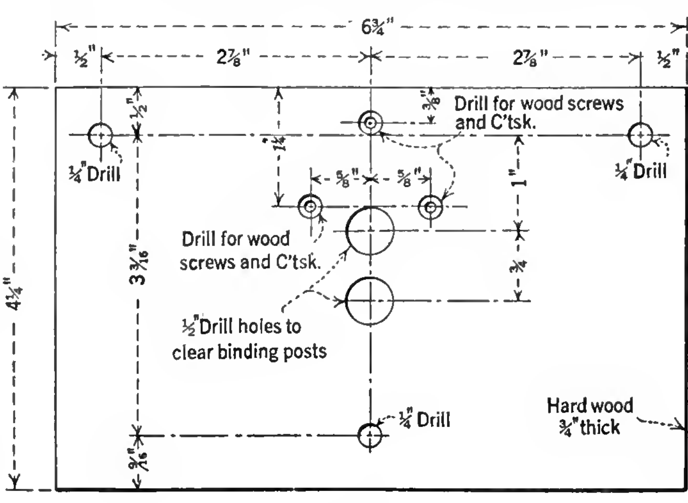


FIG. 2

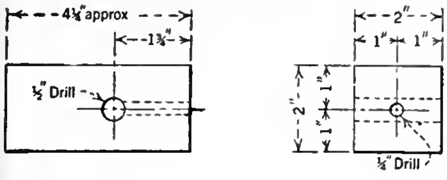


FIG. 3

and stained with walnut wood stain. A No. 14–20 machine screw, 3 inches long, is now obtained, and washers slipped over it in this order: Next to the head a lock washer, then a ¾" washer with a ¼" hole, then a 1" washer with a larger hole. The screw is passed through the ½" hole in the cross piece, through the ¼" hole in the supporting arm, and the nut, either hex or square, is placed in the ½" hole, so as to thread onto the screw, which is then tightened up. The reason for the apparently oversized ½-inch hole in the cross piece will be evident later on in the construction.

The unit is mounted on the baseboard by means of round-head machine screws 1 inch long. These may be of any size that will fit through the slots in the feet of the unit, and are passed through the slots, and through the ¼-inch holes in the base and drawn up tight. Lock washers are advisable at this point, also, together with flat washers against the surface of the wood.

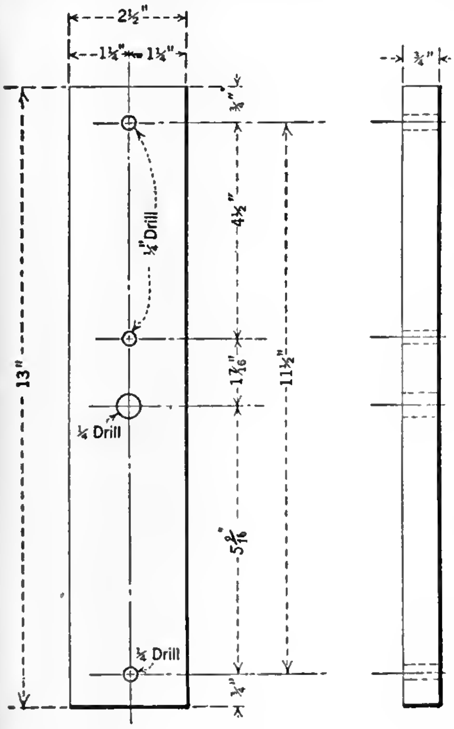


FIG. 4

THE DIAPHRAGM

THE mechanism may be laid aside now while the cone itself is made. The first consideration is the choice of a paper for the purpose. Brown Alhambra Fonotex is probably best for quality of tone, ease of working, and appearance. It can be had in sheets 38 inches square at many radio stores, or from the manufacturers' agents. Another possibility is lamp shade parchment, which comes 40 inches wide. While this is not theoretically so good, being more compact and harder-surfaced, in actual practice it works very well, although it is a little more difficult to handle in the making. A thin coat of walnut wood stain gives it a rich brown color.

A few pointers regarding decoration may not be amiss at this point. If the Alhambra paper is used, it is a simple matter to decorate the face of the cone with water colors, and a very pleasing effect can be obtained by the use of simple bands of dark brown around the outer edge, as shown in the photograph. The procedure is as follows: A 38-inch sheet of the paper is laid, rough side up, on the floor or on a flat table and the exact center determined by means of crossed diagonals. A thumb tack is driven in at the center, and a piece of wire is used as a compass for drawing the circles. The largest circle should just fit on the sheet, and will have a diameter of 38 inches, or nearly that. The wire is then shortened in steps, and four more circles drawn to locate the bands. The outer margin is ⅞ inch; then a 2-inch band; then a ½-inch space; and then a ⅜-inch band. If the constructor has access to a draftsman's ruling pen, the decorating is simplified. A good water color to use is burnt umber, or Van Dyke brown, in tube form. A little is squeezed out in a dish and thinned with water. It may then be taken up on a brush (a No. 5 flat lettering brush is excellent) and applied to the ruling pen, which is used with the wire compass arm, and a circle drawn over each of the pencil lines. This makes it much easier to get a smooth edge on the bands when filling in with the brush.

The actual construction of the cone is accomplished by cutting out a 5-inch segment as shown in Fig. 5, *with the grain* of the paper. The direction of the grain is indicated on the wrapper. The circular form is then cut out and the sheet turned over, face down, and the two edges of the segment drawn close together and weighted down. A strip of paper about 1½ inches wide is cemented over the two edges, and a ruler laid over it and heavily weighted while the glue dries. A very good adhesive to use is Ambroid cement, a celluloid base mixture which is waterproof and will not buckle the paper.

While the face of the cone is drying, the back can be made, noting that the segment is to be 5½ inches at the outer edge, as shown in Fig. 5. This cone is cemented the same as the first one, with a strip of paper, and weighted down to dry.

MOUNTING THE CONE

NEXT, the wood ring, Fig 6, is cut, drilled, sandpapered, and stained with the walnut stain. When dry, the ring is laid flat on the table and the back cone is mounted on it so that the inner circle centers, and the seam in the paper is opposite one of the projections on the ring. Care must be exercised to see that the cone is not pulled out of shape while fastening it in place. It is best to drive six tacks, evenly spaced, through the edge of the paper to hold it temporarily and then check up the placing of the cone by putting the front cone in position and noting whether or not the edges meet evenly all around. If not, the tacks should be pulled out and the paper shaped so that it will. After the back cone has been adjusted properly, and tacked down, it is firmly secured by a coating of sealing wax applied quite liberally while very hot. The wax should cover the entire circumference thoroughly, and be allowed to harden.

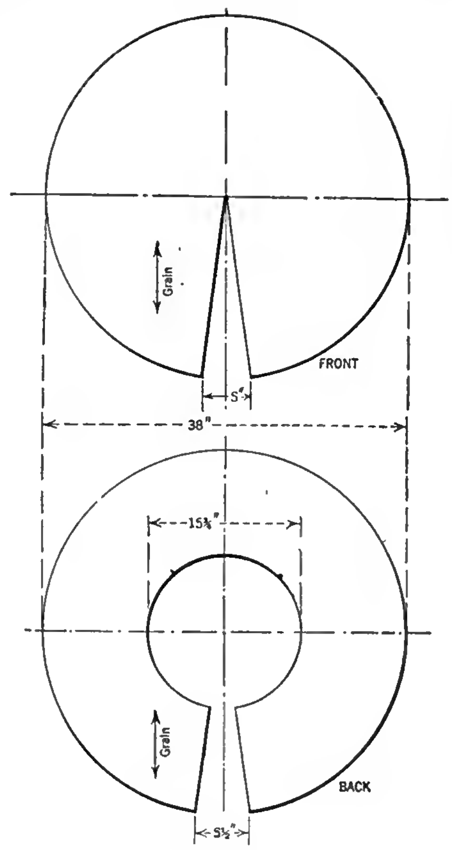


FIG. 5

The front cone is now placed, point down, in a round dish pan, which serves as a support, and the back cone fitted onto it, edge to edge, with the seams meeting. The two are joined together with the Ambroid cement, or with sealing wax. The front cone, having a smaller segment removed, will be a trifle larger than the other, and the cement or wax is applied along this slight extension. The cement or wax is applied freely, but not allowed to run over onto the face of the cone.

The next step is the making of the tip, Fig. 7.

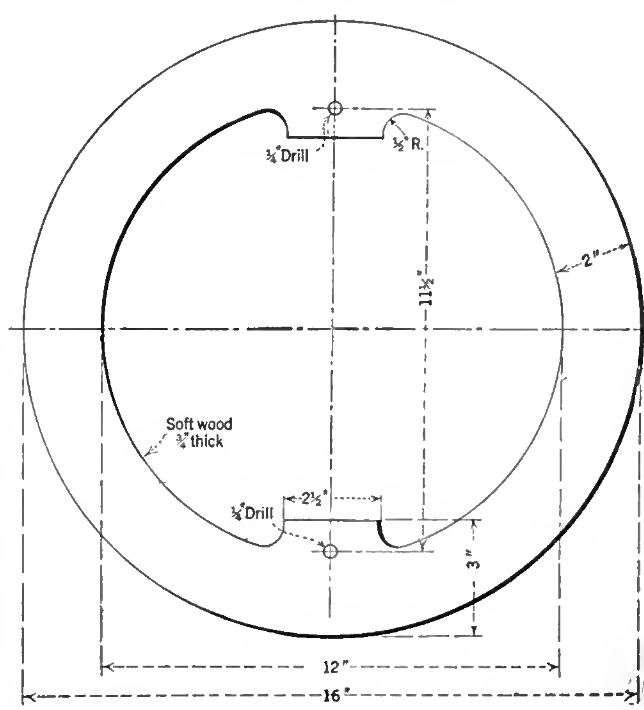


FIG. 6

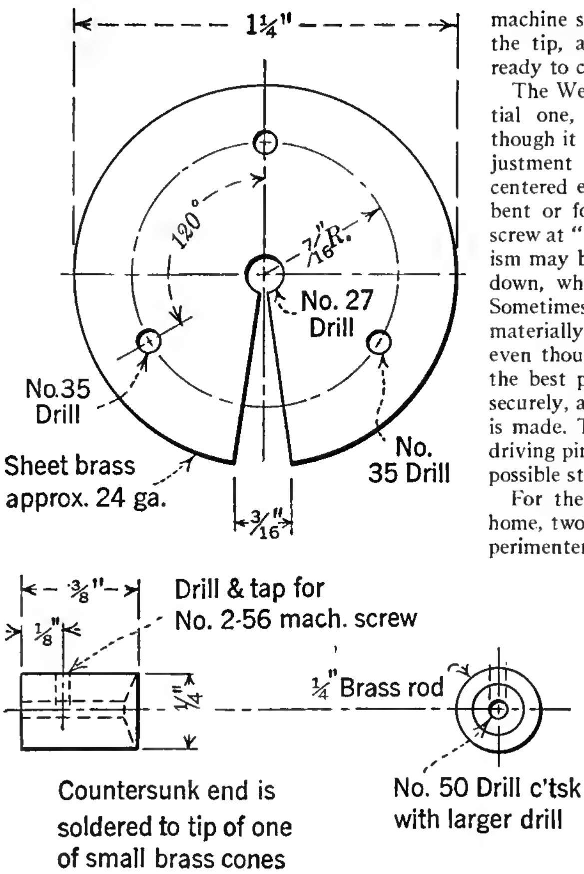


FIG. 7

The two circles are cut from thin sheet brass, drilled, and segments cut out. These should then be shaped into cones and the seams soldered lightly. The tip is cut from ¼-inch round brass rod, drilled, and tapped as shown. This tip is then soldered carefully onto the apex of one of the brass cones, and excess solder removed with a file.

The two brass cones are given a light coat of the Ambroid cement, and secured to the point of the paper cone by three No. 2–56 machine screws passed through the holes drilled for them. (See assembly, Fig. 8). The nuts are tightened on the inside, and the cone is ready to receive the actuating mechanism.

At this point the constructor will find it convenient to make a temporary stand to support the cone while work progresses. This may consist simply of a 12-inch board about 3 feet long, laid flat on the floor, with uprights nailed to the edges and braced. The uprights are fastened to the wood ring on the back of the cone with wood screws, and thus both hands are left free for adjusting the unit. Or, if the experimenter's workshop is in the basement, he may nail two narrow strips to an overhead beam and hang the cone in that fashion.

ASSEMBLING THE LOUD SPEAKER

THE cross piece, supporting the driving unit, is now put in place, the driving pin being pushed carefully through the metal tip. Should the driving pin extend too far, or should the supporting arm be too long to permit the cross piece to rest against the wood ring, the arm must be removed and cut down accordingly. No. 14–20 machine screws are inserted in the holes in the cross piece and wood ring, with flat washers and lock washers on the inside, and flat washers on the outside. The nuts are tightened on the inside, and the loud speaker cord brought out through the ¼-inch hole in the cross piece. A No. 2–56 machine screw is inserted in the tapped hole in the tip, and tightened, and the instrument is ready to connect for a test.

The Western Electric unit is a very stubstantial one, and trouble is extremely unlikely, though it may be necessary to make a slight adjustment to make sure that the driving pin is centered exactly at the tip of the cone and not bent or forced out of place. By loosening the screw at "A," Fig. 8, slightly, the entire mechanism may be shifted from side to side, or up and down, while the loud speaker is in operation. Sometimes the quality of tone can be improved materially by this process, and it should be tried, even though it may not seem necessary. When the best point is found, the screw is tightened securely, and a final adjustment of the set screw is made. The screw on the tip which holds the driving pin to the cone is loosened to relieve any possible strain and then tightened again.

For the final disposition of the cone in the home, two methods suggest themselves. The experimenter who is handy with carpenter's tools may wish to build a three-legged stand similar to the one shown in the photograph on page 148 A simpler method is to hang the loud speaker on the wall. Two small rubber-tipped cast-iron door stops are procured, such as are used to prevent doors from banging into the wall. These are screwed into the lower part of the wood ring to hold it away from the wall, and a screw eye at the top will accommodate a cord. The cone may then be hung from a hook on the picture molding.

For the benefit of the experimenter who does not possess a Western Electric 540-AW loud speaker, there are on the market several excellent units which can be handled in a manner similar to that described here, Dimensions, of course, will differ, but the general procedure is the same. The fan can readily adapt the individual unit to the plan given here, and provided the unit chosen is a good one, excellent results may be obtained at a very nominal cost.

NOTE

MR. MITHOFF'S instructions fully cover the construction of a 3-foot cone loud speaker where the Western Electric 540-AW cone loud speaker is taken apart to supply the driving unit. There are, however, as Mr. Mithoff explains, several other units which may be obtained separately and installed to good advantage in the 3-foot cone.

Several companies have for sale complete kits for the home assembly of such cones, comprising the driving unit, mountings, and cone paper. The following is a brief description of these kits:

Fenco Cone Speaker—This kit comprises two pieces of cone paper, a driving unit, wooden back ring, handle, cord, glue, and cement. The two sheets of paper are cut in circular form, both are marked for the cutting of the segment to form the seam, and one is decorated with a border stencil. Supplied by Fenco Cone Company. Price $12.00.

Ensco Cone Speaker—The parts supplied include one sheet of cone paper, uncut, one central mount block with four arms, one driving unit, and one loud speaker cord. Supplied by the Engineer's Service Company at a price of $10.00.

Penn Cone Speaker—Consisting of one driving unit, two sheets of cone paper, uncut, one set of back rings, one unit mounting, and one can of cement. Supplied by the Penn Radio Sales Company, for $14.15.

Instruction booklets explaining the construction of each of the cones listed above are supplied by the manufacturers and deal specifically with the assembly details involved.

Balsa Wood Reproducer—While this loud speaker kit is not of the cone type it is of sufficient size to be classed in that category. Instead of being circular or conical in shape it is rectangular and much like a picture frame. It is obtainable in three sizes: 24"x 13", 36"x 21", and 43"x 24".

The kit consists of frame material, three wide slats of special balsa wood, a number of pieces of narrow ribs of balsa wood, glue, brads, screws, chuck, and wood mounting for chuck.

The three slats are assembled inside the rectangular frame and the ribs are glued to the back of the slats in a radial fashion. At the center, where the ribs join, the chuck and mounting is placed to take any good loud speaker driving unit. Furnished by the Balsa Wood Reproducer Corporation, price $5.50, $8.00, or $10, depending upon size.

—THE EDITOR.

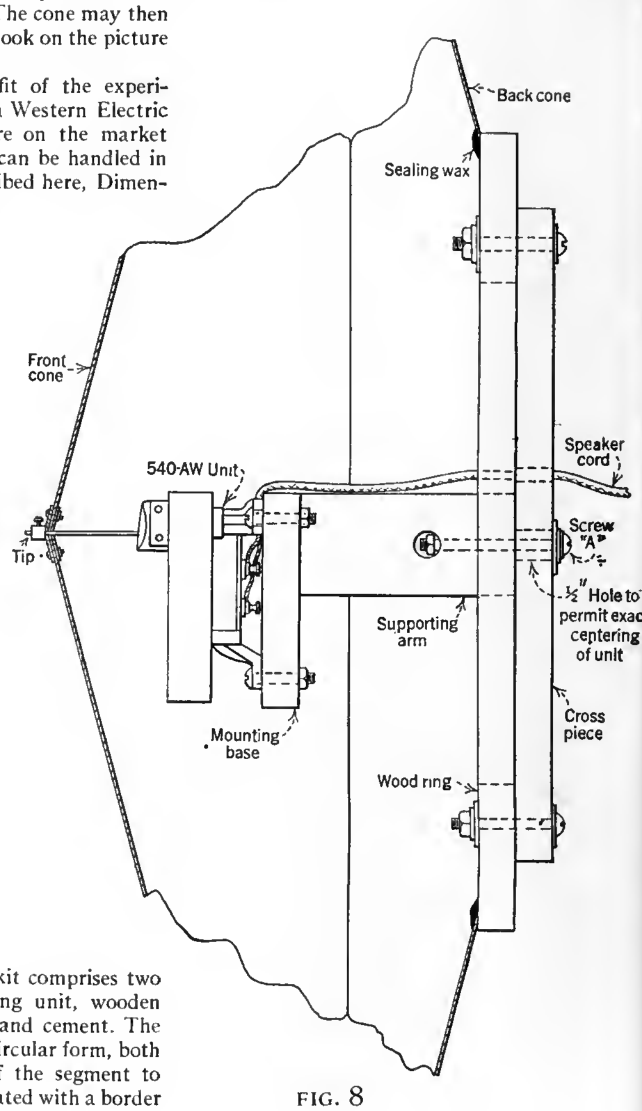


FIG. 8

Something About Single Control

Some of the Advantages and Disadvantages of Unified Control—Analyzing the Single-Control Receiver—Why Synchronism of Circuits Is Complicated

By EDGAR H. FELIX

SIMPLIFIED tuning is only one of the important advantages gained by the simultaneous adjustment of circuits by means of a single control. It is a most important advantage to the inexperienced, but even the most skilled dial twirler soon finds desirable qualities in a real one-control receiver.

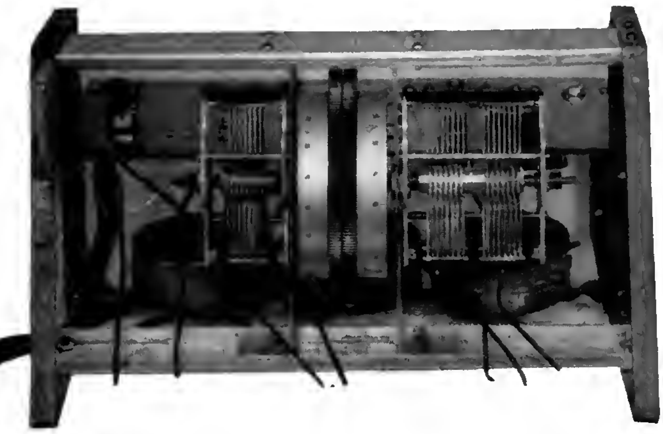
For example, the attainment of true single control makes it possible to sample all the available programs throughout the frequency range in a brief time, thereby increasing the entertainment value of the receiver. Furthermore, appearance, in the opinion of many, is improved by the reduced number of controls.

One conspicuous knob plus several small ones, however, does not necessarily make a true single-control set. There are many pseudo-single-control sets, parading as one-dial receivers, which may possess several, but not all, of the advantages of unified control. A true single-control receiver should have only one tuning dial, and this should maintain each tuned radio-frequency stage and the detector circuit in perfect resonance without requiring the use of supplementary vernier adjustments. A compensating antenna circuit adjustment, which requires setting only once when the receiver is installed, does not disqualify a set from the single-control classification. If, however, such an adjustment must be used each time the listener diverts his attention from the lower to the higher frequencies, or vice versa, the receiver in which it is incorporated is not a genuine single-control receiver but a two-control receiver.

All single-control receivers employing more than one tuned circuit so far devised, use gang condensers mechanically coupled, a system thoroughly covered and controlled under the Hogan patents. The license fees charged under these patents are so moderate, however, that evasion has been practiced only in a few instances, and the development of single-control sets has not been hampered by costly patent litigation.

When seeking to judge the desirability of a single-control receiver, the first discrimination to be made is as to whether the set under consideration is really a true single-control set. Auxiliary controls are often concealed or camouflaged in order to give the impression that the receiver is tuned by only one manipulation while, in practice, each of these extra controls may require careful adjustment to tune-in a desired station. Even so, a receiver of such design may possess important advantages over the usual two- or three-dial receiver, provided there is only *one* adjustment of the main tuning dial which brings in each station.

In examining a receiver, therefore, observe every control upon it, no matter how it is labeled. A true single-control set has but two adjustable dials, *i.e.*, the tuning control and the volume control. In addition, there may be an "on-off" switch in the filament circuit. Any additional verniers, "fine tuning" controls, or compensators take the receiver out of the single-control classification.



SINGLE CONTROL BY MEANS OF ADJACENT KNURLED KNOBS

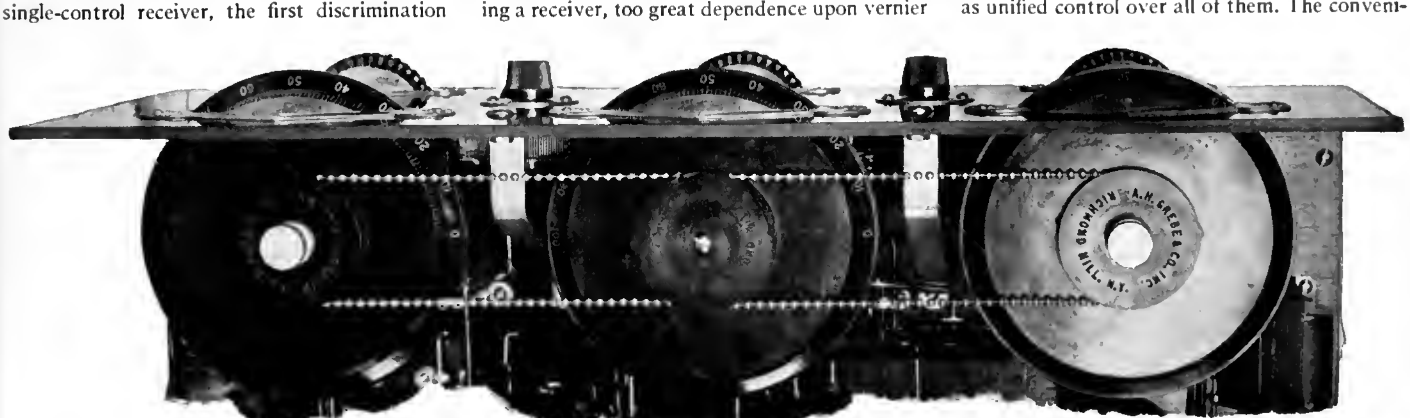
The use of vernier controls to correct deviations from exact synchronism among several circuits greatly reduces the cost of manufacture, because close accuracy in making inductances and capacities is thereby dispensed with. If simplicity of control is the objective in purchasing a receiver, too great dependence upon vernier adjustments may defeat the buyer's purpose. On the other hand, a well-designed receiver, in spite of verniers, can be a convenience, although their use should be reflected in lower cost of the receiver.

The writer has seen receivers upon which stations may be tuned-in in any position over a span of ten degrees of the main dial by correct manipulation of the verniers, thereby eliminating ease of adjustment, the most desirable quality of the single-control set. On the other hand, other receivers, although requiring vernier adjustments, can be properly tuned to a station at only one certain position of the main tuning control. Such receivers are frequently more convenient to tune than two- or three-dial sets.

Having determined whether the receiver is a true one-control set, or one equipped with verniers but so designed that only one adjustment of the main dial brings in any desired station, the efficiency of the mechanical coupling between the tuning elements should be tested. If there is back-lash, slip, or play in gears, the user can never be certain that his tuning circuits are in complete resonance.

To test the efficiency of the mechanical coupling of tuning elements, select a fairly weak station and tune to it accurately. Note the exact setting of the main dial. Turn the control to the opposite end of the scale and then restore it to precisely its original position. If the weak station is again heard to full volume, the mechanical construction is probably satisfactory. On the other hand, if the station is now found two or three degrees above or below the original setting, play and back-lash are likely to introduce tuning complications.

Some receivers depend upon the friction of adjacent knurled knobs, which may be adjusted separately or operated in unison by one hand at will thereby attaining the single-control ideal. With such a device, the user has choice of complete control over each individual circuit as well as unified control over all of them. The conveni-



SIMULTANEOUS TUNING OF CIRCUITS BY MEANS OF A CHAIN AND PULLEY SYSTEM ence of this type depends chiefly upon how closely the circuits are synchronized throughout the scale, once the correct inter-relation between the adjacent knurled knobs has been determined.

The degree of synchronism attained throughout the dial scale with the knurled knob arrangement is easily ascertained. Tune-in a station at the low end of the scale, making fine adjustment of each of the knurled knobs separately. Next tune-in a station preferably of moderate volume at the high end of the scale, by turning the knurled knobs as a group, being careful as you do so not to change the relation between the knurled controls. Having thus tuned-in a station as well as possible, note the volume carefully. Then adjust each circuit separately, noting whether adjustment of the individual circuits is required to secure accurate resonance. If the same relationship between the several knurled knobs which establishes resonance at one end of the dial scale holds for the other, the set is, in effect, a single-control one. On the other hand, if a new relationship between the various knurled knobs is required at different points along the dials, the set may be considered as having as many controls as there are knobs. Then the only gain by the knurled knob over the ordinary dial is in appearance, and in the ease with which it is adjusted by one hand. There are several makes of receivers employing adjacent knurled knobs for control which, when correctly adjusted with respect to each other, can thereafter be operated as a single control. Such receivers represent the last word in convenience and attain simplicity of control without sacrifice in efficiency.

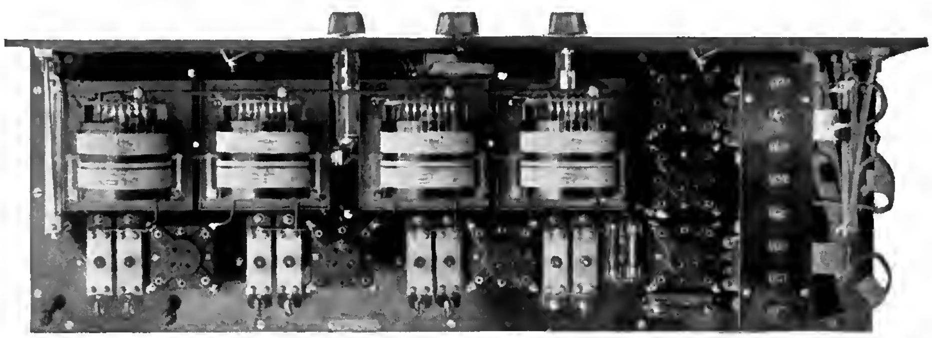
COMPLICATIONS OF SINGLE CONTROL

THE relative cost of obtaining exact synchronism of circuits manipulated by a single control depends on the sharpness of tuning attained for each individual circuit. With radio-frequency amplifiers of high gain and good sharpness of tuning, true single control is rather difficult to secure inexpensively without the aid of verniers. It is a question of precision manufacture, engineering tests, and painstaking design, all of which are naturally reflected in the cost of the receiver. If, at any point along the dial scale, one circuit falls slightly out of step, quality is seriously affected unless the set is fairly broad in its tuning.

There are a number of possible compromises involved in the design of a single-control receiver which account for the wide range in their prices. If quality of reproduction is sacrificed, great sensitiveness and selectivity may be secured at relatively low cost. If on the other hand, sharpness of tuning is sacrificed, a high standard of tonal quality without excessive cost is attainable. If high efficiency, high gain, perfect synchronism, and good quality of reproduction are combined without appreciable sacrifice of any of these qualities, such accuracy in design and manufacture requires that the cost of the set be necessarily high.

Eliminating the most expensive types, which have true single control, sensitiveness, selectivity, and good quality, how may we judge and balance all these diverse qualities in order to make the wisest purchase? To repeat: sensitivity, selectivity, or quality must be sacrificed to secure low cost. Obviously the most desirable sacrifice is not quality of reproduction, but sensitiveness or selectivity. By choosing a receiver, admittedly a little broad in tuning, you may have single-control simplicity, good quality, and satisfactory volume from local stations at reasonable cost. If troubled by local interference, changes in the antenna installation often minimize the difficulty. A long antenna brings in considerable energy from near-by stations and therefore broadens tuning. By shortening the antenna, selectivity may be increased to a point where interference troubles are minimized. Shortening the antenna reduces sensitiveness as the penalty for improving selectivity.

For the long-distance enthusiast who desires single-control simplicity, sensitiveness, and low cost, there are a number of receivers which, in a measure, attain all of these qualities by introducing regeneration in the radio-frequency circuits. Such receivers usually have a volume control, which, when turned toward maximum, sets the receiver into oscillation throughout the tuning scale, or perhaps does so only at the higher frequencies. These are often radiating receivers of the most pernicious type, feeding oscillations directly into the antenna circuit. Such receivers may be recognized not only by the fact that they flop into vigorous oscillation at the high frequencies, and give a piercing whistle as the dial setting for a station is passed, but also by the fact that stations are often heard at two or three closely adjacent points on the dials. A circuit closely approaching the regeneration point must be tuned with the utmost accuracy, a degree of accuracy almost unattained by any but the most precise of single-control receivers. Therefore, with single-control near-regenerative sets, stations are frequently heard at each point that the individual stages are precisely in tune with the incoming signal.



SIMPLIFIED ADJUSTMENT OF SEVERAL TAPPED COILS BY ONE KNOB

Such single-control near-regenerative receivers receive from long distances on the shorter waves, annoy the neighbors for miles around, and give good quality only with high-power local stations.

The better single-control receivers are absolutely non-regenerative. It must be realized that the absence of a tickler or regenerative adjustment is in no wise an indication that the receiver is not regenerative, nor need there be a plate coil feedback inductance or capacity or any other physical evidence of a regenerative circuit. The mere presence of a vacuum tube with elements having electrostatic capacity offers the foundations for a regenerative system. Whether this is avoided by neutralization or by the introduction of losses through counter-couplings or weak couplings is not obvious from any external inspection. Hence the real proof is an actual test of the receiver, particularly at the high frequencies where regenerative effects are most likely to be strongly manifest.

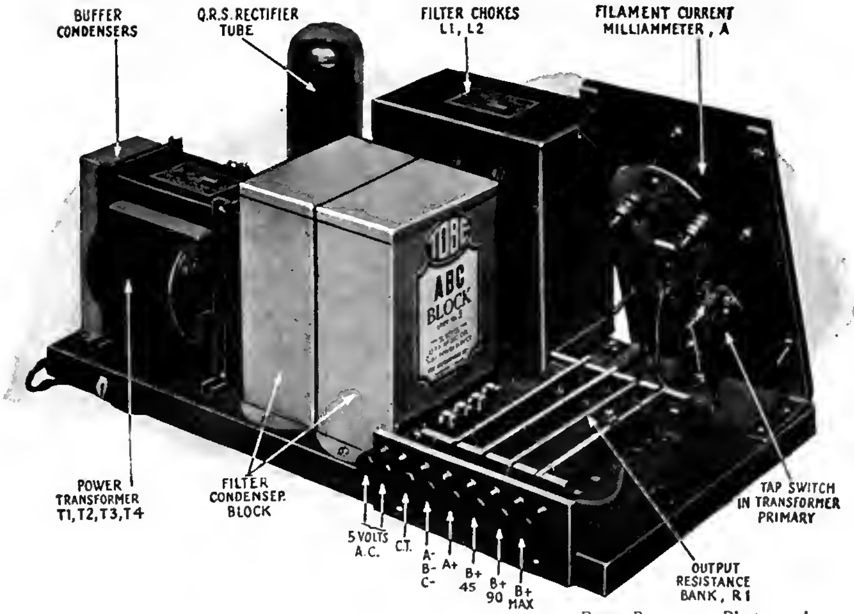
The high-grade, single-control receiver, which is well engineered through effective shielding and correct neutralization of regenerative effects, tunes sharply at both ends of the scale. The stations fall in and out of resonance like a parade as you go up and down the dial scale, with volume proportionate to their incoming signal strength. Such sets represent the last word in efficiency and simplicity of control—the product of precision manufacture and sound engineering. Many such receivers are equipped with three and four stages of radio-frequency amplification, associated with a directional loop.

An effective compromise in the attainment of convenient control without excessive cost is by the use of two controls, designed to operate as one, once their relative settings are fixed. Concentric or adjacent knurled knobs coupled by friction are used for this purpose. These are turned naturally as one, unless the user particularly desires to change their relative adjustment. Usually two controls are used in this way with receivers employing a separately tuned antenna circuit and unified control for the remaining stages of the radio-frequency amplifier. In this case, the input stage is made one of high gain, giving the receiver considerably greater sensitiveness. Different antennas have varying inductance, capacity, and resistance, and these factors affect the correct adjustment of the input circuit, making dual tuning necessary.

The difficulties of varying antenna constants may be obviated by using a loop designed as a part of the set, thus making dual control unnecessary. Other sets are designed for use with a very small antenna, or a large antenna in series with a small capacity, and the various circuits accordingly matched to meet such conditions.

Another method of attaining true single control, is to employ the input stage merely as a collector of antenna energy, without causing it to contribute any great amplification. The input stage is then untuned, a resistance or choke being used across the tube, through which the incoming signals are impressed upon its filament and grid. The remaining circuits, all being fed from the plate circuit of a preceding tube, are easily synchronized without any great manufacturing difficulties. Although contributing little or no amplification, the first tube introduces its share of tube noises and does not materially improve selectivity, a serious disadvantage if there is an excessively strong near-by signal. Considering the low cost of tubes, an inefficient stage is not a great disadvantage from an economy standpoint particularly as it makes possible single-control simplicity. On the other hand, it brings out the fallacy of rating a receiver's power by the number of tubes. The real criterion, by number of tubes, is dependent upon the number of stages of high-gain tuned radio-frequency amplification with which the receiver is equipped.

By this time, the reader will appreciate that judging a single-control receiver lends itself to no simple diagnosis. It is better to thrust aside all considerations of design, unless a most detailed study is made, in favor of a few simple observations and performance tests.



RADIO BROADCAST Photograph

A COMPACT A, B, C POWER-SUPPLY UNIT

This entire unit is constructed on a baseboard measuring 17" x 9". The following parts were used: Dongan power transformer and filter chokes, Tobe filter condensers, Carter output resistance, Yaxley tapped switch, Eby binding posts, Jewell milliammeter. Other parts that might be substituted are indicated in the table given in this article

A Lamp Socket A, B, C Device

The Design of a Power-Supply Unit Using the New Q. R. S. High-Current Gaseous Rectifier Tube

By GILBERT EDGAR

IT WOULD be difficult to estimate the amount of engineering research work that in the past has been devoted to the problem of complete a. c. operation of receivers. Probably the first really satisfactory all a. c. receivers were those using 199 tubes in series, with their filaments supplied with rectified a. c. from a B socket-power unit, and with a power tube in the last stage with its filament supplied by raw a. c. directly from a transformer. Such receivers as this were described in the October, 1926, RADIO BROADCAST, but evidently the development was somewhat premature, for not many such sets were built. Since then the question of a. c. operation has become a common subject of discussion and there is evidently considerable interest in this topic.

Two months ago, in the advertising pages of this magazine, there was announced a new rectifier tube, manufactured by the Q. R. S. Music Company, which could be satisfactorily used to supply complete power to a receiver from the power mains. One advantage that accrues from the use of this new tube is that 201-A type tubes may be used in the receiver, their filaments being wired in series. To wire a receiver with the filaments in series is not any more difficult than wiring them in parallel, and it is also an easy matter to rewire an existing receiver for series filament operation. The energy required by the new rectifier to supply A, B, and C voltage to a receiver is sufficiently low so that a. c. operation is not only convenient but also economically practicable. The audible hum heard in the output of a receiver operating from an A, B, C power unit is no greater than that experienced when the same receiver is operated with a storage-battery supply for the filaments and a B socket-power unit to supply the plate voltage. For normal operation the device must supply ¼ ampere (250 milliamperes) to light the filaments of the tubes and it must also supply plate current, so that the total load is generally about 280 to 300 milliamperes. This value of current is much greater than is found in a power unit designed to supply only plate voltage to a receiver and, therefore, the various chokes, condensers, and resistors used in such a unit cannot be used with this new tube. It is necessary that the various parts used have characteristics adapted to the use to which the device is to be put. The main power transformer has four windings, as shown in Figs. 1 and 2. T_1 is a primary preferably tapped for line voltages between 100 and 120; T_2 is a 5-volt winding capable of supplying ½ ampere for a 171 type power tube; T_3 a high-voltage secondary winding capable of delivering 375 volts each side of the center tap, and T_4 is a 4-volt winding to supply 5 amperes to a small ionizer designed to lower the internal resistance of the tube. The two filter coils, L_1 and L_2, must carry all the filament and plate current for the receiver and, at this very high current drain, they should have an inductance of between 3 and 5 henries. The condensers in Fig. 1 should have the following characteristics:

C_1—0.2-mfd. Buffer Condenser, } 600 Volts.
C_2—0.2-mfd. Buffer Condenser, } D. C. Working Voltage.
C_3, C_4—0.1-mfd. Condenser, }
C_5—5-mfd. Condenser, 400 Volts D. C. Working Voltage
C_6—10-mfd. Condenser, 400 Volts D. C. Working Voltage
C_7—1-mfd. Condenser, 200 Volts, D. C. Working Voltage
C_8—1-mfd. Condenser, 200 Volts D. C. Working Voltage
C_9—1-mfd. Condenser, 150 Volts D. C. Working Voltage

The resistances used in the output system are required to carry large amounts of current and special units are therefore necessary which are capable of dissipating considerable power. The resistance R_1 should be capable of carrying about 350 milliamperes and should have a total resistance of about 800 ohms. It is preferable that this resistance should be semi-variable because its value will depend upon the number of tubes in the receiver. Various manufacturers have designed transformers, chokes, condensers, and resistors especially for use with the QRS tube and a complete list of those companies making them is given in the table on page 154.

To determine the characteristics of the device, a complete power unit was constructed in the RADIO BROADCAST Laboratory in accordance

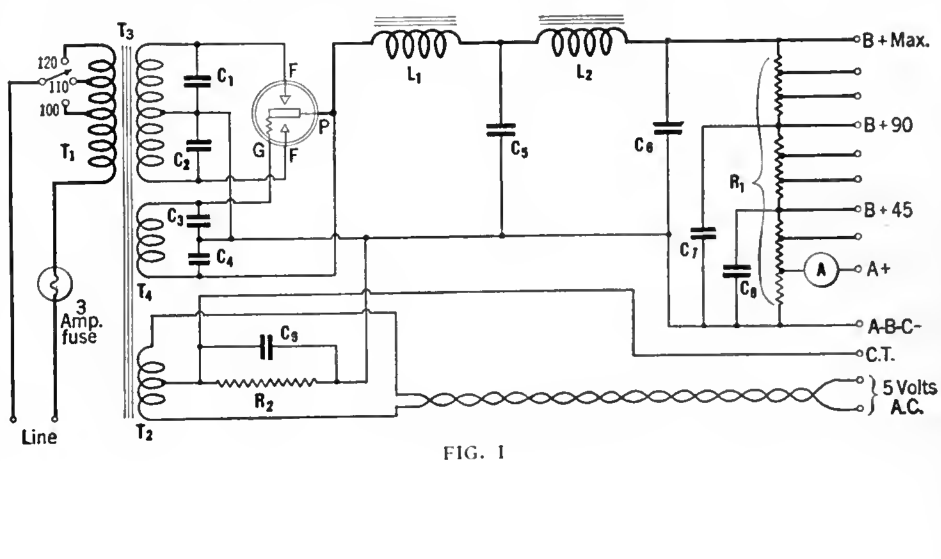


FIG. 1

with Fig. 1. Data were then taken on the unit, a photograph of which can be seen on page 153, to determine the input power and output voltage at various loads. In Fig. 3 is given a curve showing the power required by the device at various current drains. The total current drain from the device is equal to 250 milliamperes (that required to operate the series filaments of the tubes in the receiver) plus the total plate current required by all the tubes. Therefore if a receiver required 30 milliamperes of plate current, the total current drain from the device would be 250 milliamperes for the filaments plus 30 milliamperes for the plates, or a total of 280 milliamperes. The input power at this current drain is about 127 watts, which is approximately the power which the device requires when it is used to operate an ordinary five-tube receiver using a 171 type power tube. In Fig. 4, curve A, are plotted the data taken to determine the voltage delivered in normal operation. It is evident from the curve that, with a total plate-current load of 30 milliamperes (average load of a five-tube receiver), the unit will deliver about 200 volts, which is sufficient to satisfactorily supply plate and grid voltages for a 171 type tube. Curve B in Fig. 4 was made with transformer winding T_4 disconnected so that the ionizer filament was not functioning and, under such conditions, the device only delivers 145 volts with a plate load of 30 milliamperes. It is evident, therefore, that this tube will function without the ionizer but that under such conditions the output voltage is lowered.

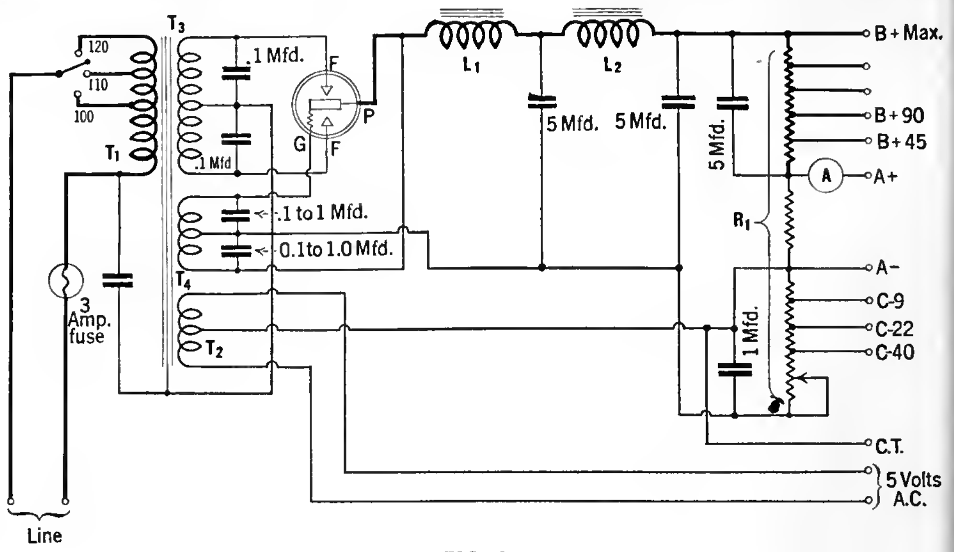


FIG. 2

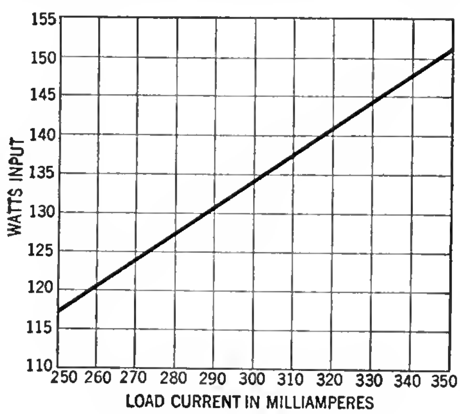


FIG. 3

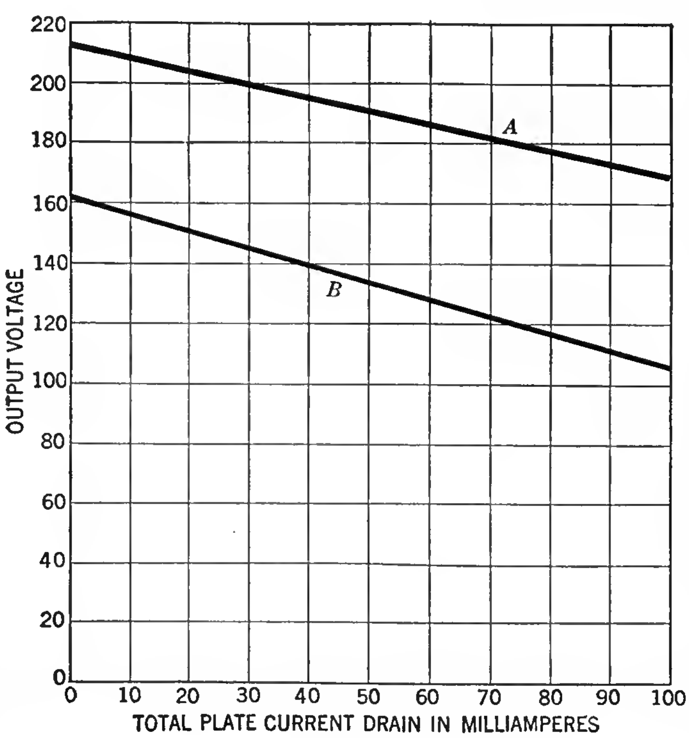


FIG. 4

OUTPUT SYSTEM

It is necessary to use at the output end of the unit a voltage divider, or potentiometer arrangement, to obtain the various voltages required by the receiver. The simplest, and in many cases an entirely satisfactory arrangement, is that shown in Figs. 1 and 2, in which the A and B voltages are taken from various taps along a tapped resistance, R_1.

The B voltages obtained by using such an arrangement are constant because the current flowing through the resistance due to the filament load is very much greater than the current drawn by the plate circuits from the various taps and, therefore, the plate-current is of a negligible quantity compared to the total current flowing through the resistors. With some receivers, however, especially those using audio amplification other than transformer coupling, some difficulty will frequently be experienced due to "motor boating," in which case it is necessary to use a different output arrangement. Complete information regarding the various output arrangements that should be used in such circumstances will be found in the article starting on page 157 of this issue.

C bias for the 171 tube is best obtained by connecting a resistance, R_2, in series with the center tap of the filament transformer supplying the filament of the 171 (See Fig. 1), while C bias for the other tubes is obtained by connecting resistances in series with their filaments at the correct points, as shown in the circuit diagrams accompanying the article beginning on page 157. A lead is brought out from the center tap of the filament winding T_2 to a terminal marked CT, and this terminal should connect to one side of the loud speaker jack in the receiver. In this way, the signal energy flowing through the loud speaker is brought back directly to the filament of the 171 tube, and this tends to make the operation of the receiver more stable.

Parts for the A, B, C Unit

Several manufacturers are now putting out parts capable of meeting the rigid requirements of high-current power-supply devices. Parts made by the following manufacturers, and suitable for such devices as that one described here, are approved by Radio Broadcast Laboratory.

Transformers and Filter Chokes: Dongan, Thordarson.
Condensers: Aerovox, Dubilier, Fast, Muter, Wilson Electrical Laboratories, Tobe, Potter.
Resistors: Aerovox, Allen-Bradley, Amsco, Carter, Centralab, Clarostat, Electro-Motive Engineering Corporation, Lynch, Ward-Leonard.

A complete A, B, C device is as simple to construct as an ordinary B power unit and is no more difficult to get operating properly. The entire device can be constructed on an ordinary baseboard. It will be found advisable to mount the baseboard on small rubber feet so that most of the wiring can be done under the baseboard. Use well insulated wire in the construction because the transformer supplies rather high voltages. The two leads from transformer winding T_2 supplying 5 volts a. c. to the filament of the 171 should be twisted together. In constructing a unit do not so arrange the apparatus that the filter chokes and transformer cores are near and in line with each other but endeavor to leave a space of several inches between them and place them out of line or at right angles to each other. The power unit shown schematically in Fig. 1 has been on test for some time, and has given very good results. The circuit diagram in Fig. 2 was supplied by the Q.R.S. Company. Very excellent results have been reported from the use of this latter circuit with all receivers.

For complete details regarding the correct manner in which to wire a receiver for series filament operation the reader is referred to the article starting on page 157 of this issue in which the subject is carefully explained. Pertinent data on this subject also appeared in articles in the two preceding issues of Radio Broadcast.

An A, B, C Power-Supply Unit for 201-A Type Tubes

A Power Device Which Provides for the Complete Elimination of All Batteries in a Radio Receiver—Some Design Hints and Precautionary Measures

By ROLAND F. BEERS

THE purpose of this article is to describe a satisfactory unit for supplying A, B, and C power to any radio receiver employing 201-A type radio tubes. It is the writer's belief that this article describes the first really satisfactory method, for the home-constructor, whereby complete radio power for 201-A tubes can be obtained from one unit. It is true that there have been separate A and B units in use for some time, and that their performance has been above reproach. For one who desires simplicity, however, the new method has many advantages to offer. Here is complete radio power from the light socket, without batteries or liquids, and the unit when completed requires absolutely no attention.

To use the power unit described necessitates that the filaments of the tubes in the receiver be wired in series. The writer has explained this method of connection in the two preceding articles of this series, and many diagrams and other data were given showing how to wire a receiver for series filament operation and how to obtain C bias for the various tubes; precautions necessary in using such an arrangement were also outlined. If the reader is not thoroughly familiar with the subject, the details thereof may be found on pages 33 to 35 of the May RADIO BROADCAST, and on pages 101 to 103 of the June issue. The writer has used series filament connection in practically all of the fundamental radio circuits and has found no reason why it cannot be used with any type of existing receiver if proper precautions are taken. An article starting on page 157 of this issue explains how the supply unit described here may be adapted to various well-known circuits.

The entire A, B, C power supply unit is built around the new Raytheon Type BA-350 mA. rectifier tube. This new development is a full-wave device, operating upon the principles of gaseous conduction. It has no filament. The principles involved in the design of this new unit are an extension of the fundamentals of all Raytheon gaseous rectifiers, and reveal improvements which increase the efficiency of these devices to a remarkable degree. These improvements were really a necessity, in order that a rectifier of reasonable proportions might be constructed. The loss in a device of this type takes the form of heat, which must be radiated by the glass bulb of the rectifier, and if the power losses were excessive, it would be essential to build a glass bulb several inches in diameter in order to keep the operating temperature at a safe value. By the improvement in the efficiency, it has been possible to keep the size of the BA rectifier down to moderate proportions.

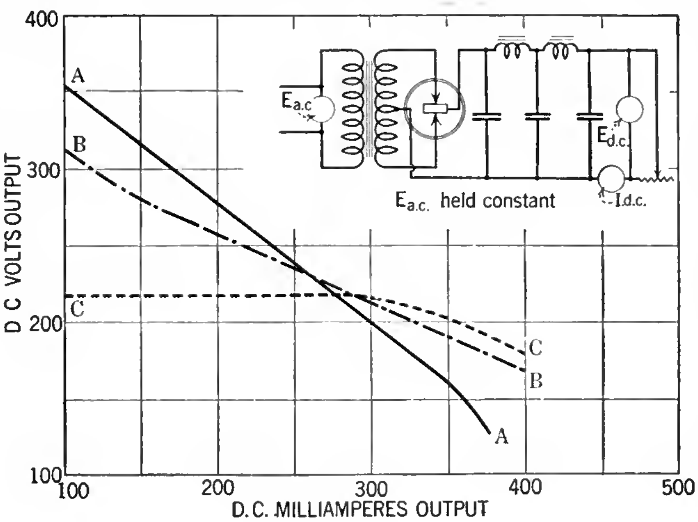
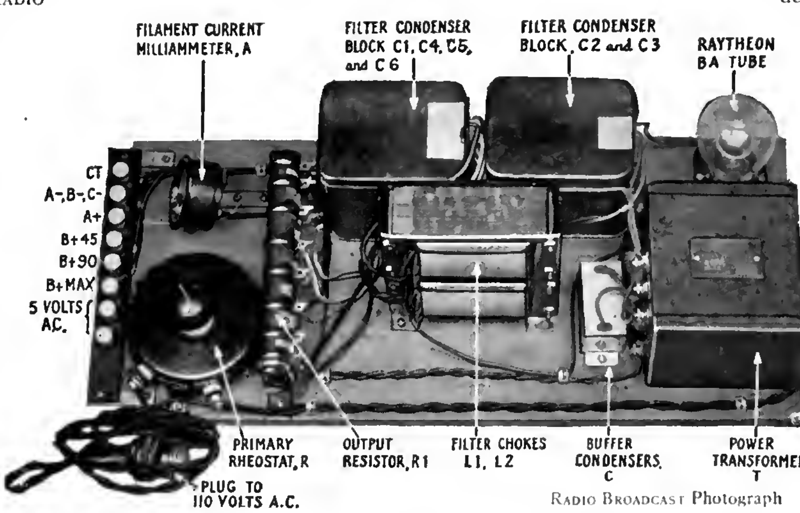


FIG. 1

Three output voltage curves for three different experimental designs of the Raytheon BA rectifier, curve C being the design that was finally adopted. Note that the output voltage is constant from 0 to 300 milliamperes. Curve A is a very unsatisfactory one for if a tube is suddenly removed from a receiver and the load on the power unit tube reduced to practically zero, the voltage will rise to a comparatively high value and endanger the filter condensers

The full load rating of the tube has been placed at 350 milliamperes and 200 volts d.c. output at the terminals of the filter circuit. This rating, which includes the watts which are bypassed through the filter circuit, is sufficient to operate any receiver having up to ten tubes and a power amplifier. A minimum life of 1000 hours may be expected from these new rectifiers provided they are not overloaded or abused. Fig. 1, "C," shows the characteristic of a typical BA rectifier used in a complete power unit. It should be noted that the voltage is practically constant at all loads and, therefore, if a tube is suddenly removed from the circuit and the load as a result drops from something around 300 milliamperes to about 20, the voltage will not rise excessively and endanger the filter condensers.

In other words, the voltage remains practically constant independent of the load and, therefore, there is almost an unlimited current capacity in the device This large reserve of power is very desirable as long as it does not exceed the useful power required by the radio receiver, and means must evidently be taken to limit the output of the power unit to this useful value. It is therefore necessary to use special methods of design in the power transformer and filter circuit, and it is consequently not feasible to recommend that the radio constructor build his own power transformer or filter. Their characteristics are very unusual, and it is doubtful if the average constructor could meet the requirements of the design in home-built units. Manufacturers have coöperated with the designers of the BA rectifier, and have affected the design which is best suited for the purpose.



RADIO BROADCAST Photograph

A COMPLETE A, B, C POWER SUPPLY

Using a Raytheon BA tube. This particular unit uses a Thordarson transformer T, Thordarson choke coils L_1 and L_2, Dubilier condensers type BA2 for C_2 and C_3, type BA3 for C_1, C_4, C_6, and C_6, and Type BA1 for the two buffer condensers, C. The primary rheostat R, and the tapped output resistance R_1, are made by Ward-Leonard, while the 2000-ohm C bias resistance R_2 (this resistance cannot be seen in the photograph) is a 2000-ohm Tobe Veritas resistance. The filament milliammeter, A, is a 300-milliampere Weston model 506 meter. Eight X-L binding posts are used and the unit is wired with Kellogg Switchboard Company hook-up wire. It can be built at a cost of about $90.00

The power transformer is rated at approximately 175

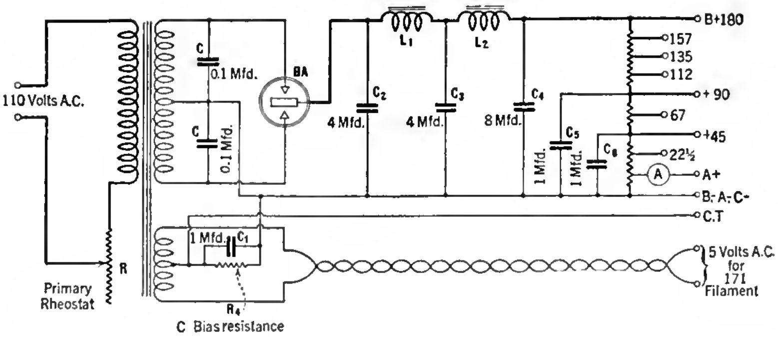


FIG. 2

All the plate-, filament-, and C-battery potentials required by a receiver can be obtained from an A, B, C socket-power unit constructed in accordance with the circuit diagram given in this diagram. The various A and B voltages are obtained across a tapped fixed resistance in the output. A 171 power tube is supplied with 5 volts a.c. for its filament, while the C bias for this same tube is obtained by means of a voltage drop across resistance R_1. "R" is the primary rheostat which compensates variations in the line voltage

watts; it has a secondary winding delivering 320 volts per side for the BA rectifier, and a filament winding of 5 volts at 0.5 amperes for a 171 type power amplifier tube. The choke coils, L_1 and L_2, are of special design, and have a minimum inductance requirement of 10 henrys at 350 mA. direct current. Their d.c. resistance lies between 150 and 200 ohms each. Ordinary choke coils cannot be used in this circuit on account of the large amount of direct current which must flow through the windings. The transformer and chokes are offered by the Acme Apparatus Company, Cambridge, Massachusetts; the Dongan Electric Manufacturing Company, Detroit, Michigan; and the Thordarson Electric Manufacturing Company, Chicago, Illinois.

The normal operating voltage of the filter condenser block should be at least 400 volts d.c. The two buffer condensers in series across the secondary of the power transformer have a capacity of 0.1 mfd., and an operating voltage rating of 1000 volts d.c. (Various manufacturers have arranged to supply condensers that meet these recommendations. At the present time they are being made by Dubilier, Tobe, Aerovox, Muter, Mayolian, Potter, and Fast, and very likely by the time this article appears in print other manufacturers will also be making them.—*Editor.*)

The resistance units used in the device are also special for they must have a wattage rating much in excess of that necessary for a resistance used in an ordinary B socket power unit. Excellent resistances have been designed, however, and are being made by Clarostat, Carter, Ward-Leonard, Centralab, Aerovox, Amsco, Lynch, and the Electro-Motive Engineering Corporation.

HOW THE UNIT FUNCTIONS

A BRIEF explanation of how the A, B, C unit functions will be interesting. The alternating current from the power transformer passes through the BA rectifier, where it is converted into pulsating direct current. This pulsating current may be considered as consisting of a pure direct current and an a.c. component. It is the function of the filter circuit to absorb or bypass the alternating current and to pass on only pure d.c. Approximately 60 mA. of a.c. are bypassed through the filter circuit for a d.c. output of 350 mA. Having obtained a uniform and smooth direct current at the output of the filter circuit, it is now our purpose to dispose of it with reference to the radio receiver, in the proper voltages and currents.

This is effectively accomplished in one of two ways. The first is to use a tapped fixed resistance across the output of the filter circuit as shown in Fig. 2. This unit has a resistance of about 470 ohms, and is supplied with a plurality of taps so that a great range of voltages is available. By the use of this single resistance all the plate and filament voltages are obtained with little difficulty, and since the points at which to take taps can be easily determined in designing the resistance, the method has the advantage that the voltages available at each tap are fairly definitely known. All the plate voltage taps which are used should be bypassed to A minus with a 1-mfd. condenser to prevent undesirable coupling effects.

Fig. 3 shows an alternative means of obtaining the proper plate and filament voltages, and in this arrangement practically any voltage from zero to maximum can be obtained from each voltage tap. This latter system is therefore quite flexible, but it has the disadvantage that the voltages are not known unless a voltmeter is available to measure them. In Fig. 3 the voltages are obtained through variable resistance units, R_2 and R_3, such as Clarostats, and filament control is obtained through a fixed or semi-variable resistance, R_1. In such an arrangement, R_1 must be capable of carrying $\frac{1}{4}$ ampere.

The most important control resistance is that shown in the primary of the power transformer and marked "R" in Figs. 2 and 3. The purpose of this resistance is to offer a degree of control over the primary line voltage and it will be found most valuable in obtaining satisfactory operation from the entire unit. The maximum value of this resistance should be about 15 ohms, and its minimum value about 4 ohms. In the case of the Acme transformer, a 4-ohm resistor is mounted on it so that the additional resistance may be obtained by the use of a 10- or 12-ohm rheostat. The rheostat must be capable of carrying $1\frac{1}{2}$ amperes continuously without undue heating. Rheostats for this purpose are made by Clarostat and Ward-Leonard.

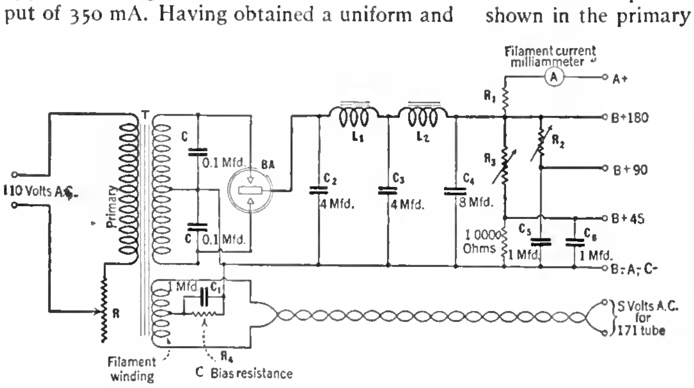


FIG. 3

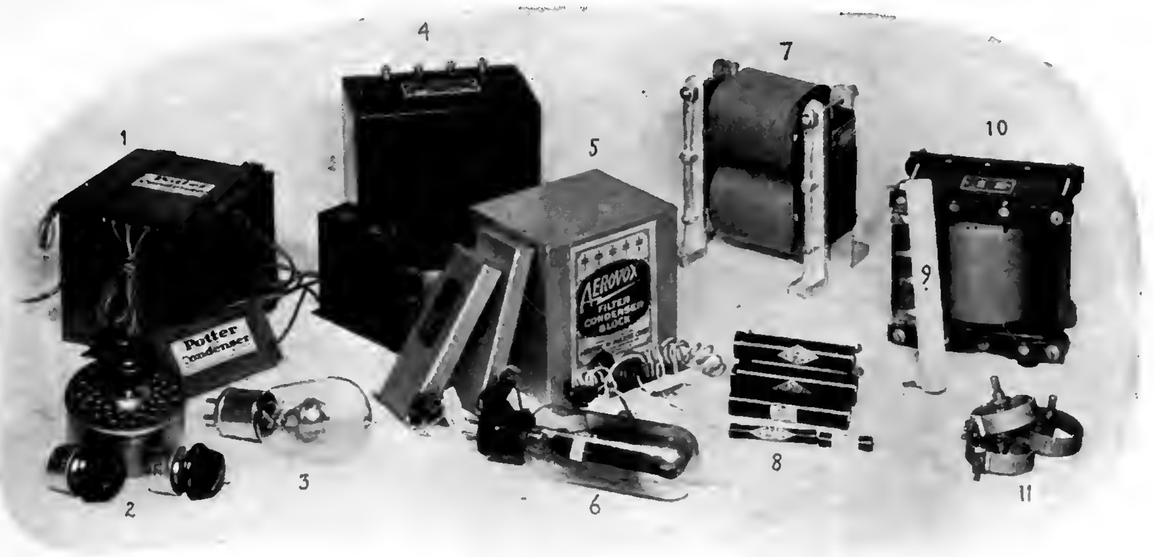
This circuit diagram shows an arrangement using variable resistances in the output so that various voltages can be obtained whereas, in Fig. 2, the various voltages were obtained from taps in a fixed resistance. The primary rheostat, "R," should be adjusted so that the milliammeter, "A," in the filament circuit, reads between 240 and 250 milliamperes. The BA tube when it is first turned on will glow brilliantly but this glow should disappear in a few seconds

If the experimenter desires, he may build up a power supply unit of this type as an accessory to his series filament radio receiver, or he may construct it as an integral part of the receiver. The performance of the unit will be the same in either case and it is simply a matter of choice which type of power supply the home constructor will build. The photograph shows the manner in which the various parts are assembled. Particular attention should be paid to the arrangement of the power transformer and the filter chokes, so that the effects of good filtering will not be offset by the cores of the filter chokes becoming saturated with leakage flux from the power transformer. Place the iron cores at right angles or out of line with each other.

In building a case or housing for the power supply unit, it should be borne in mind that there is a considerable amount of heat to be dissipated, and that sufficient ventilating means must be employed for this purpose. It is therefore not advisable to build a completely enclosed cabinet which will prevent the circulation of cool air throughout the interior. The rectifier bulb must not be allowed to become over-heated, neither must the transformer nor control resistances be prevented from radiating the normal amount of heat.

The operation of a series filament receiver supplied with the Raytheon power unit just described is not greatly different from that of the ordinary type of receiver. Variations in filament current of the order of 10 per cent. have very little effect upon the output of the radio receiver. In normal operation the Raytheon BA rectifier will be found to run fairly warm, as its efficiency is dependent upon a certain amount of heat within the rectifier, but if the bulb of the rectifier is hot enough to sizzle when it is touched with a moistened finger, it is evident that there is some overload on the rectifier, and the cause of this should immediately be determined. It may be caused by a blown condenser in the filter circuit, or by a short-circuit of the output. Such a condition as this would of course be otherwise manifest by faulty reproduction, or total failure of the output voltage. Any such overload on the rectifier should be immediately removed in order not seriously to shorten its life. If a red-hot spot is seen within the rectifier at any time, it is direct proof that there is a short-circuit in the output of the power unit, which should be corrected at once. The power transformer will run slightly warm under normal full load and the filter chokes should show a very slight rise in temperature. The output resistance units will all run approximately 190° F. If a higher temperature than this is attained it is not safe for inflammable material near by, but if the resistance is housed in a metal container it may be considered reasonable if these units do not exceed 300° F. It is of course a matter of common sense that the resistor units should be mounted in such a position that the hot surfaces do not come in contact with inflammable materials.

During the normal operation of the power unit it may be noticed that there are slight variations of the filament milliammeter which will be caused by fluctuations in the a.c. line voltage. It will be found convenient to maintain average filament currents at a figure between 240 and 250 mA., so that a 10 per cent. change will neither overload the filaments nor cause the amplification to go below normal values.



Radio Broadcast Photograph

APPARATUS FOR A, B, C POWER UNITS

The equipment shown in this photograph, in addition to that specified for the units in the two preceding articles, has been especially designed for A, B, C devices. (1) Potter filter condensers; (2) Clarostat variable resistances, including the new power Clarostat for controlling the primary voltage; (3) Raytheon BA tube; (4) John E. Fast filter condensers; (5) Aerovox filter condensers; (6) Q. R. S. 400-mil. tube; (7) Acme filter chokes; (8) Amsco A, B, C resistor kit; (9) Lynch A, B, C resistor; (10) Acme power transformer; (11) Centralab A, B, C resistor kit

Receiver Design for A. C. Operation

Rewiring the Filament Circuits of Some Popular Receivers to Conform With the Requirements for A, B, C Socket Power Supply—New Circuits for the "Lab," "Universal," Browning-Drake, and Neutrodyne Receivers

By HOWARD E. RHODES

IN THE two preceding articles there has been given information regarding the construction of A, B, C power units, using two different rectifier tubes. In this article we will explain how to apply these power units to various receivers. The circuit diagrams of these two power units differ in some details but fortunately the output connections on both are exactly the same and, consequently, there is no need to differentiate between them in applying them to receivers. A receiver designed for use with the unit using the Raytheon tube will work equally well if supplied from the Q.R.S. power unit. Therefore, in the various diagrams in this article we will not include the power unit, and the reader should understand that in all cases the various terminals on the receiver are to be connected to the corresponding terminals on the power unit.

Tests have been conducted in the Laboratory using a five-tube receiver consisting of a stage of r.f. amplification, regenerative detector, and a three-stage double-impedance amplifier. A regenerative receiver using this type of amplification is frequently difficult to get working properly with a power-supply unit because of a marked tendency to "motor-boat," and it was felt that, if this receiver could be made to function satisfactorily with an A,B,C power unit, any other receiver would surely work satisfactorily. It was found that the receiver "motor boated" badly using the output circuit shown in Fig. 1, A, although when a two-stage transformer-coupled amplifier was substituted for the double-impedance affair, results were excellent. To prevent "motor boating" with the impedance amplifier, the output potentiometer circuits shown at B, C, D, or E, Fig. 1, had to be used.

The output arrangement indicated at "B" differs from the output arrangement shown at "A" in that the filament and plate circuits have been separated. In this arrangement R_1 should have a value of about 700 ohms and be capable of carrying the filament current, and R_2 may be a fixed resistance of about 4000 ohms capable of carrying 50 milliamperes. The total resistance of R_3, R_4, and R_5 should be about 10,000 ohms with taps at various points for different plate voltages. The three latter resistances can be obtained from Amsco, Ward-Leonard, Lynch, or other reputable manufacturers.

In the arrangement shown at "C" the filament current and plate voltages for all the tubes except the detector are obtained from a common resistor. The detector plate voltage, however, is obtained from a separate resistor, R_1, which should have a value of 40,000 ohms. A variable resistance, such as the high-range Clarostat, may

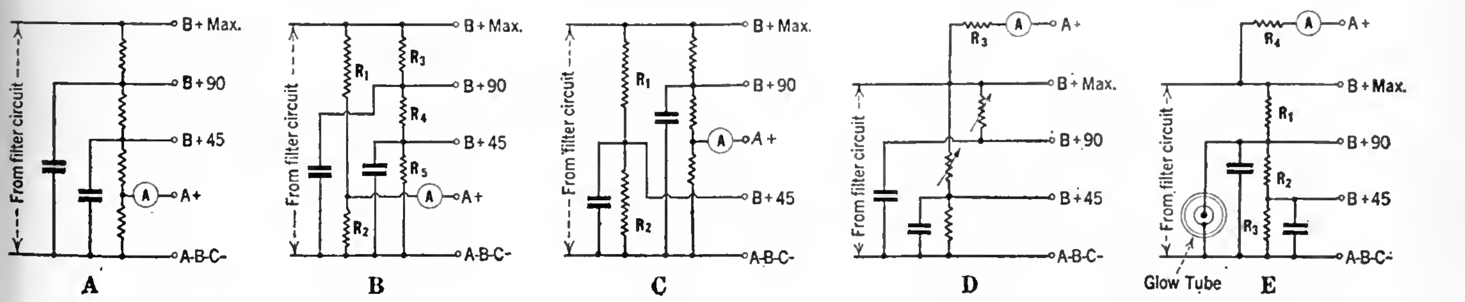


FIG. 1

also be used here. R_2 is a discharge resistor with a value of 10,000 ohms.

At "D" is shown an arrangement using variable resistances to obtain amplifier and detector voltages. Due to the use of two separate resistances for this purpose there is little or no common coupling and, therefore, freedom from "motor boating" is obtained. The filaments are here supplied from a separate resistance, R_3, which should be capable of carrying the filament current. All of these resistances may be obtained from the American Mechanical Laboratories in the Clarostat "A" kit, or they may be obtained as supplied by Centralab.

At "E" we have an arrangement using a glow tube which has also been found very effective in preventing "motor boating." In this circuit, R_1 should have a value of 1500 ohms, R_2 a value of 4000 ohms, and R_3 a value of 6000 ohms, and R_4 must be capable of carrying the filament current. A circuit somewhat similar to this has been worked out by Amsco and a drawing showing it is being supplied with the resistors which they have designed for the job.

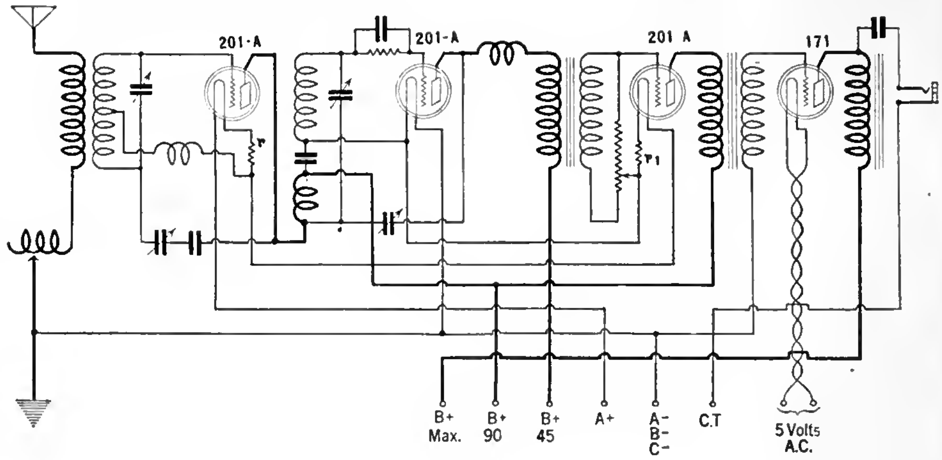


FIG. 2

ADAPTING POPULAR CIRCUITS

In FIG. 2 is the circuit diagram of the four-tube "Lab" receiver, described in the November, 1926, Radio Broadcast, revised for series filament operation. The order of the tubes from the A plus terminal is r. f. tube first, first a.f. tube second, and detector tube third. The output tube is, of course, supplied with raw a. c. Resistances r and r_1 in the filament circuit are used to obtain grid bias for the r. f. and first audio tubes respectively. They should both have a value of 18 ohms (such as Carter type H-18), which will give each tube a grid bias of $4\frac{1}{2}$ volts. The Carter Radio Company makes a complete line of resistors for use in this connection and they are very satisfactory. The two leads from the 171 tube filament should be twisted together and brought down to two a.c. filament terminals, and it is absolutely necessary that the output circuit shown in the plate circuit of the 171 be used and that one side of the loud speaker jack connect to the center tap, CT, as indicated. The negative A should be grounded. No trouble should be experienced with this receiver due to "motor boating" and, for this reason, any output arrangement indicated in Fig. 1 may be used. However, in the event that the "Lab" receiver has been constructed using a different type of audio amplifier, such as an impedance- or resistance-coupled circuit, it will very likely be necessary to use a special output arrangement in the power unit to prevent "motor boating." Separating the detector plate voltage supply from the rest of the A and B circuits, as shown in B, Fig. 1, will generally eliminate the trouble, but if "motor boating" is very persistent it will be necessary to use the glow tube arrangement shown at "E" in Fig. 1.

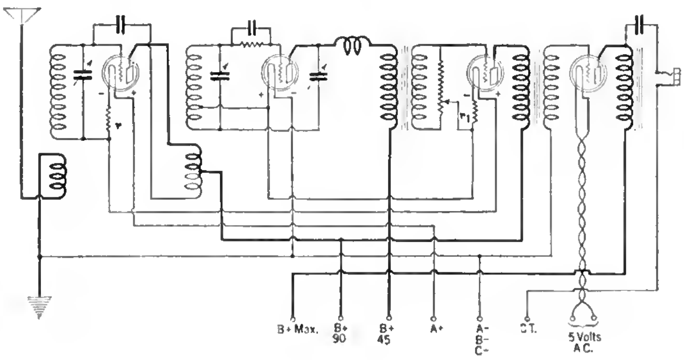


FIG. 3

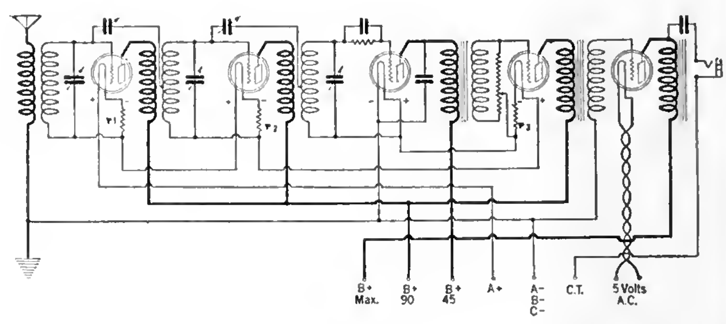


FIG. 4

In Fig. 3 we have a diagram of the new "Universal" receiver, described in Radio Broadcast for December, 1926, wired for a.c. operation. The order of filaments is the same as in the case of the "Lab" receiver, and the two resistances, r and r_1, should each also have a value of 18 ohms. This receiver will operate satisfactorily using any of the output arrangements indicated in Fig. 1.

In Fig. 4 is given the circuit diagram of an all-a.c. neutrodyne receiver. The resistances r_1, r_2, and r_3 should each have a value of 18 ohms, which will give the two r. f. tubes and the first a. f. tube a grid bias of 4.5 volts. The receiver will function satisfactorily with any of the output arrangements indicated in Fig. 1.

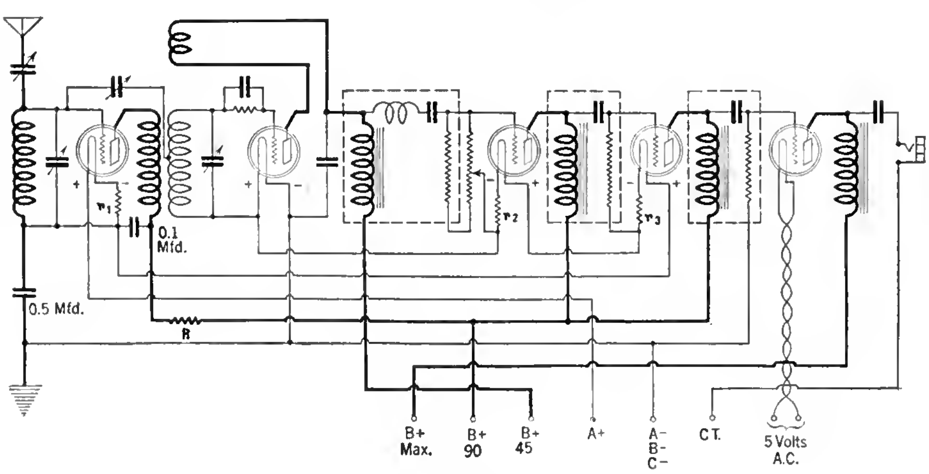


FIG. 5

Fig. 5 is the circuit diagram of the impedance-coupled Browning-Drake receiver which was described in the September, 1926, Radio Broadcast, now connected so as to be satisfactory for use in conjunction with A, B, C power units. The order of the filaments from the A plus terminal is r.f. tube first, second a.f. tube secondly, first a.f. tube third, and detector finally. The resistance r_1 should have a value of 12 ohms; r_2 should have a value of 4 ohms, and r_3, a value of 12 ohms. The negative A should be grounded and should also connect through a 0.5-mfd. fixed bypass condenser to the lower side of the coil in the antenna circuit. It is unlikely that this receiver will give satisfactory results with the output circuit arrangements of the power unit shown at "A", "B," or "C," Fig. 1. For this set it will be preferable to use the circuit arrangement indicated at "D" or "E."

The 15,000-ohm resistance, r, in the plate circuit of the r.f. tube, is used to cut down the voltage to about 65 from 90 to prevent any possibility of trouble due to oscillations in the r.f. amplifier. A. C. operation can also be applied to other receivers by following the suggestions given in this article.

THE LISTENERS' POINT OF VIEW

Conducted by John Wallace

Sunday Broadcasting Is Five Years Behind the Times

ALAS, what a sad affair is Sunday daytime broadcasting! In respect to its other hours of duty, radio has progressed remarkably since its earliest days, but Sunday has lagged behind and is as bad as it ever was. Sunday of all days!—the very day when radio should be neatly polished as to boot, washed as to ear, and comporting itself at its very best—the one day of the week when the man of the family who foots its bills is on hand to listen to it.

Before commencing to write this article we led ourself to a darkened room, sat ourself down in a not too comfortable chair, and forced ourself with the most hurculean efforts of will to ponder solemnly for one half hour as to the reason why. The conclusion of that thirty minutes of terrific concentration found us still entirely in the dark—in both senses. It is still utterly inexplicable why radio stations, the country over, and without exception, should put forth their very worst at the one time of the week when it would be most advantageous for them to put forth their very best. We pass the question on to you: Why?

That they blare forth either their worst—or nothing at all—is a matter of record, which record we shall presently submit to you. We are concerned in this present discussion simply with the program offerings of Sunday mornings and Sunday afternoons, that is, all those up to 6:00 P. M. The day time broadcasts may be divided into two kinds: First, those which are holy; and second, those which are not holy. In both departments a very low level of quality exists.

But to consider them one at a time, the non-holy offerings first. The complaint on this score can be briefly put—*where are they?* The few offerings aren't so bad, a couple of them are really good, but they are so lamentably few. The good soul who gets himself up early of a Sunday morning to go to church or to till the garden often finds himself with a couple of idle hours on his hands while he awaits dinner. Is there anything entertaining for him to listen to? There is not—unless he be interested in a radio reading of the funnies. It is practically impossible to get any respectable dinner music, unmixed with vocal solos, around Sunday noon, though on any given evening of the week a dozen dinner orchestras are available. In the afternoon he is little better off. In summer, few people are hanging around their parlors—one look at the roads proves that point. But in winter there are millions of potential listeners during the afternoon hours. Nevertheless the winter Sunday afternoon programs are no better than the summer ones.

We do our listening near Chicago and here is what is available to us on an average Sunday: Nothing at all before 1:15 when WGN offers a forty-five minute program from Lyon and Healy's; a string quartette from WMAQ at 1:45; a couple of mediocre orchestras from unimportant stations at 2:00 o'clock; at 3:00 (until recently) a very good concert by the Chicago Philharmonic Orchestra through WGN (but unfortunately its season ended in April); at 4:00 o'clock a fair program from WBBM, and at 5:00 another fair one from WEBH.

A RELIGIOUS SERVICE AT WMBI, CHICAGO

We do not argue that these offerings, and some by other stations, are not likely to be good. But we protest that our choice is so limited. The 2:00 to 6:00 hours on Sunday should discover us choosing from a plethora of good things; instead it more often finds us giving up a fruitless search in disgust and switching off the receiver.

Since daytime distance reception doesn't exist we can't be sure whether listeners in the East and in the West are as bad off as we are, but a reading of the Sunday program listings in those sections leads us to suppose so. A careful perusal of the New York programs for a recent Sunday in April suggested only five programs that we would consider tuning-in: WJZ at 2:00, Roxy and his gang; WGL at 3:00, Orthophonic Musicale; WPG at 3:15, Organ Recital; WOR at 4:30, Studio Guild Program; and WRNY at 4:30, Clarinet Quartette. Even then it would be a gamble whether all or any of them would be worth while.

In a west coast program magazine we could find, of the twenty-seven stations listed, only four programs that seemed to promise any interest whatsoever: KFWI at 1:00, Vocal Selections; KFWB at 2:00, Organ Recital; and KGW at 1:00 and 4:00, Orchestra.

Well, so much for the non-holy Sunday offerings—the only trouble with them is that they ain't!

SIGNING THE "BOOK OF FRIENDSHIP" AT WRVA

Following a program of Indian songs, Chief Wa-hun-sun-a-Cook, Chief of Chiefs and Great Sachem of the Pamunkey tribe, spoke from WRVA. He is shown signing up Studio Director Elmer G. Hoelzle in the "Book of Friendship." Assisting in the honors are Pocahontas, the Chief's daughter, and Minnehaha, his wife

As to the religious broadcasting, we hesitate to stick our foot into a so highly controversial subject, but perhaps we can maintain a perch on the fence and prod about in the material with a long and disinterested stick.

No one can deny that there is plenty of religious broadcasting. Turn to any part of the dial at any part of the day and hear rantings of all kinds and descriptions. As to whether all this talk accomplishes a very tremendous or very negligible good, it is decidedly out of our province to opine. As a radio program reviewer our concern is solely that the listeners, as a body, be given their money's worth in programs. Unquestionably there are great numbers of individuals interested in furnishing religious broadcasts. It is likewise unquestionable, if not so easily demonstrable, that there are great numbers of persons interested in hearing religious broadcasts, even such (to us) irritating bombast as that ladled out by the Reverend Bradley (WMAQ).

Religious broadcasting, as now done, should be continued. We would be the first one to protest if the Ultra-Advanced-Thinkers should attempt to eliminate the religious matter now being broadcast. However, still in our disinterested rôle of program critic, we think it should be clearly realized that there exists a great number of radio receiving set owners who can not conceivably be interested in this type of program. It is a matter of simple equity that they also be shown some consideration.

Zeh Bouck, whose comments on radio and things in general appear in the *Sun* (New York) writes us on this topic. He evidently finds himself in this unchurchly section of the radio audience. His arguments are convincing, if caustic. He says in part:

"I should like to see something done in the way of reasonable religious broadcasting. There is entirely too much hymn singing, damning of lost souls, and evangelizing in our Sunday ether. In other words, we have entirely too much theology and not enough religion. Is there no broadcasting station with sufficient courage to devote an hour each week to a philosophical discourse on right living—considering morality from a scientific, not theological, point of view?

"Aside from assisting Elmer Gantry in the preparation of sermons, Bob Ingersoll performed other useful functions during his life, one of which is summarized in his remark that, 'What we need is religion that will teach us how to live, not how to die.'

"While there are people who demand theology (the religion of golden streets, pearly gates, and seraphim), I see no really good reason why it should not be given to them. At the same time there are hundreds of thousands who are unable to reconcile Christian theology with their sense of criticism and scientific education.

"The type of religious broadcast that I suggest would be most welcome and helpful to this legion, which increases daily as the absurdities of fundamentalism—and even modernism—become more apparent in the light of a growing tendency to think clearly and independently."

Maintaining our position on the fence, we refuse to take sides either with the modernists, the fundamentalists, or with the skeptical group to which Mr. Bouck belongs. Each of these three groups should be given adequate attention, and service, in proportion to the numbers. Certainly under present conditions the fundamentalists are getting a disproportionately large share of the Sunday broadcasting time. This is well and good for the fundamentalists. For the others who chance to listen-in on Sundays it is no good at all. Why? Because they don't listen to it.

It seems absurd to bring out this point, which is so plainly evident. But it would seem to be a fact that is not clearly realized by the religious broadcasters. Or perhaps they realize it and ignore it. If so, we do not see how they can conscientiously ignore it—and they are conscientious folk. The worthiness of the final aims of an evangelical fundamentalist preacher might be readily agreed to by both the other factions in the radio audience. Yet neither of these factions would lend an ear to this same preacher's radio sermons. The reason is plain enough—they can not understand the language he is speaking. You might protest until blue in the face that they *should* understand the language he is speaking, but that will in no way alter the practical fact that they don't.

So it seems to us that the radio station which books its Sunday solidly with sermons of this type is discriminating unfairly, and deliberately closing the gates of salvation, or denying the formula for right living, or—call it what you will, to a vast section of its regular listeners.

If a radio station owner sincerely and genuinely assumes a certain satisfaction for his part

JEROME DAMONTE, AT KGO

This artist is heard regularly on the luncheon concert program over this station on Mondays, Wednesdays, and Fridays. He is a member of the Novelty Trio

in conveying words of wisdom to thousands of souls, he must, if he be truly sincere and genuine, also assume the burden of his crime of omission in denying these same messages to half his clientele.

If he feels duty bound to turn over his facilities to such orthodox preachers as ask his service, he is by that same sense of duty, bound, as a purveyor of public service, to turn over his facilities to such speakers as could conceivably reach the ignored half of his audience.

This does not mean that he must act in nonaccordance with his principles. It is his own radio station and surely he should not be asked to use it for the dissemination of doctrines which he sincerely believes to be pernicious. But it is perfectly possible for him to be of service to the unbelieving section of his listeners without violating any of his own pet beliefs. There are no end of contemporary writers and scientists, sociologists and philosophers who, without recourse to religious dogma at all, come to precisely the same fundamental conclusions concerning right and wrong human conduct as have the venerable and understanding doctors of the churches.

Let the radio station manager select from this group of thinkers the men who reach, in their own quaint fashion, conclusions compatible with his own. Let him invite, urge, coax, or even pay these gentlemen to give Sunday talks from his radio station. In other words, let him appeal to the non-conformist group of his listeners in a language which they can understand.

To put our point concretely: Suppose some contemporary psychologist, through long years of scientific research and observation of his fellow humans, has come to the conclusion, moral aspects disregarded, that it is unscientific, unreasonable, unprogressive, and otherwise subversive of happiness, for a man to tread the primrose path. . . . Given a present day radio preacher holding forth on the same theme; he approaches it in an entirely different, if equally valid, method. But his method is so antagonistic to certain listeners, such as our correspondent, that they either refuse to listen to him or discount his conclusion. These same individuals might have been easily reached by a talk by the aforementioned psychologist.

The way is quite clear; it remains only for some enterprising radio station to take it up.

At any rate something should be done, and shortly, to improve Sunday broadcasting. In such a low state is it at the present time that we will hazard the guess that half the receiving sets in the nation lie idle the whole day through.

How It Feels to Face a Microphone For the First Time

MANY articles have been written on this subject, but none has afforded us more amusement, or seemed to more accurately portray the situation, than that written by Francis Hackett, the Irish novelist, for the *Radio Times* (London). A few paragraphs culled from the midst of others equally droll:

". . . In the studio there is perfect silence. You must begin. And for two instants you are struck by a dumb futility. How do you know that anyone is listening? This audience is a blank. It is inanimate. It cannot clap or boo or say 'Hear, hear.' For all you know, everyone has gone away to dinner and you are about to chatter to the void. This thick suspicion is so unbearable that you brace yourself to believe in something totally outside your experience.

"It is like a dive. In the way that a diver must say good-bye to his springboard and launch his body into the air, so must you pass from the sure footing of silence and launch into speech. With a rushing and breathless celerity you give your words to space, and what you are saying flicks by you unrecognized, like telegraph poles

MUSICIANS ON THE STAFF OF WSM, NASHVILLE

Edward Stockman, baritone; Mildred King, pianist; Vito Pellettieri, violinist and director of Vito's Radio Seven; Lillian Watt, soprano from a train window. This is a strange confusion. You know you have actually begun to speak, but what exactly you are expressing, what the words are conveying, is not in your grasp. In the first moments you have more sensations than you can deal with. This plunge is headlong, dizzying, and obliterating. You have broken with the habit of a lifetime, have lost the earth. Whenever before you have spoken in public you have had your victims before you. They looked at you, you looked at them; they coughed if you bored them, and when they fell asleep you could enjoy their peaceful expression.

"After the first five minutes, what you want to say really takes possession of your mind, and you definitely want to communicate to these invisible listeners exactly what you have felt. As this conviction mounts, the act of speaking becomes more natural and more amusing. You are not courageous enough to look at the clock, which is glaring at you from the right, and you dare not glance away from the microphone lest it should turn its back on you.

"The dive is over; you are no longer gulping the water and gasping; you begin to time your strokes, to find a rhythm, to swim. And as you do this, the futility of your own ideas gradually becomes less apparent; you actually convince yourself that what you are saying is not so idiotic.

"Then the pleasure of speaking to invisible listeners begins to gain on you. Can they escape from you? You don't believe it. The disease which attacks all speakers seizes on you—verbal elephantiasis. Your words begin to swell. You feel you have a greal deal more to say, and you turn away so that the ugly, sour-faced clock can no longer see you.

"Several athletic young men loom up at this point and make formidable gestures. You plead. They threaten. They drag you away."

British Listeners Want Lighter Broadcast Fare

THE business of operating a broadcasting monopoly, it would seem to us from our occasional reading of English periodicals, is no more of a sinecure than the operating of a competitive station in America. Complaints are continually visible in the British press concerning the manner in which the B. B. C. presents its programs. Most of the complaints seem to be to the effect that the B.B.C. is too highbrow and is taking advantage of its monopolistic position to "high hat" the common peepul.

The London *Daily Mail* conducted a ballot of the preferences of the listening public and received the astonishing number of 1,285,083 replies. A vote of this size, it seems to us, can be taken as a very adequate expression of the general opinion in Great Britain, and this is how it resulted:

SUBJECT	VOTES CAST
Variety and Concert Parties	238,489
Light Orchestral Music	179,153
Military Bands	164,613
Dance Music	134,027
Talk: Topical, Sport, and News	114,571
Symphony Concerts	78,781
Solos: Vocal and Instrumental	72,658
Opera and Oratorio	60,983
Outside Broadcasts	51,755
Short Plays and Sketches	49,857
Talk: Scientific and Informative	30,919
Glees, Choruses, Sea Chanties	30,445
Chamber Music	27,467
Revues	27,059
Long Plays	17,576
Readings and Recitations	2,717
Free votes not recorded	4,013
	1,285,083

The tenor of the vote was, as can be seen: (1.) A vote for more fun. (2.) A vote for fewer features which need sustained attention. The British conclusions rather parallel those gained from the questionnaire run in this department. Our readers have an overwhelming preference for instrumental music and a comparative indifference to plays, scientific talks, readings, and so forth. If a comparison to our questionnaire, which resulted in only one-hundredth as many replies, were fair, we might argue that the American public has a more sophisticated taste in music, since serious music, as of symphony orchestras, topped the list in our readers' vote, but is relegated to sixth place in the British vote.

THUMB NAIL REVIEWS

KYW and the blue network—The Philco Hour making its initial bow. We were playing bridge at the time and so couldn't give it very close attention, but we doubt if, conditions being otherwise, we would have. It struck us as an awful hodge podge of every sort and variety of entertainment that could be jammed into sixty minutes.

WMAQ and the red network—Another new advertising hour, this time an orchestra sponsored by the Cadillac-La Salle automobile manufacturers. The orchestra was all right but oh the drivel that was plentifully interlarded! Long spiels such as "and now the beckoning roads and the sunny skies call us to the great outdoors and the next number will be in the spirit of the springtime and of the motor car we are selling, the La Salle. Grieg's 'To Spring'."

WEAF (and network)—We listened to an Eveready Hour devoted to "musical hits of pre-radio days," a program we had looked forward to with greedy anticipation. Sadly, though, but few of the tunes we heard were other than those one might listen to on any dinner music program, from any broadcasting station, on any night. However, a poor Eveready hour these days is sufficiently rare to merit notice.

KDKA—"The Prisoner's Song"!!!

WABC—We accidentally happened upon WABC a while ago just as "An Evening at Tony Pastor's" had begun to unroll itself. "Tony Pastor's," so we gathered from a rather brief announcement, was a one-time music hall on 14th Street, New York City, and the radio audience of WABC was asked to imagine itself seated before the stage of the Hall in the year 1895. So efficacious were the efforts of those responsible for the staging of the program in the studio that we did

THE WHITNEY TRIO

A capable organization frequently heard through WMAQ, Chicago, of whose staff they are members. From left to right they are Noreen, Robert, and Grace Whitney, brother and sisters not find it in the least difficult to imagine that we were present at "Tony's," actually enjoying the show on the stage. We got a great kick out of hearing such old timers as "Take Back Your Gold," "Everybody Works but Father," and "My Mother Was a Lady." And when the foreign gentleman got into difficulties trying to explain his act, in which his three lions were to leap through burning "hopps" (recognize "hoops?"), we thought we'd die laughing. The only thing that was a bit overdone, we thought, was the incidental conversation of the onlookers, which too obviously was spoken right into the microphone, and was rather inane anyhow.

Microphone Miscellany

CAMOUFLAGE FOR RADIO ARTISTS

THE new studios of the National Broadcasting Company in its Fifth Avenue home now under construction will make use of every device of color and decoration as a psychological means of egging the performers on to their best efforts. Operatic and stage stars, for example, will face the microphone in a large studio, with a spotlight playing upon them. The rest of the room will be dimly lighted, with the microphone placed in shadow where the artist cannot discern it, and the vista which will open before the performer will present the effect of a large auditorium, with a silent audience waiting to applaud the broadcaster's efforts.

One studio has been designed to appeal to prominent men. The suggested effect is that of the Roman Forum! Columns appear in the background, and a scheme of Pompeian decoration will be produced by hidden lights. Another studio is designed to stimulate minds to which the mystic carries a great appeal. Here the impression will be that of a Gothic church, with alternate light and dark sections suggesting the arch and aisles of such an edifice. From a concealed point near the ceiling the pattern of a church window will be thrown on the floor in light. The performer whose cosmic urge is titillated to activity by the proximity of pinchbeck, will be ushered into a studio of the style Louis XIV. Gilt and pastel colors will be much in evidence and through a window the effect of looking into an elaborate garden will be produced. One of the smaller studios will be decorated to stimulate jazz performers. In this room the decoration scheme will be wildly futuristic with plenty of color in bizarre designs. Another studio, designed to appeal to serious minds will pass itself off as a library. And, lo and behold, the advance report from the NBC goes on to state that two small studios will be left unadorned for the use of experienced broadcasters who react strongly to the mere presence of the microphone and the knowledge that millions of radio listeners are hearing them, although the audience is an invisible one.

We might suggest that a swimming pool be provided for Channel conquerors to make their speeches from; that a bed room with a yawping brat be supplied for the Uncle Charlies; that a saw-dust covered bar room floor be installed for singers of sentimental ballads; that a street scene in Madrid be improvised for temperamental Spanish instructors; that a—oh well, and so forth! But we refrain from this obvious pose. Adverse as our reaction is to such frumpery, we suspect that the powers of the National Broadcasting Company like it no more than we do and ordered the gew-gaws with their tongue in their cheek. Further, we extend to them our sympathy, for full well we know that they will become awfully sick of spending their working days amid psuedo Gothic cathedrals and Rococo drawing rooms. Besides, if we were pressed, we would admit that the psychology behind all this sham work seems to us sound enough. The interpretative, or recreative, artist is notoriously devoid of good taste and his reactions to, and demands of, his surroundings continue to old age to be very childlike. This is only natural since his art is not self contained but comes from the outside. Your composer can sit him down in the most barrenly furnished, drab, little attic room and emerge hours later with a sublimely beautiful musical composition tucked under his arm. Set an average performer to playing that same tune in that same unattractive chamber and he will very likely protest that the surroundings are too depressing for him to do his best work. To rekindle in himself the emotions which charged the composer, he needs the warming lights, the dim auditorium, the silent, waiting audience, and all the other inspiriting adjuncts of the theater. Four walls and a microphone cannot be an adequate substitute. So we think he is justly entitled to all the illusory trappings the National Broadcasting Company is preparing for him. And we are thankful that radio is still non-visual!

UNIFORM WAVELENGTH FOR CHAIN FEATURES

KNOWING nothing ourself of the mechanical problems involved, and having heard none of the probable several valid objections to the plan, we shall not comment on the contention of C. B. Smith of WBBM in his open letter to the Federal Radio Commission that the broadcasting of all chain stations on a uniform wavelength would be more convenient for the listener. He says:

> The chain stations since the first of the year have done much to raise the standard of air entertainment in the United States. They should be highly commended. Nevertheless I do not believe this is sufficient reason to allow them to take up several air channels for these programs. My thought in this case, therefore, is that you might well give to each chain now in existence or which may be organized, a certain air channel. When a broadcast is given by the chain over several stations, each station should be compelled to change its wavelength to the wavelength of the chain's key station.
>
> Assuming that the key station of a chain was located in Chicago and that its channel was 400 meters, when there is to be a broadcast over this chain every station involved should change its wavelength to 400 meters. As it is now, the same program from a chain station may be heard at many points on the dial of a receiving set.
>
> This would in no way interfere with the chain broadcasts, but it would permit of more programs. It would in fact simplify matters for the listeners. For instance if the channel of the XYZ Chain was 430 meters, the listeners would always know just where to pick up the programs from that chain.

Communications

SIR:

I am a BCL of five years experience. I long ago got over the notion that I owe anything to the broadcasting stations, but once in a while when the announcer says they have made some change in the station and desire reports on reception I still write a report. But I think I am through. You send a report, date, time, set, audibility, R2., etc., and in due course receive a circular letter beginning, "We are glad you enjoy our program." The chances are that you were listening on the phones, late at night when you should be asleep, and that the program came in bits mixed up with other stations, static, etc. The rest of the letter tells you that their garden seeds, night club, etc., is as good as their station and will you send them an order or come in and spend something.

The more enterprising put you on their mailing list and there is that much more mail to put in the waste basket. I have reached a state of mind where I am inclined to regard requests for reports on reception—as distinguished from direct requests for applesauce—as just another way of asking for the same thing.

Of course if WEAF asks for reports when they open up at Bellmore I'll send one, but the average station, even if they do boast a thousand watts, can get its reports elsewhere.

Yours for more sleep and less stamps,

BEECHER OGDEN,
PLEASANTVILLE, New York.

SIR:

I admit that I think enough of RADIO BROADCAST to read it carefully every month, but if I ever secretly entertained an ambition to become an announcer, your editorial in the January issue ought to be an antidote. If everybody is as hard on them as you are, I do not envy them the job. Even at that, I bet you were just sore because you could not grab a gun and go after the ducks that WOC gave the whereabouts of. And if WSBT asked everybody who "could do something" to drop in at their studio, is that such a serious offence? Did you ever try to get up a program without Atwater Kent's money to do it with?

"Next we will play for you—" Well, who are they playing for anyway? "You" takes in quite a few, you know. And then comes the fellow who wants the announcer to say: "Sit by!" It never occurred to me to stand up when the announcer says: "Stand by." I just turn the dials.

The only time an announcer almost frightened me was when he boldly stated that he was going to "Sign off the air." I had a sort of choking sensation as I pictured him shutting off the oxygen, but we lived through, and found the air clearer after he was "off," because he took with him some of the most miserable jazz I ever heard.

Just let them go ahead and read wires and dedicate, and "play for you," just so they play. But, please shed a tear for us out here who are expected to listen for hours at a fiend, who is doing his "durndest" to sell automobile tires, plants, batteries, shrubbery, etc., and, as I write, on a stolen wavelength, too.

JAMES NEWBURGH,
SIOUX CITY, Iowa.

SIR:

Broadcasters are rather neglecting their country audience, as well as many of the worker class of their city audiences, by listing all their best programs at too late an hour. Even 9 P. M. is too late an hour for many of their most interested listeners, such as farmers, mechanics, the aged, etc. Of course these people do not write letters very freely, although they are most appreciative of good programs.

H. T. DEMAREST,
WARWICK, New York.

SIR:

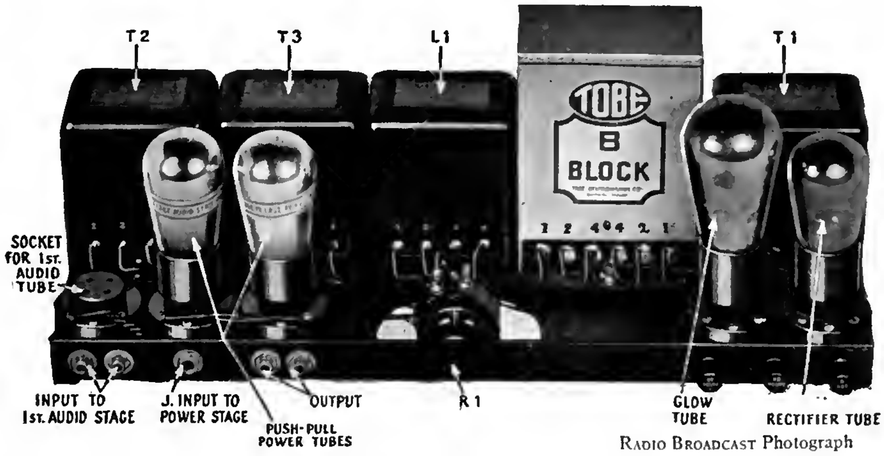
Too much is said against Henry Field and Earl May stations, KFNF and KMA. Both are clean and satisfy our Iowa farm homes. They are a temperance people and we need more like them.

MRS. W. W. W.,
ESTHERVILLE, Iowa.

A Combined Push-Pull Power Amplifier and Socket B Device

Glow Tube Used to Maintain Constant Voltage and Prevent "Motor Boating"

Provision Is Made to Include Extra Audio Stage for Electrical Phonograph Pick-up



Radio Broadcast Photograph

WITH THE CASE REMOVED
The parts are lettered to coincide with Fig. 2

By THE LABORATORY STAFF

IN THE May Radio Broadcast was described by Howard E. Rhodes an interesting power supply outfit designed by McMurdo Silver. This unit, shown here in Fig. 1, employed a full-wave rectifier, such as the ux–213 (cx–313), with the Clough filtering system, and delivered sufficient voltage for the operation of a 171 type tube in the final power stage in a receiver. Mr. Silver's unit, however, differed from others described recently in that it used the ux–874 (cx–374) glow tube to maintain the 90-volt tap at a constant voltage even though the current drain from that tap—and from the detector or 45-volt tap—varied through a wide range. The immediate effect of the glow tube is to decrease the apparent terminal impedance of the plate supply device so that "motor boating" trouble, experienced with resistance or impedance amplifiers when operated from socket power devices, is eliminated.

The photographs and Fig. 2 of the present article represent basically this same B supply device but with the addition of the necessary transformers to make up a power amplifier. Mr. Silver in this combination amplifier-B supply device has used a push-pull amplifier in which may be used either 112 or 171 type tubes.

If the broadcast listener who constructs this combination unit (all he really has to do is to wire it up) is near local high-quality broadcast stations of average power, he will use 171 tubes. If, on the other hand, he is some distance from powerful stations, 112 type tubes will produce more volume owing to their greater amplification factor, although their handling capacity is more limited.

The complete equipment is housed in a metal case that not only protects the tubes from damage but lends a finished appearance to the unit. Space is provided for an extra socket so that, with a resistance coupling unit which may be installed below the baseboard, a two-stage amplifier results, which can be worked out of a detector. It will be necessary to use batteries for the filament and C bias of this first-stage audio tube, and since it is only to be used as a voltage amplifier, a 199 can be utilized with results almost comparable to a storage battery tube. Three dry cells may be used, two for filament and one for C bias; they will last long enough to provide, for all practical purposes, an extremely economical amplifier.

The development of the combination B supply device and power amplifier started from two separate angles, *i.e.*, the demand for high-quality audio reproduction which necessitated the use of a power tube, and the need for a powerful B supply to furnish power for this last stage audio tube. At the time the combination unit was developed, many existing receiver installations were unable to supply the necessary voltage for the operation of a power tube inserted in the last audio stage, while the audio coupling devices found in many receivers of that period were poor, to say the least. The combined power amplifier stage and B supply was an important development then, not only from the standpoint of quality reproduction, but also from the standpoint of simplicity.

The power-supply device described here is capable of furnishing well rectified and filtered power to the receiver proper and to the power amplifier. This power is sufficient to take care of the demands of a good amplifier, that is, one which amplifies the lowest notes which are now being transmitted, and this power is furnished by a device with as low a terminal impedance as possible to prevent "motor boating" and kindred effects. This feature is accomplished by the use of the glow tube (ux-874 or cx-374). The amplifier has a good frequency characteristic, and secondly, it is capable of handling considerable input voltages. It is also efficient; that is, with a given input voltage, it will deliver to the loud speaker as great an undistorted power as possible.

PUSH-PULL AMPLIFICATION

THE push-pull form of amplification is employed in this power amplifier, and it has several advantages. In the General Radio *Experimenter* for May, 1927, Mr. C. T. Burke claims for the push-pull circuit "greater undistorted output than is possible with two tubes in parallel or a single tube. Even harmonics are eliminated. As most of the harmonics introduced by tube overloading are even, this permits operation of the tubes at heavier loads than is possible with the usual system. Another advantage is the elimination of d.c. magnetization of the output core as the direct current flows in opposite directions from the two tubes."

Considering several amplifiers each worked into its own impedance the power output may be found by multiplying the

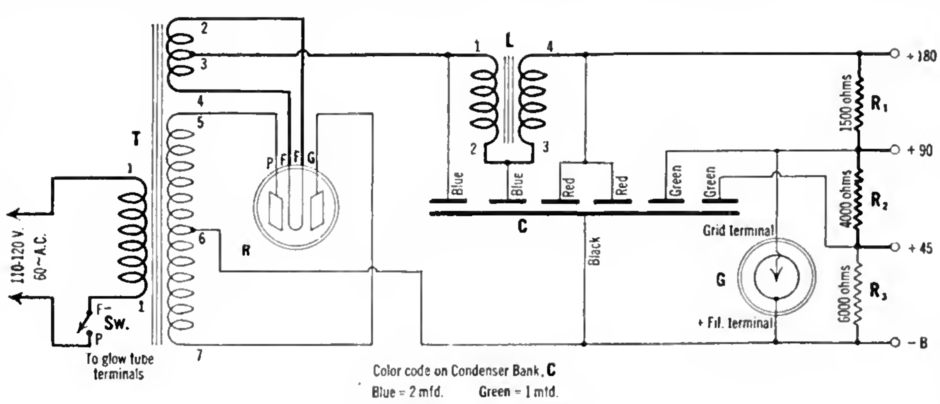


FIG. 1

factors below by the square of the input r.m.s. volts:

SINGLE 171	SINGLE 112	SINGLE 210	PARALLEL OR PUSH-PULL: 171	112
1.125	3.34	3.04	2.25	6.7

The maximum power in milliwatts obtainable, however, under the condition of maximum allowable plate and grid voltages, is as follows·

SINGLE 171	SINGLE 112	SINGLE 210	PARALLEL OR PUSH-PULL: 171	112
920	184	1860	1840	368

There is another consideration. It has been demonstrated mathematically that the greatest undistorted power output will be delivered when the load impedance is double that of the amplifier output. It must be remembered too that the above figures are for a resistance load and that a single 171 will deliver its greatest power to a loud speaker whose impedance at some frequency is equal to about 2000 ohms. The parallel arrangement will do the same at a frequency where the impedance is 1000 ohms, while the push-pull amplifier "matches" at approximately 4000 ohms. The Silver output transformer is designed to match the average cone type loud speaker to the amplifier at approximately 30 cycles. As Mr. Burke points out, greater input voltages can be placed on a push-pull amplifier without distortion due to overloading becoming evident or objectionable. Thus this type of amplification which has been neglected since the advent of high-quality transformers, once more is made available for the home constructor, this time in an attractive form and with excellent electrical characteristics. The input transformer is similar in frequency characteristics to the S-M 220.

Some trouble may be had with the amplifier singing when 112 tubes are used—a difficulty that push-pull amplifiers of good construction frequently get into. The remedy is simple: Place a 0.0001-to 0.0004-mfd. fixed condenser across one-half of the input push-pull secondary windings, which will unbalance the amplifier enough at high frequencies to prevent singing.

The circuit diagram of the complete power amplifier and plate power supply is shown in an accompanying diagram, Fig. 2. In this case a gaseous rectifier such as the Raytheon BH or the QRS 85-milliampere tube is used instead of the thermionic rectifier that was used in the original device described in May. The filament winding on the S-M 329 transformer is used to light the filaments of the push-pull amplifier tubes. Connections are also shown for the resistance input to the extra tube which may be used or not as the constructor desires. If this tube is a 199 it is possible to light its filament from the combined rectified current taken by the power tubes and the glow tube, although this makes the connections, adjustment, and regulation somewhat more complicated. It is much simpler to use dry cells. If a 201-A tube is used in the extra socket, a pair of leads must be brought out to the storage battery, and some arrangement made whereby turning on the set turns on this tube. For example, its filament can be placed in parallel with that of any of the receiver's tubes, and with the proper ballast or rheostat so that both tubes get the proper current, automatic control over all filaments is secured.

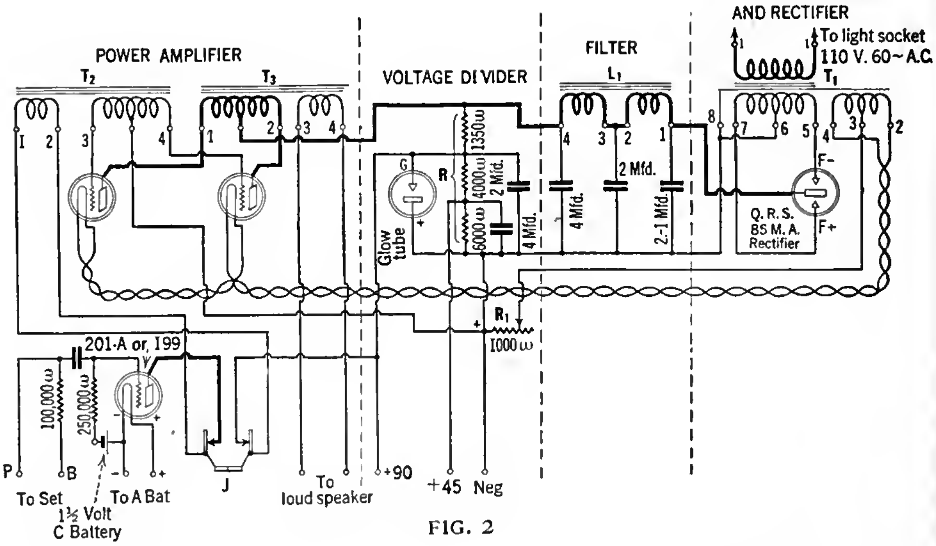
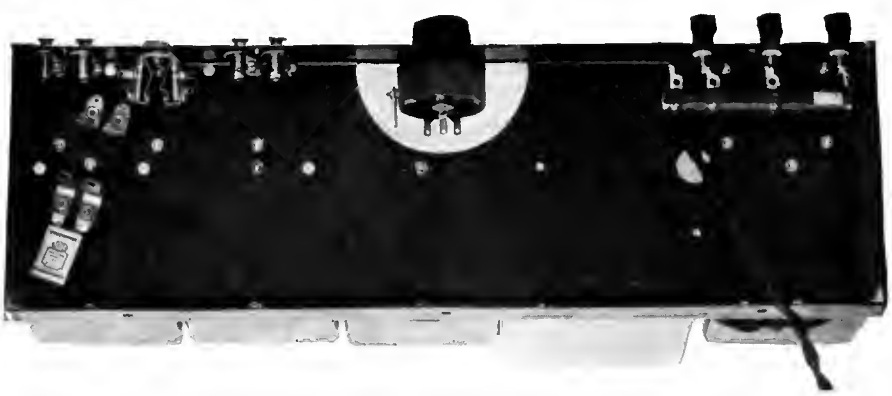


FIG. 2



UNDERNEATH THE UNIT

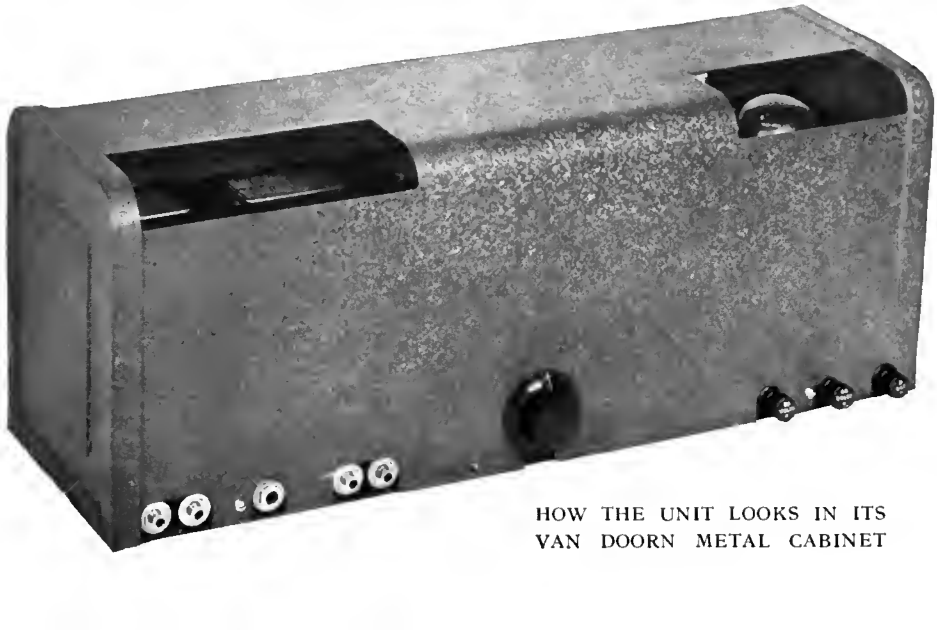
The additional socket provided in the assembly makes it possible to use this combination amplifier-B supply device with a phonograph pick-up. Greater signal strength will be obtained by connecting the pick-up to the first tube by means of a good audio transformer. In the Laboratory several of the well-known pick-up devices were used with success.

The following is a list of parts used in the amplifier-B supply unit described here:

T1—S-M No. 329 Power Transformer.	$ 6.00
T2—S-M No. 230 Push-Pull Input Transformer	10.00
T3—S-M No. 231 Push-Pull Output Transformer	10.00
L1—S-M No. 331 Unichoke. . . .	6.00
Tobe No. 660 Condenser Block (Containing Two 4-Mfd., Two 1-Mfd., and Two 2-Mfd. Condensers) .	12.00
R—Ward-Leonard S-11,350 Tapped Resistance or S-M No. 655 .	2.50
R1—Frost No. 834, 1000-Ohm Potentiometer	1.00
Four S-M No. 511 Tube Sockets . .	2.00
Four Frost No. 253 Tip Jacks . . .	.60
Van Doorn No. 661 Steel Chassis and Cabinet with Hardware . . .	6.00
Three Eby Binding Posts (B Minus, Plus 45. Plus 90)	.45
Q.R.S. 85-Mil. Rectifier Tube . . .	5.00
CX-374 or UX-874 Voltage Regulator Tube	5.50
Two 112 or 371 Type Amplifier Tubes	9.00
TOTAL	$76.05

ADDITIONAL PARTS FOR FIRST AUDIO STAGE

S-M No. 511 Tube Socket	.50
Lynch Double Resistor Mount . .	50
Lynch $\frac{1}{10}$-Megohm Resistor . . .	.75
Lynch $\frac{1}{4}$-Megohm Resistor	.50
Tinytobe 0.01-Mfd. Fixed Condenser .	.55
Frost No. 951 Four-Contact, Double-Circuit Jack	.50
TOTAL	$ 3.30



HOW THE UNIT LOOKS IN ITS VAN DOORN METAL CABINET

A Portable Long-Wave Receiver

A Description of the Receiver Built by the Laboratory for the American Geographical Society —Some of the Signals That May be Heard

By KEITH HENNEY

Director of the Laboratory

RADIO BROADCAST Photograph

THE FINISHED RECEIVER

This illustration clearly indicates how the aluminum sheets are arranged to divide the metal cabinet into compartments for batteries and phones, etc.

AMONG other noteworthy services due to radio is the increasing ease and accuracy with which navigators and explorers can determine their distance east or west from the Greenwich meridian. Time signals transmitted by wireless, which are used for such calculations, can be heard in practically all parts of the world with apparatus simple enough to be built by unskilled constructors, and light enough in weight to be carried, complete with batteries, on a man's back. The apparatus described and illustrated in this article is the result of several receivers constructed by RADIO BROADCAST Laboratory for explorers and for the American Geographical Society.

The receiver consists, in radio language, of a single-circuit long-wave set using honeycomb coils, and having two stages of audio amplification. The set first picks up and detects the signals, after which they are amplified sufficiently to be audible in a pair of headphones. Three dry-cell tubes (199 type), three A batteries, and two small B batteries (one is a spare) of 22.5 volts, are included in the metal case, together with antenna and ground wires, extra tubes, headphones, and simple tools.

The diagram of connections is shown in Fig. 1 and any one who has ever built or torn down a radio set will have no difficulty in constructing this simple receiver. Although the tubes are delicate, experience has shown that their life is quite long even when they must withstand severe shocks encountered in the field.

Several receivers of this general type have been built and placed in the hands of explorers in Brazil, Guatemala, and Venezuela. The first was placed in a Signal Corps telephone box having the approximate dimensions of four by eight by ten inches. The second was housed in a stout wooden box specially made and sufficiently large to accommodate the entire equipment. The third was placed in a metal tool box made by the Kennedy Manufacturing Company, with a tight fitting cover, and is perhaps the most satisfactory design. It is shown in the accompanying photographs. Complete with batteries, wire, and tools, it weighs about 22.5 pounds.

THE ANTENNA

THE antenna is very simple, consisting of a single wire from 50 to 100 feet long, and may be of any kind of wire, insulated or not. A simple manner of solving the antenna problem is to use a spool of rather fine wire so that many hundred feet may be included without adding much weight. Each antenna may be abandoned in this case after signals have been received, since the spool will contain enough wire to last an expedition several weeks listening-in once each day. A one-pound spool of No. 28 bare copper wire is about 2000 feet in length. Such a spool therefore, would provide sufficient wire for twenty antennas of 100 feet in length.

Some success has been had using loops in place of external antennas. They are useful in thick country where a long external wire would be difficult to erect. Signals, however, are not so loud with a loop although the directional effect is useful in avoiding interference and increasing the signal-to-static ratio.

A wire about 50 feet long, attached to a metal stake or plate and thrown into a creek or driven into moist earth, constitutes the ground connection. In dry or rocky territory the wire may be laid on the ground with practically the same results.

The accompanying diagrams and photographs give in sufficient detail the actual construction of this receiver. The Kennedy metal cabinet is divided into three compartments by means of two aluminum sheets 8″ x 7″ x 1′ 16″, and these are held in place by means of $\frac{3}{4}$″ angle brass. The three $1\frac{1}{2}$-volt A batteries are placed in the right-hand end metal compartment. An extra set of A batteries is usually carried with the exploring party, ready to slip into the receiver box. In tropical climates, and with reasonable care in handling the tubes, it should be possible to receive time signals daily for a period of about six months without requiring new batteries or tubes. All connections should be rigidly made of well insulated wire, and should be well soldered.

The receiver is placed into operation by opening the cover, making the ground connection, throwing a length of wire over a tree limb, or over any other elevation, plugging in the ear phones, and turning on the current to the tubes. At once signals should be received, since there are many high-powered long-wavelength stations pounding away at all hours of the day or night with sufficient intensity to be heard anywhere in the world.

In the United States the largest station sending time signals is Annapolis, a Navy station, whose call is NSS, wavelength 17,130 meters (17.6 kc.). With a 1500-turn honeycomb coil and a 0.001-mfd. tuning condenser, signals from this station will be heard from about 40 to 50 degrees on the condenser dial. About the time the signals are to be transmitted, this station may be heard emitting a continuous note while others will be transmitting in irregular dots and dashes. Time signals from this station—and from all other American stations—consist of a series of dots, and no difficulty should be experienced in distinguishing them from the more or less irregular sending of the other stations which will be heard at the same time. Adjusting the tuning condenser will enable the operator to find a point where NSS, or whatever station is being heard, is less bothered by interfering stations.

Time signals from NSS and from all United States stations consist of dots at every second from 11h. 55m. 00s. to 11h. 59m. 49s. and from 21h. 55m. 00s. to 21h. 59m. 49s., except at the 29th second of each minute and the last 5 seconds of each minute. The beginning of a dash at noon and at 22h. 00m. 00s. Standard Time, indicates the exact time. The lag constant for Annapolis time signals has been determined as 0.08 seconds.

Time signals transmitted from other stations are given in Table No. 1, and complete details of the transmission may be obtained from the stations themselves or from *Radio Aids*

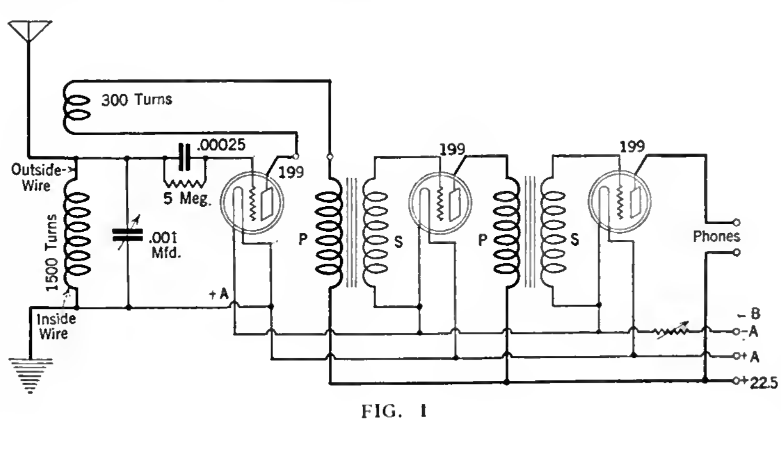


FIG. 1

to Navigation, published by the Hydrographic Office of the U. S. Navy, at 90 cents.

For those interested in learning the code, the receiver described here will be found to be very helpful. At all times of day or night, in any part of the world, signals may be heard, some very fast, others slow enough for the novice to copy. Some of it is in secret code, long words with absolutely no meaning or context, admittedly the best material for code practice. Other signals are in readable English and often the words are repeated twice. In the Laboratory, press has been received from LY in France and GBL in England.

Technically, the method of receiving used here is very inefficient. The receiver employs the beat note system of reception. That is, the detector tube oscillates, and the signals actually heard in the headphones are the beat notes caused by heterodyning of the incoming signals with those generated in the receiver. In other words, the receiver is actually detuned from the incoming frequency. For example, suppose we are listening to a station transmitting on 20,000 meters (15,000 cycles). Our ears and our headphones are most sensitive to notes of the order of 1000 cycles, so we detune our detector circuit to, say, 16,000 cycles, so that the desirable 1000-cycle beat note will result (the frequency of that beat note is equal to the difference of the two heterodyning frequencies, 16,000 15,000 kc. in this case. At the same time suppose a station to be transmitting on 16,000 meters (18,750 cycles), this will produce a second beat note in our headphones of 2750 cycles, so this latter station too may be heard.

When the detector is tuned to the exact frequency of the incoming signals, we shall hear nothing, for there is no beat note being produced.

Code listeners in the United States should be able to hear the stations listed in Table No. 2 and, under good conditions, many others in foreign countries. It is interesting to note that all of the stations in table No. 2 are operating in a frequency band only 8.2 kilocycles wide, a condition that seems appalling when one considers the wide bands available for broadcast or amateur work. In commercial receiving stations signals are picked up on special antennas which have considerable directive effect, after which they are filtered through circuits which pass a band only 200 cycles wide. They are then amplified until strong enough to operate relays which print the dots and dashes on tape. The receiving operator can copy either by sound or by watching the tape, or both.

An approximate calibration of a receiver similar to that shown in the photographs is given in Fig. 2. Owing to the broad tuning, a given

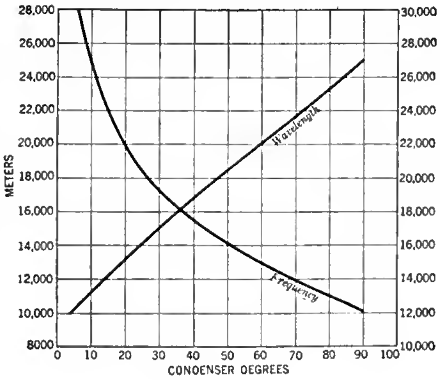


FIG. 2

station may be heard over rather a wide condenser variation, and several stations may be heard at the same time, as described above.

APPARATUS NECESSARY

THE list of apparatus gives the equipment that went into the metal encased receiver built for the American Geographical Society. The problem is one of limiting the space and weight requirements. Unmounted transformers made by Modern, of Toledo, and the hedgehog type transformer of the Premier Electric Company, of Chicago, have been successfully used. The Kennedy tool box is made of sheet iron and the coils must be mounted so that they will not be close or parallel to the metal wall. The tickler coil should be placed between the secondary coil and the iron, and if the detector does not at first oscillate, the tickler coil connections should be reversed. Some transformers may require a bypass condenser across the primary to insure good detector oscillations. The hedgehog did not require such a condenser but in case it is needed it should be of about 0.006 mfd

Station	Call Letters	Wave-length	Fre-quency
Marion, Massachusetts	WSO	11620	25800
Marion, Massachusetts	WRQ	13505	22205
Bolinas, California	KDU	13100	22890
Rocky Point, New York	WQK	16465	18250
Rocky Point, New York	WQL	17500	17130
Rocky Point, New York	WSS	16120	18600
Annapolis, Maryland	NSS	17030	17600
Tuckerton, New Jersey	WCI	16700	17950
Tuckerton, New Jersey	WGC	15900	18860

TABLE NO. 2

3	Benjamin Sockets	$1.80
2	Hedgehog Transformers	7.00
1	0.001 Mfd. General Radio Condenser and Dial	7.50
1	1500-Turn Honeycomb Coil	3.20
1	300-Turn Honeycomb Coil	1.05
1	Baseboard 8″ x 7″ x 13/16″	.10
1	Kennedy Metal Cabinet, 16″x8″x9″	3.25
1	22½-Volt B Battery	1.75
3	1½-Volt Dry Cells	1.20
1	Pair Phones	5.00
1	20-Ohm Carter Combined Rheostat and Switch	1.00
4	XL Binding Posts	.60
1	8″ x 6″ Panel	1.00
3	UX-199 Tubes	5.25
1	Grid Condenser	.50
1	Grid Leak	.50
4	Pieces ¾″ Angle Brass 7″ Long	.30
2	Pieces Aluminum 8″ x 7″x1/16″	.25
	Total	$41.25

The Kennedy metal cabinet referred to in the above list of parts is manufactured by the Kennedy Manufacturing Company, Van Wert, Ohio.

Using the two coils specified in the above list of parts, the receiver described will have a wavelength range of from about 10,000 to 25,000 meters (30 to 12 kilocycles). To cover other wavelengths, coils with a different number of turns than those specified should be used. The following list gives the various standard coils which should be used in the antenna circuit with a 0.001-mfd. tuning condenser together with the wavelengths they cover: 25 turns, 120-355 meters; 35 turns, 160 to 480 meters; 50 turns, 220-690 meters; 75 turns, 340-1020 meters; 100 turns, 430-1330 meters; 150 turns, 680-2060 meters; 200 turns, 900-2700 meters; 250, 1100-3410 meters; 300 1400-4120 meters; 400 turns, 1800-5500 meters; 500 turns, 2300-7000 meters; 600 turns, 2800-8200 meters; 750 turns, 3500-10400 meters; 1000 turns, 4700-13800 meters; 1250 turns, 6000-18000 meters.

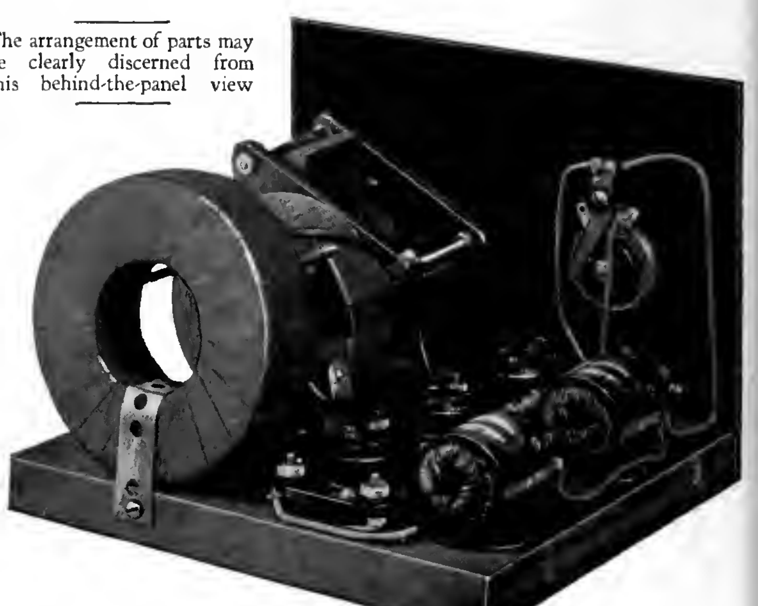
The tickler coil should have from a third to half as many turns as the coil to which it is coupled.

Country	Station	Call	G. C. T. h.	m.	s.	Wave-length (Meters)	Dial Setting (Approx.)
United States	Annapolis	NSS	17	00	00	17130	42
			3	00	00	17130	42
	San Diego	NPL	20	00	00	9801	0
Panama	Colon	NBA	10	00	00	6663	—
			18	00	00	6663	—
Hawaiian Islands	Pearl Harbor	NPM	00	00	00	11490	15
France	Bordeaux	LY	8	00	00	23400	80
	Lyons	YN	9	00	00	15500	35
Germany	Nauen	POZ	11	58	10	18050	50
			23	58	10	18050	50
Russia	Petrograd	RET	19	00	00	7100	—
	Moscow	RAI	21	00	00	7480	—
Eritrea	Massawa	ICX	10	00	00	11150	
Java	Malabar	PKX	1	00	00	7700	—

Note: G. C. T. is an abbreviation for Greenwich Common Time. It is five hours ahead of Eastern Standard (75th meridian) Time. Thus 12 noon in New York is 17h. 00m. 00s. in G. C. T., which starts at midnight with 00h. 00m. 00s. and runs to 24h. 00m. 00.s. Thus 8h. 00m. 00s G. C. T., when LY sends time signals, is 3 a. m. E. S. T.

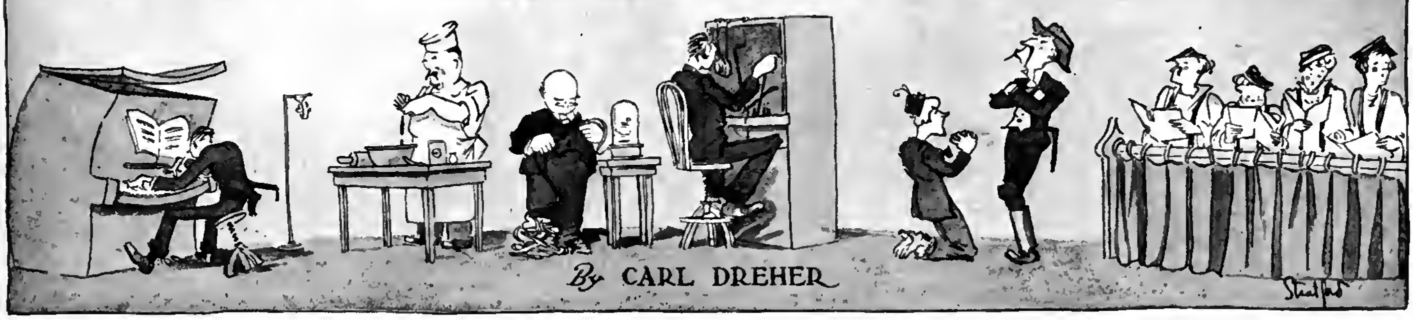
TABLE NO. 1

The arrangement of parts may be clearly discerned from this behind-the-panel view



RADIO BROADCAST Photograph

AS THE BROADCASTER SEES IT



By CARL DREHER

Drawings by Franklyn F. Stratford

The Place of Television in the Progress of Science

ONE of the New York newspapers, commenting editorially on the recent television demonstration by the American Telephone and Telegraph Company, points out that there is no immediate commercial application for this latest marvel of technology, in view of the elaborate equipment and skilled attendance required. But, the writer adds, other inventions, such as the electric light, the phonograph, the airplane, and radio, have appeared with the same limitations, and he predicts that the televisor will undergo the same process of simplification and adaptation for everyday use. "Meanwhile," he speculates, "the invention may function in small but important fields. It would seem to make the identification of a kidnapped child or a murderer, found in some distant city, an easy matter."

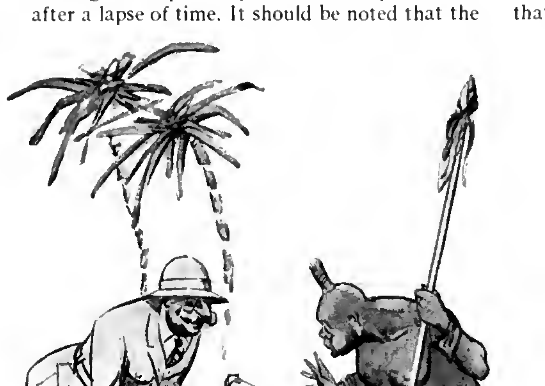
The example is poorly chosen. For such purposes of identification the already more or less perfected and commercialized transmission of photographs would seem a much superior means. It takes only a fraction of an hour to take the photograph and reproduce it at a distance by wire or radio, and the results, at this stage of the game, are apt to be better. The expense should also be less. Television is inherently more complicated than telephotography, just as taking moving pictures is necessarily more difficult than snapping a still photograph, although with sufficient development both processes may be brought within the layman's reach. The editorial, however, suggests the need of thought on the subject of what rôles may best be played in the drama of modern life by such scientific applications as television, telephony, the phonograph, talking movies, aural broadcasting, and allied inventions.

In Table No. I below, the characteristics of the principal sense- and intelligence-reproducing inventions in this group are given:

TABLE No. I

SOUND	*Nature of Utility*	LIGHT
Phonograph	Permanent record	Photograph (static) Motion Picture (kinetic)
Telephone	Rapid reproduction at a distance	Television

Sight and hearing are the two principal senses of the higher animals. The other senses are quite limited in range and contribute less to the picture of the universe which man, especially, must try to construct for the purposes of his life. Accordingly, inventions in communication specialize in these two senses. We find, on this basis, two inventions—the phonograph and the motion picture—which permit the recording of sounds and sights, respectively, and their reproduction after a lapse of time. It should be noted that the motion picture, not the still photograph, is the logical counterpart of the phonograph. The motion picture gives a kinetic visual reproduction, corresponding to the kinetic aural reproduction of the phonograph. In music or speech one sound follows another, just as moving bodies are seen in one position following another in our visual perception of the external world. The motion picture is made possible, however, only through the physiological lag of the eye—the persistence of vision phenomenon—which enables us to merge a rapid succession of still pictures into apparently continuous motion.



"THE WAX DISCS MAY BE CARRIED TO DISTANT POINTS"

Both the motion picture and the phonograph may be regarded as part of man's efforts to overcome the transitoriness of life. As Heraclitus pointed out some 3200 years ago, the most noticeable characteristic of the universe is that it exists in a state of constant flux. This means that many interesting or beautiful things will happen while some people are not present and must be reproduced artificially for those persons if they are to enjoy them. Even those who were present at the original occurrence in order to reexperience their sensations must have recourse to such machines as the motion picture camera-projector and the phonograph recorder-reproducer. Being machines, such devices are capable of mass reproduction of prototypes. In this way, John Barrymore and Caruso, alive and dead, are spread over the earth. In other words, by means of motion pictures and talking machines we try not only to protect ourselves against the fleeting nature of desirable events but also to multiply those events artificially by making them take place elsewhere than at the original location. Caruso and Barrymore cannot be transported to all the places where their presence is desired, but the wax discs and rolls of celluloid which are capable of reproducing their remarkable qualities may be carried to distant points very readily, and not less readily when the artists, having died, no longer emit beautiful tones nor present a pleasing appearance to the eye. Essentially, therefore, motion pictures, phonographs, and their synthesis, the talking motion picture, are means of, first, resisting the passage of time, and, secondly, overcoming the spatial and energic limitations of certain special human beings whose performances are of great interest to their fellows. By the refinement of machinery these aims are being accomplished with a constantly closer approach to perfection as regards sight and hearing, the two essential senses in the particular relationships involved.

As the phonograph and motion picture apparatus are basically systems to overcome the passage of time, so the telephone and televisor have the aim of overcoming the obstacle of intervening distance in the fields of sound and light respectively. By means of the telephone, sounds are transmitted practically instantaneously over distances which would otherwise render them inaudible, and now the television apparatus performs the same service for the sense of sight. The American Telephone and Telegraph Company's demonstration was really a combination of two inventions—the telephone and the televisor, in the same way that the talking motion picture combines the phonograph and the motion picture, but everyone is so used to the telephone that this aspect of the situation has been overlooked. Another explanation for this lies in the fact that voice and appearance are automatically linked in the television-telephone subjects, without the necessity for synchronization of sound and light vibrations which we must effect in the picture-phonograph combination. But, leaving this point to return to the main thread of our analysis, we note that by means of the telephone and the televisor we project ourselves, sensorially, through space; with the phonograph and motion picture we project ourselves backward through time.

The telephone and the televisor, like all the inventions of the "tele" group, utilize electric waves. This is because such waves, traversing space at a speed of 186,000 miles per second, cover terrestrial distances instantaneously as far as most activities of human beings are concerned. Even when, as in the telephoto process, the complete transmission takes an appreciable fraction of an hour, this is merely because the breaking up and re-integration of the picture, optically, takes time. In Table No. II the principal inventions of the "tele" group are summarized, with the dates, not of initial invention, which are controversial and difficult to determine in some cases, but of practical demonstration, when it became evident that the problem was well on the way to complete solution:

TABLE No. II

Date	Invention	Nature of Utility
1835	Telegraph	Transmission of symbols
1876	Telephone	" " sounds
1922	Telephoto	" " sights (static)
1927	Television	" " " (kinetic)

The inventions of the "permanent record" group all use the device of impressing a performance which, being functional, passes with time, on some material substance which, to a degree, is independent of time and may also be multiplied indefinitely, each multiplication adding a large number of possible reproductions of the original event. The invention of printing is one of the early applications of this principle. A man has ideas, which are functional in their nature. By printing them he transmutes the ideas into the material form of symbols on paper, which may be read and reproduced as ideas by another man reading the symbols perhaps centuries later. The author projects himself functionally into the future, the reader into the past, by this physical device. The recent inventions of this group, which have to do with sight and hearing, are summarized below:

TABLE No. III

Date	Invention	Nature of Utility
1839	Photograph	Recording and later reproduction of sights (static)
1877	Phonograph	Recording and later reproduction of sounds
1893	Motion picture	Recording and later reproduction of sights (kinetic)
1926	Talking motion pictures	Recording and later reproduction of sights and sounds

From Tables No. II and III some of the relationships between these inventions may be traced. The telegraph, invented in 1835, utilized the crudest possible form of modulation of electric waves—simply starting and stopping a constant amplitude current according to a code. A little later the chemical fixation of the images in the *camera obscura* was accomplished. The telephone, following the telegraph in 1876 after an interval of 41 years, required a much more subtle modulation of the electric currents, and this has been further complicated in telephotography and television. The phonograph was invented almost at the same time as the telephone. The motion picture, following the still photograph after 54 years, is merely an ingenious elaboration of the latter. Talking movies, as has been pointed out before, are produced by combining the phonograph and cinematograph. In the same way the telephoto process may be considered a synthesis of photography and the principles of the telegraph and telephone. Television is derived from the two latter, the telephoto systems, and the motion picture art. The fundamental inventions, in this sense, are the telegraph, the camera, and the phonograph. The others are elaborations and cross-breedings. Taking them all in all, in a space of 100 years (1835–1935), allowing 8 more years for the development of television, the effective rapid transmission of symbols, sounds, and sights will have been accomplished; and the art of recording and reproducing at a later time sounds and sights, separately and in combination, will have been, for all practical purposes, perfected.

It will be noted that nothing has been said about broadcasting and wireless telegraphy in this discussion. That is because, coming down to fundamentals, radio is only a part of telegraphy and telephony. In wire telephony we modulate a direct current at audio frequency and send it directively along a wire. In broadcasting we superimpose the same variations on a radio-frequency current, and transmit them from an antenna in all directions through space. In each case our object is to reproduce sounds at a distance. One form happens to be suited for point-to-point communication between individuals, while the other is suited for one individual addressing an audience, or for the distribution of a single performance to a large number of individuals separated in space, but the difference is a secondary one. As in all telephony, the sound-emitters and sound-receivers are separated in space, but not in time. This will result in profound differences in the social application of the arts in question, but the metaphysics remain identical.

All these inventions are, in the last analysis, means by which human beings secure agreeable or necessary sensations, in the absence or because of the unavailability of the original sources of those sensations, owing to the movement of time and the non-movement of space. When agreeable sensations are involved we are dealing with entertainment; when the sensations are necessary, rather than merely pleasant, we speak of utility. There is no sharp dividing line. Broadly, one sustains life; the other helps make it worth while. Let us hope that television will do both. For the present we shall be satisfied with this outline of the hundred-year era which it closes, and, seeing it against this background, we shall be less likely to go astray in the hazardous business of prophecy.

Concerning the specific applications of television among the other arts of communication we shall have more to say hereafter.

What the Broadcast Technician Should Read

OVER two years ago (in the April, 1925, RADIO BROADCAST) we printed a short bibliography for broadcast operators and engineers, consisting mainly of references to articles in the *Proceedings of the Institute of Radio Engineers* and the *Journal of the American Institute of Electrical Engineers*. Since then a considerable number of valuable contributions have been added to the literature, so that it now appears advisable to reprint the original list with the additions. This is also done in response to requests which we receive at intervals from readers interested in the technique of broadcasting or speech reproduction, and in need of help in selecting their reading matter. While this department is always ready to advise broadcasters with regard to the literature in this field, and to give individual attention to special problems, the present summary of available books and papers should serve the requirements of a majority of readers. The list is not confined to works on broadcasting as such, since to attempt to master the technique of broadcasting, without preparation in the general principles of radio communication and acoustics, is like trying to fence before one has learned how to hold a foil:

GOVERNMENT PUBLICATIONS

Obtainable from Superintendent of Documents, Government Printing Office, Washington, D. C.

Principles Underlying Radio Communication—Second Edition. (Radio Communication Pamphlet No. 40; Signal Corps, U. S. Army). $1.00
Radio Instruments and Measurements (Bureau of Standards Circular No. 74). 60
Telephone Service (Bureau of Standards Circular No. 112) 65
Sources of Elementary Radio Information (Bureau of Standards Circular No. 122) 05
Architectural Acoustics (Bureau of Standards Circular No. 300) 05

BOOKS

Morecroft: *Principles of Radio Communication*. John Wiley & Sons, Inc.
Van Der Bijl: *The Thermionic Vacuum Tube*. McGraw Hill Book Co.
Moullin: *Radio Frequency Measurements*, J. B. Lippincott Co.
Johnson: *Transmission Circuits for Telephone Communication*. D. Van Nostrand Co.
Miller: *Science of Musical Sounds*. Second Edition. Macmillan.
Sabine: *Collected Papers on Acoustics*. Harvard University Press.

JOURNAL OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Issues obtainable from American Institute of Electrical Engineers, 33 West 39th Street, New York.

Martin and Clark: "Use of Public Address Systems with Telephone Lines." April, 1923.
Green and Maxfield: "Public Address System." April, 1923.
Arnold and Espenschied: "Transatlantic Radio Telephony. August, 1923.
Osborne: "Telephone Transmission over Long Distances." October, 1923.
Hitchcock: "Applications of Long-Distance Telephony on the Pacific Coast." December, 1923.
Jones: "The Nature of Language." April, 1924.
Martin and Fletcher: "High-Quality Transmission and Reproduction of Speech and Music." March, 1924.
Casper: "Telephone Transformers." March, 1924.
Martin: "The Transmission Unit." June, 1924.
Harden: "Practice in Telephone Transmission—Maintenance." December, 1924.
Ferris and McCurdy: "Telephony Circuit Imbalances." December, 1924.
Kellogg: "Design of Non-Distorting Power Amplifiers." May, 1925.
Discussion on above. June, 1925.
Maxfield and Harrison: "Methods of High-Quality Recording and Reproducing of Music and Speech Based on Telephone Research." March, 1926.
Nance and Jacobs: "Transmission Features of Transcontinental Telephony." November, 1926.
Espenschied: "Radio Broadcast Coverage of City Areas." January, 1927.
Discussion on above. April, 1927.

PROCEEDINGS OF THE INSTITUTE OF RADIO ENGINEERS

Obtainable from The Institute of Radio Engineers, 37 West 39th St., New York.

Espenschied: "Applications to Radio of Wire Transmission Engineering." October, 1922.
Nichols and Espenschied: "Radio Extension of the Telephone System to Ships at Sea." June, 1923.
Baker: "Description of the General Electric Company Broadcasting Station at Schenectady, N. Y." August 1923.
Baker: "Commercial Radio Tube Transmitters." December, 1923.
Little: "KDKA, the Radio Telephone Broadcasting Station of the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa." June, 1924.
Nelson: "Transmitting Equipment for Radio Telephone Broadcasting." October, 1924.
Weinberger: "Broadcast Transmitting Stations of the Radio Corporation of America." December, 1924.

Cummings: "Recent Developments in Vacuum-Tube Transmitters." February, 1925.
Heising: "Production of Single Side-Band for Transatlantic Radio." June, 1925.
Oswald and Schelling: "Power Amplifiers in Transatlantic Radio Telephony." June, 1925.
Espenschied, Anderson, and Bailey: "Transatlantic Radio Telephone Transmission." February, 1926.
Bown, Martin, and Potter: "Some Studies in Radio Broadcast Transmission." February, 1926.
Jensen: "Portable Receiving Sets for Measuring Field Strengths at Broadcasting Frequencies." June, 1926.
Little and Davis: "KDKA." August, 1926.
Goldsmith: "Reduction of Interference in Broadcast Reception." October, 1926.
Crossley: "Piezo-Electric Crystal-Controlled Transmitters." January, 1927.

In addition to the above engineering articles, the reader interested in the technique of practical broadcasting may be referred to the twenty short papers on various aspects of broadcast operation which have appeared in this department since September, 1925. These discussions have been on such subjects as "Microphone Placing," "Wire Lines," "Multiple Pick-Up," "Equalization," "Calculation of Gain," "Modulator Plate Current Variation," "The Condenser Transmitter," "Studio Design," etc. The object of the treatment in each case has been to aid broadcasters looking for information on their immediate problems, rather than to attain originality or high engineering calibre.

Technical Problems for Broadcasters. No. 2

A RECEIVING set is equipped with an output tube capable of delivering energy to a loud speaker, without distortion, at a level of not over +10 TU. It is normally tuned to a given broadcasting station and so adjusted that the audio output is +8 TU, allowing an overload margin of 2 TU. All other factors remaining constant, the power of the broadcasting station is doubled. By how many TU will the output tube of the receiving set be overloaded? Give all the steps in the solution. Answer on page 170.

Technical Problems for Broadcasters. No. 3.

THE ratio of energy between fortissimo and pianissimo passages of an orchestra is 1,000,000:1. The orchestra is reproduced without distortion by a public address system in another room. The operator brings up the pianissimo passages so that they are over the room noise level at a certain point near the projector, always returning to a base gain level for louder parts of the performance. The faintest pianissimo passages produce in the air at this point an R.M.S. pressure of 0.0001 dynes per square centimeter. The loudest passages produce a corresponding pressure of 1 dyne per square centimeter. By how many TU did the P.A. operator bring up the gain during pianissimo intervals? Solution on page 170.

Thirteen Years Ago

THE Institute of Radio Engineers was founded, as all good and even middling radio men know, in 1912, by the amalgamation of the "Society of Wireless Telegraph Engineers" and the "Wireless Institute." At the time of its formation the Institute boasted of less than 50 paid-up members. I do not know just how many members are on the rolls now, but Mr. Robert H. Marriott, the first President remarked to me the other day that at the present rate of increase the membership is headed for the ten thousand mark within a few years. The recently compiled index to the *Proceedings*, the engineering publication of the organization, which was issued quarterly in 1913 and now goes out to the members monthly, contains references to every conceivable radio subject, from acoustic tuning to wired wireless, and all the authors, great and small, from Alexanderson to Zenneck, are represented. I wrote an article some time ago, pointing out the advantages of membership to all serious-minded radio men, but it appears that there are still some strange creatures in the profession who fail to dig down for $6.00 a year, to their own advantage. The Institute needs them, but they need the Institute a lot more, if they only knew it. The Secretary will be pleased to mail application blanks from 37 West 39th Street, New York.

Important as this is, it is not precisely what I started to write about. The fact is that I thought it might amuse some of the faithful customers to peruse a few personal excerpts from Volume 2 of the *Proceedings*, issued in 1914. Unfortunately, I lack the first, or 1913, volume, and cannot get a copy for love or money. My only hope is that one of the reverend elders of the society will remember me in his will. At any rate, around that time a Year Book was issued (which I also lack), and Supplementary Lists of Members were printed in some of the issues. In these lists some of the great names of radio in our day appear. In some cases they were already great, but in others they had only begun the climb. I abstract a few below.

"THERE ARE STILL SOME WHO FAIL TO DIG DOWN FOR $6 A YEAR"

Henry E. Hallborg, who is now one of the Radio Corporation's chief short-wave experts and who, with Messrs. Hansell and Briggs, wrote a highly informing paper on that subject which should appear in the *Proceedings* around this time, was elevated to the grade of Member in 1914. He was then in charge of the newly finished or going-to-be-finished Marconi transatlantic stations at New Brunswick and Belmar. Lawrence M. Cockaday, the Technical Editor of *Popular Radio*, became an Associate that year; he was then General Secretary of the Cathedral Choir School; whether that helped him run his four-inch spark coil, he will have to tell us. Next among my victims I spy the name of the illustrious Paul F. Godley, he who first picked up American amateur signals on the other side of the Atlantic (From 1 BCG, in 1921—listen to the Radio Club of America contingent yell!)—he was Radio Inspector for the Brazilian Government, and lived, then as now, in New Jersey. Presumably the Brazilians had placed an order for some radio equipment in the United States, and Mr. Godley was there to see that they did not get any celluloid spark gaps in the shipment. DeLoss K. Martin had not yet issued from the Polytechnic College at Oakland, California; to-day he is known as a colleague of Dr. Ralph Bown, the President of the Institute, and Mr. R. K. Potter, in the work which resulted in the paper on "Some Studies in Radio Broadcast Transmission," printed in the *Proceedings* for February, 1926, and recognized as one of the most brilliant pieces of research in all radio history. Elmo Neale Pickerill was exercising his perfect fist as an instructor at the Marconi Wireless Telegraph Company's school. Nowadays, as Chief on the *Leviathan*, he probably seldom touches a key. I should like to hear the fast but unhurried dots and dashes rippling once more from under his hand—I who was brought up among such artists of the brass lever, and now must earn my living among artists of another kind.

But to continue. There stands the name of Harry Sadenwater, now the engineer in charge of the General Electric Company's chain of broadcast stations, from Schenectady to Oakland. In 1914 Mr. Sadenwater was the radio instructor at the East Side Y. M. C. A. in New York City. If you didn't hear him in those days you missed another copperplate hand, and I do not refer to calligraphy. Thomas M. Stevens, Superintendent of the Eastern Division of the Marconi Company then, runs the whole Marine Department of the Radio Corporation now. Behold also Ellery W. Stone, a student at the University of California in 1914, and President of the Federal Telegraph Company to-day. Bowden Washington, an engineer of Cutting and Washington and Colonial Radio prominence these latter days, was testing for Clapp-Eastham thirteen years ago. Joseph O. Mauborgne was a First Lieutenant in the United States Army; First Lieutenants become Colonels. Allen D. Cardwell, one of the manufacturers who, with the advent of broadcasting, continued to take pride in turning out precise and decent apparatus when junk sold just as well, may have learned his craft as Chief Engineer of the American Telegraph Typewriter Company. Lewis Mason Clement, Chief Engineer of Fada, was a Shift Engineer in the Marconi station at Kahuku, in the Hawaiian Islands. Edwin H. Colpitts, in 1914, was a Research Engineer of the Western Electric Company; one does not become an Assistant Vice-President of the American Telephone and Telegraph Company overnight. Of William H. Howard, now in charge of the tube division in the Radio Corporation's Technical and Test Department, I shall have more to say hereafter, in the "Memoirs." He was a Laboratory Assistant of the Marconi Company in the ancient days to which we are applying the pick and spade. And here appears the name of Arthur H. Lynch, a Radio Operator of the same Marconi Company, a radio manufacturer now, and once Editor of this magazine. Also Lee L. Manley, Assistant Service Manager of R. C. A., came from about the same cradle, save that his title was "Radio Electrician." Did that mean that he got $2.00 a month more, or less, in the old Marconi days? Never mind, none of us got much. But here is a genuine pioneer of not only the radio, but the telegraph and cable business, Edward Butler Pillsbury, in 1914 Assistant Traffic Manager of the same Marconi Company, and now Vice-President and General Manager of the Radio Real Estate Corporation of America. With Mr. Pillsbury's name we may well close the present account. All these were members of the Institute of Radio Engineers in 1914, and all are members now.

Radio Revolutionized Again

ONCE again a revolutionary radio invention is heralded. A good-sized headline in one of the conservative journals, followed by 112 lines of type, informs us that "Crystal Device Turns Phone into Complete Radio System."

How? There are two pins, which connect the crystal detector or vacuum tubes—for, marvellous to relate, either may be used—to the telephone line and ground. The telephone line then acts as an antenna. The device may be clamped to the telephone, the only apparatus required for this job being a telephone and a clamp. The inventor is a "tea specialist" employed by the Department of Agriculture. "As paradoxical as it may seem," states the article, "this invention was conceived in a dearth rather than a wealth of radio knowledge. The inventor is recognized the country over as an authority on teas, but he boldly admits that he is not versed in the elemental principles of radio."

Patent specifications have been drawn up. "Patents are pending," as a sweetly familiar phrase has it. Alas, in the present instance, they will never cease to pend. Fifteen years ago some obscure amateur, whose name had been forgotten and whose body may be dust, first connected power and telephone lines, capacitively and even conductively, to his primitive receiver, and heard MCC out on the Cape sending press in code to the Atlantic. If someone is cruel enough and has the time, let him dig up the precise number of *Modern Electrics* in which the discovery was chronicled. And let the telephone companies whose lines are unbalanced by this recrudescence of the marvel deal gently with the tea expert of Washington, D. C. He is, after all, a tea expert.

Solution to Technical Problem No. 2

THE power in the transmitting antenna, expressed in terms of antenna current and resistance, is:

$$Pt = It\ Rt \qquad (1)$$

$$\text{Whence} \quad It \propto \sqrt{Pt} \qquad (2)$$

From the Austin-Cohen formula and the theory of radio propagation, we know that the current and voltage in a receiving antenna vary directly as the current in the transmitting antenna. That is:

$$Ir \propto It \qquad (3)$$

$$\text{and} \quad Er \propto It \qquad (4)$$

$$\text{Therefore} \quad Er \propto \sqrt{Pt} \qquad (5)$$

That is, the radio-frequency voltage impressed on the receiver varies as the square root of the power in the transmitting antenna. This holds through the r. f. amplifier of the receiver, so that the voltage impressed on the grid of the detector (the second detector in a super-heterodyne receiver) varies as the square root of the power in the transmitting antenna. But, as the usual vacuum-tube rectifier follows a square law, the audio plate current or voltage varying as the square of the grid potential, we may write:

$$Ia \propto E^2r \propto Pt \qquad (6)$$

where Ia is the audio or post-detection current in the receiver.

But, impedance remaining constant, the TU level in any circuit is given by:

$$TU = 20 \log_{10} \frac{I_1}{I_2} \qquad (7)$$

as explained in previous technical articles, based on engineering literature, in this department.

Hence, in the output of the receiver, a change in level is given by:

$$G = 20 \log_{10} \frac{Ia_1}{Ia_2} \qquad (8)$$

Referring to (6) above, we may rewrite (8) in the final form:

$$G = 20 \log_{10} \frac{Pt_1}{Pt_2} \qquad (9)$$

Equation No. 9 is the expression for level changes in the output of the receiver, in terms of different transmitter powers. The equation having been derived, the problem practically solves itself. The gain, with the doubling of power at the transmitter, is:

$$G = 20 \log 2 = 20\ (0.301) = 6.0\ TU$$

As, by the conditions of the problem, the overload margin of the output tube is only 2.0 TU, with the doubling of transmitter power the receiver will overload by 6 minus 2, or 4 TU.

Solution to Technical Problem No. 3

THIS problem is not as complicated as it looks. We are given that the sound pressure in air at a certain point varies between 1.0 and 0.0001 dynes per square centimeter. This pressure is expressed in force per unit of area. By definition, energy is expressed as a force acting through a given distance. If *E* represents energy, *F* force, and *d* a distance through which *F* operates, then

$$E = Fd$$

$$\text{Hence} \quad \frac{E_1}{E_2} = \frac{F_1}{F_2}$$

And since power is directly proportional to energy, we may also write for the power *P* that

$$\frac{P_1}{P_2} = \frac{F_1}{F_2}$$

By definition the telephonic gain variation in TU, as we have seen in previous articles and problems, is given by

$$TU = 10 \log_{10} \frac{P_1}{P_2}.$$

Or, in the P. A. system described above, the gain range is given by

$$G_0 = 10 \log_{10} \frac{F_1}{F_2} = 10 \log_{10} \frac{1.0}{0.0001}.$$

$$= 10 \log_{10} 10000 = 40\ TU$$

The subscript "o" in the above expression stands for "out" or "output."

We are also given that the orchestra itself plays with a power ratio of 1,000,000: 1, so that the gain range *into* the P. A. system is

$$G^1 = 10 \log_{10} 1000000 = 60\ TU$$

Therefore the answer is that the operator narrowed the volume range by 60 minus 40, or 20 TU.

A RADIO LABORATORY OF A DECADE AGO

This picture was taken in 1917 in the college of the City of New York. Doctor Goldsmith is sitting with face to the camera and Mr. Julius Weinberger, now of the Radio Corporation, is at his left. Carl Dreher is to the right of the picture, adjusting the Marconi transmitter

Description of a Short-Wave Station

Details of the 500-Watt Crystal-Controlled Transmitter at 2 AG—The Four-Tube Short-Wave Receiver—A Radio Club of America Paper

By C. R. RUNYON, JR.

THE TRANSMITTER

THE short-wave crystal-controlled transmitter at radio station 2 AG employs seven transmitting tubes in the following combination: One UX-210 as a crystal oscillator tube; two UX-210's in the first intermediate push-pull amplifier; two UV-203-A's in the second intermediate push-pull amplifier; two UV-204-A's in the push-pull radio-frequency amplifier.

A schematic diagram of the crystal oscillator stage, together with its power supply, is shown in Fig. 1. The crystal is connected between the grid and filament terminals of the UX-210 crystal oscillator tube. The crystal used has a fundamental frequency of 3665 kc. (81.9 meters), so, in view of the fact that this station transmits on the 80-meter band, there are no frequency multiplier stages between the crystal oscillator and the antenna system, straight amplification being all that is required.

While we are discussing the grid circuit of the oscillator, it is logical that we consider the system of modulation that can be employed when it is desired, as modulation is effected in this circuit.

When the transmitter is in operation, the chopper disc (shown in Fig. 1) rotates at such a speed that it opens and closes the circuit through the primary winding of the modulation transformer (T_1) at an audio-frequency rate. The shunt across the chopper contacts is removed when the set is in operation, by virtue of the fact that relay No. 5 is energized at that time.

When the circuit is closed through the chopper contacts, a direct current flows through the primary winding of the modulation transformer (T_1), this current being supplied by a 6-volt storage battery, and being limited by the 50-ohm rheostat (R_4) and the resistance of the primary winding in question.

Every time the circuit through the chopper contacts is closed, we get a direct-current flow through the primary winding of (T_1), which sets up a field which cuts through the secondary winding of (T_1) and produces a potential "kick" across it. This voltage "kick" is passed on to the terminals of the crystal oscillator, and subsequently to the grid of the first amplifier tube. The effect of each one of these "kicks" is to change the frequency, right at the source; hence, the frequency of the transmitted signals is also changed.

The amount of this change, as near as the ear can tell, is between 500 and 1000 cycles. Thus, by this novel method of modulation, the frequency of the transmitted signals is changed through a band 500 to 1000 cycles wide, at an audio-frequency rate (the rate of make and break at the chopper contacts).

Plate voltage is supplied to the crystal oscillator tube from a full-wave rectifier system which employs two UX-216-B rectifier tubes. This plate supply lead is prevented from offering a radio-frequency shunt across the crystal oscillator tube output circuit by means of the radio-frequency choke coil RFC_2 which is inserted in series with it. A d.c. milliammeter (0-100 mils.) is connected in series with this plate lead to indicate the plate current drawn by this tube.

The blocking condenser C_7, which has a capacity of 0.002 mfd., bypasses radio-frequency energy, but prevents the coil L_1 from short-circuiting the d.c. plate supply.

The output circuit of the crystal oscillator tube is tuned to 80 meters by means of the 0.0005-mfd. variable condenser C_8 and the coil L_1. The "0 to 3" thermo-ammeter, A_2, indicates the radio-frequency current circulating in the output circuit of the crystal oscillator tube.

The filament of this tube is supplied with alternating current from one of the low-voltage windings on the Acme 200-watt power transformer, T_2. This filament current is controlled by means of the 2-ohm General Radio rheostat, R_2. C_4 and C_5 are 0.002-mfd. radio-frequency bypass condensers.

The filaments of the two UX-216-B rectifier tubes are heated by means of current from another low-voltage winding on transformer T_2. The plates of the rectifier tubes are supplied with high-voltage alternating current from a secondary winding of T_2 which has a potential of 550 volts (r. m. s.) between its extremities and its mid-tap. The filament current to the rectifier tubes is limited by the General Radio 2-ohm rheostat, R_3.

In the rectifier filter circuit there are two 2-mfd. condensers and one 10-mfd. condenser for smoothing, designated as C_1, C_2, and C_3 respectively. Two 30-henry chokes, X_1 and X_2, are also used in this filter circuit. The high-voltage direct-current output of this No. 1 rectifier can be switched either to the plate of the crystal amplifier tube, or the plates of the tubes in a receiver, by means of the switch S_1.

The output voltage of the rectifier can be controlled to a certain extent by means of the 30-ohm rheostat R_1. When the master control switch at the operator's desk is thrown to the "send" position, relay No. 3 closes, closing the circuit through the primary winding of the power transformer, T_2, and thus lighting the filament of the crystal oscillator tube and applying plate potential to the crystal oscillator tube. Relay No. 5 also closes when the master control switch is thrown to the "send" position, and the resultant action of this relay is to remove the shunt across the chopper contacts.

When the master control switch is returned to the "receive" position, the circuit to the chopper motor is opened and it starts to slow down. The main function of relay No. 5 is to place a shunt across the chopper contacts when the master control switch is in the "receive" position, so that the make and break of the contacts will not cause Q R M (interference) when the chopper motor is slowing down.

Energy is transferred from the crystal oscillator tube output circuit to the input circuit of the first intermediate amplifier (the latter being push-pull, using two UX-210's), by means of the inductive coupling between the two coils, L_1 and L_2, the former being in the output circuit of the crystal oscillator, and the latter being in the input circuit of the first intermediate push-pull amplifier.

The mid-tap on the coil L_2 is connected to ground through a 45-volt bias battery, which applies a negative bias to the grids of both of the UX-210 tubes in the first intermediate amplifier. There is a 0.002-mfd. radio-frequency bypass condenser across this bias battery.

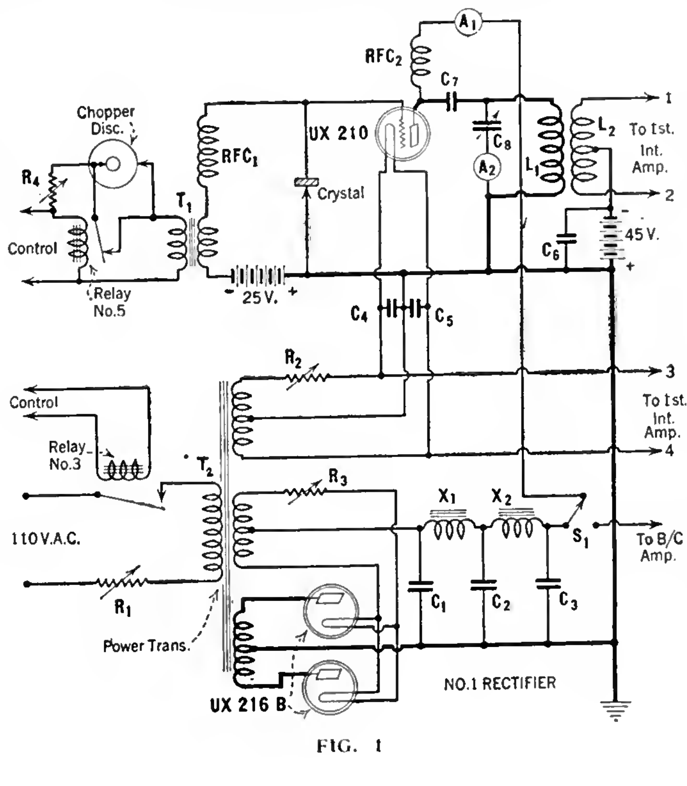


FIG. 1

FIRST INTERMEDIATE AMPLIFIER AND ITS POWER SUPPLY

A SCHEMATIC diagram of the first intermediate amplifier is shown in Fig. 2. The attendant rectifier system is also shown in Fig. 2.

Midget, five-plate, neutralizing condensers are connected from the grid of one tube to the plate of the other in this stage of amplification, to neutralize the feed-back effect due to the inter-electrode capacity of the amplifier tubes used. This is an application of the "bridge" method of neutralization. For instance, when C_1 is adjusted to a value of capacity equal to the plate-grid capacity of the UX-210 whose grid is connected to No. 1 terminal in Fig. 2, the grid of the tube in question is at ground potential as far as the radio-frequency energy in the output cir-

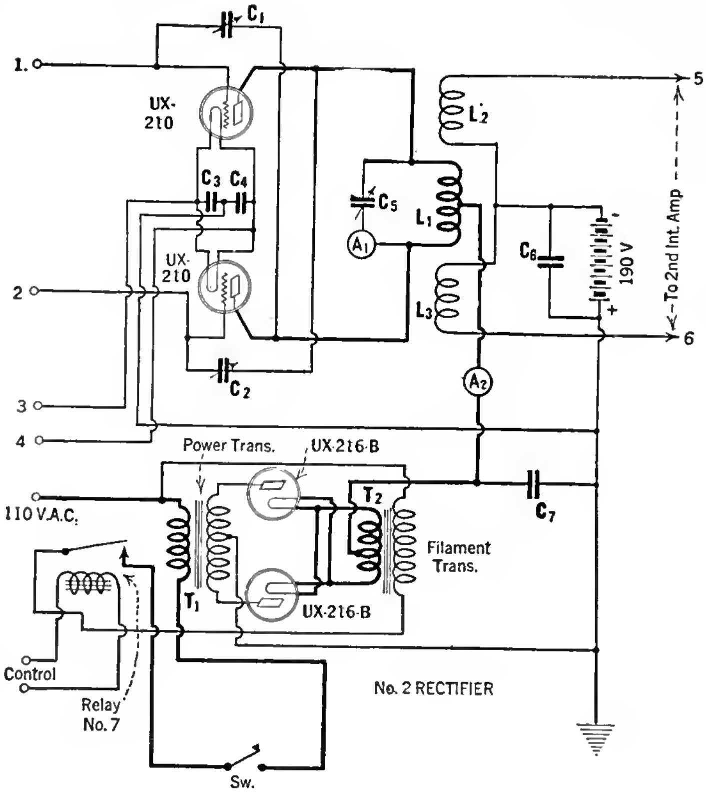


FIG. 2

cuit of this amplifier stage is concerned. Therefore, since the filament of this tube is metallically connected to ground, there can be no application of radio-frequency voltage to the grid of the tube in question, due to the radio-frequency energy in the output circuit of this amplifier stage.

The filaments of these two amplifier tubes are supplied with energy from the oscillator filament winding on the power transformer in the No. 1 rectifier assembly.

The output circuit of this stage of amplification is tuned by means of the coil L_1 and the 0.0005-mfd. variable condenser, C_5. The radio-frequency current flowing in this tuned circuit is indicated by the "0 to 5" thermo-ammeter, A_1.

The plate potential is supplied to the midpoint of the coil L_1, and the plate current is indicated by the 0 to 150 mil. meter (A_2). The source of this high-voltage d. c. supply is the No. 2 rectifier system. This rectifier employs two UX-216-B rectifier tubes which receive their plate supply from the high-voltage secondary winding of a step-up transformer, T_1.

A separate filament transformer is used to supply filament heating energy to the two rectifier tubes used, due to the fact that keying is effected by opening and closing the circuit through the primary winding of the power transformer, T_1, which removes and applies, respectively, high-voltage rectified a. c. to the plates of the two tubes in this amplifier stage.

If the filaments of the tubes in this No.2 rectifier were energized from a low-voltage winding on the transformer T_1, keying could not be satisfactorily effected, due to the time lag involved in bringing the rectifier tube filaments up to normal operating temperature, once the circuit through the primary winding of the transformer is closed.

When the master control switch is thrown to the "send" position, relay No. 7 closes, thus closing the circuit to the primary winding of the high-voltage transformer T_1, this circuit being under the control of the transmitting key.

Radio-frequency energy is induced into the input circuit of the second intermediate amplifier by means of the inductive coupling between L_1 in the output circuit of the first intermediate amplifier and L_2 and L_3 in the input circuit of the second intermediate amplifier.

The mid-point between the coils L_2 and L_3 is connected to ground through the 190-volt bias battery which maintains a negative bias on the grids of the two UV-203-A tubes in the second intermediate amplifier stage. This bias battery is bypassed by the radio-frequency bypass condenser, C_6

SECOND INTERMEDIATE AMPLIFIER

THE schematic diagram of this stage of amplification is shown in Fig. 3. The "bridge" method of neutralization is used in this amplifier stage and is effected by means of the two neutralizing condensers C_1 and C_2. The output circuit of this push-pull amplifier is tuned by means of the coil L_1 and the condenser C_5. The circulating current in this tuned circuit is indicated by the "0 to 10" thermo-ammeter, A_1.

The filaments of these two 50-watt tubes are supplied with filament heating energy from a separate transformer T_1, this current being controlled by means of the rheostat R_1. The plate supply for these two tubes is obtained from a 2000-volt d.c. generator, a plate resistor, R_2, functioning to drop the plate voltage from 2000, at the generator source, to 1000 volts at the plates of the 50-watt tubes in this stage of amplification. There is a 0.002-mfd. bypass condenser from the low side of R_2 to ground.

When the master control switch is closed, it operates relay No. 4, which closes the circuit through the primary winding of the filament transformer T_1 for the two 50-watt tubes in this second intermediate amplifier stage.

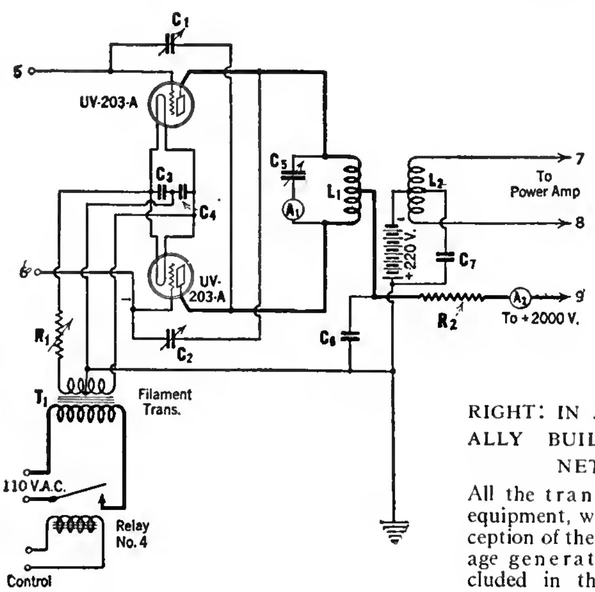
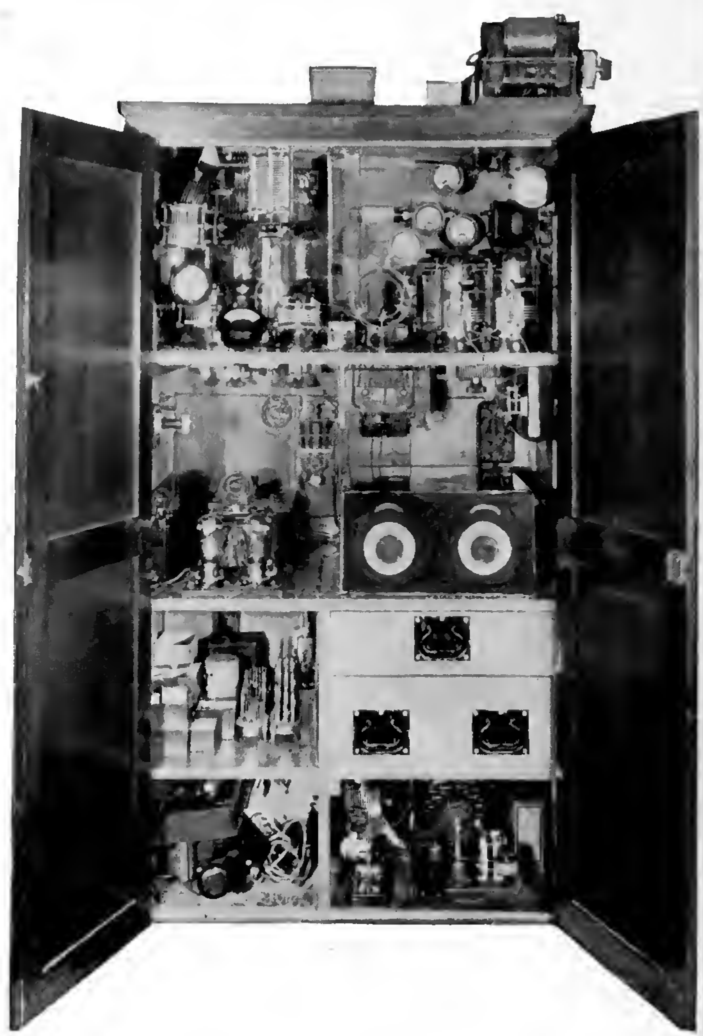
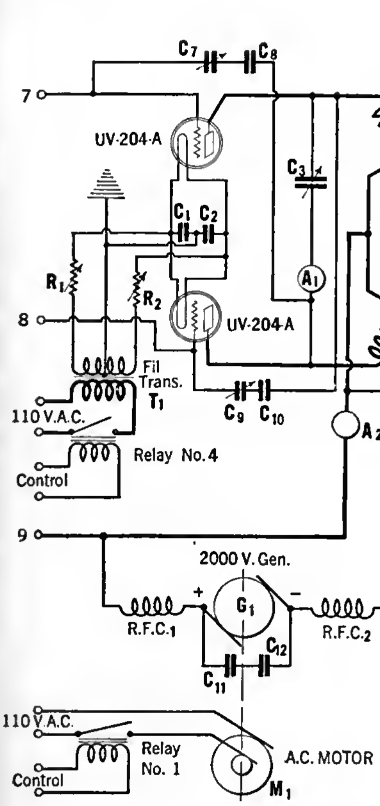


FIG. 3

RIGHT: IN A SPECIALLY BUILT CABINET

All the transmitting equipment, with the exception of the high-voltage generator, is included in the cabinet





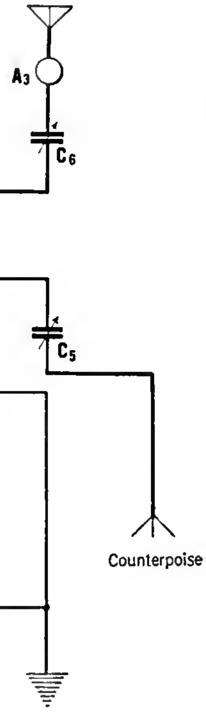


FIG. 4

The radio-frequency energy in the output circuit of this stage of amplification is induced into the input circuit of the succeeding stage, which is also push-pull, by means of the inductive coupling between the coil L_1 in the output circuit of the 50 watters, and the coil, L_2, in the input circuit of the power amplifier stage.

The mid point of the coil L_2 is connected to ground through a 220-volt bias battery, and, since the extremities of L_2 are connected to the grids of two UV-204-A 250-watt power tubes, the grids of the tubes in question are held 220 volts negative. There is a radio-frequency bypass condenser, C_7, across this bias battery.

POWER AMPLIFIER AND ITS POWER SUPPLY

THE schematic diagram of the power amplifier stage of amplification, its power supply, and the antenna system at station 2 AG, is shown in Fig. 4.

Filament heating energy for the two UV-204-A tubes in this stage of amplification is supplied from a separate step-down transformer, T_1. The filament current is controlled by means of two rheostats, R_1 and R_2.

Here again, the "bridge" method of neutralization is used, and is effected by neutralizing condensers, C_7 and C_9. The condensers C_8 and C_{10}, which are in series with the neutralizing condensers, are radio-frequency bypass condensers, and simply function to cut down the voltage drop across the neutralizing condensers and thus prevent the possibility of their arcing over.

The power amplifier output circuit is tuned by means of the coils L_1 and L_3 and the variable condenser C_3. The circulating current in this tuned circuit is indicated by the "0 to 20" thermo-ammeter. The mid-point between the two plate coils is connected to the positive 2000-volt terminal of the high-voltage d. c. generator through the "0 to 1000" milliammeter, A_2.

The high-voltage plate generator is driven by an a. c. motor which operates on 110 volts. When the master control switch is closed, relay No. 1 operates and closes the 110-volt circuit to the motor of the high-voltage motor generator set. Relay No. 4 also operates when the master control switch is closed, closing the circuit through the primary winding of the filament transformer T_1 which supplies filament heating energy to the two 250-watt tubes in this stage of amplification.

The energy in the output circuit of the power amplifier is fed into the antenna system by means of the inductive coupling between the power amplifier output coils, L_1 and L_3, and the antenna coil, L_2. A counterpoise is used in the antenna system at 2 AG and the whole arrangement is tuned by means of the variable condensers C_5 and C_6. The current in the antenna circuit is indicated by the "0 to 5" thermo-ammeter.

COMPLETE TRANSMITTER ASSEMBLY

A PHOTOGRAPH on page 172 shows the complete transmitter assembly at station 2 AG. The entire equipment is included in a cabinet built for the purpose, with the exception of the high-voltage generator which is located in the basement.

The chopper unit is located in the lower right-hand corner of the cabinet. The crystal oscillator and first intermediate amplifier are located on the middle shelf behind a shield painted black. No. 2 rectifier is just to the left of this black box, and rectifier No. 1 is located on the top of the cabinet.

The second intermediate amplifier is located in the upper right corner, and the power amplifier is to the left of the latter, in the upper left-hand corner of the cabinet. The operators' desk is just to the left of this cabinet.

A schematic diagram of the transmitter is shown in Fig. 5. Note that the diagrams of the various stages have given the complete details concerning each stage, whereas the diagram of the entire transmitter does not include the control relays or the power supply units.

CONTROL RELAY SYSTEM

WHEN the operator at station 2 AG closes the master control switch to the "send" position, there are a great many actions that take place. This can best be explained by a study of Fig. 6, which shows the control relay system alone.

When the single-pole single-throw switches, S_1 and S_2, are closed, the control relays are under the control of the master switch. The pilot lamps are lighted when S_1 and S_2 are closed. The former is in an 8-volt circuit and the latter is in a 6-volt circuit.

With the master control switch thrown to the "transmit" position ("T" in the diagram), the following actions take place:

(A). Relay No. 2 closes. Relay No. 1 is thrown on the 110-volt a. c. line and it closes. When relay No. 1 closes, 110 volts a. c. is applied directly across the terminals of the a. c. motor which drives the high-voltage d. c. generator for the plates of the two 50 watters, and the plates of the two 250 watters.

(B). Relay No. 3 closes. The 110-volt a. c. circuit is closed through the primary winding of the power transformer in the No. 1 rectifier assembly.

(C). Relay No. 4 closes. An a. c. voltage of 110 is applied to the primary winding of the filament transformer for the two UX-216-B rectifier tubes in No. 2 rectifier.
A similar voltage is applied to the primary winding of the filament transformer for the two UV-203-A tubes in the second intermediate amplifier circuit.
A voltage of 110 is applied to the primary winding of the filament transformer for the two UV-204-A tubes in the power amplifier.
One hundred and ten volts a. c. is applied to the terminals of the motor that drives the chopper disc.

(D). Relay No. 5 opens. The shunt across the chopper contacts is removed.

(E). Relay No. 6 closes. The terminals of the headphones are connected to the output of the monitor receiver which allows the operator to hear the quality of his outgoing signals.

(F). Relay No. 7 closes. The circuit from the 110-volt a. c. supply, through the primary winding of the plate transformer for the No. 2 rectifier, is closed.

(G). Relay No. 8 closes. The A battery circuit to the filaments of the tubes in the monitor receiver is closed.

(H). The 8-volt control battery is connected in series with the modulation transformer and the chopper contacts.

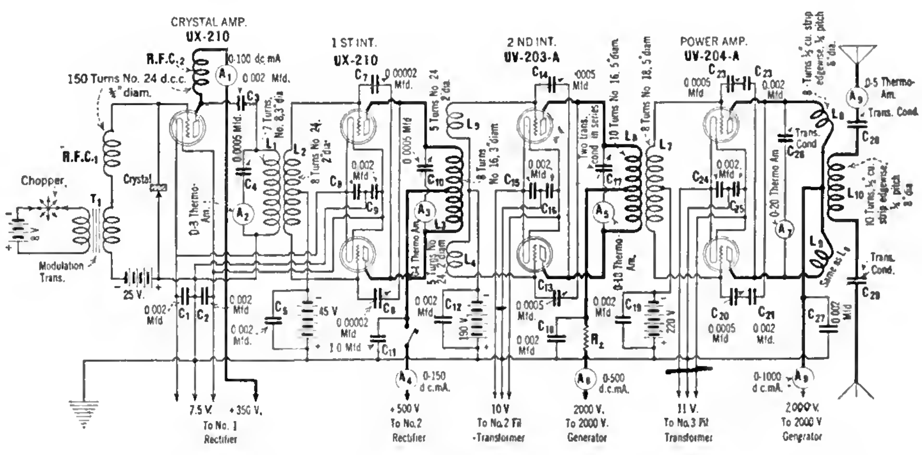


FIG. 5

A diagram of the complete 500-watt transmitter, 2 AG. The control relays and power supply equipment has been omitted in the diagram. This diagram combines Figs. 1, 2, 3, and 4, but the lettering of the parts is different

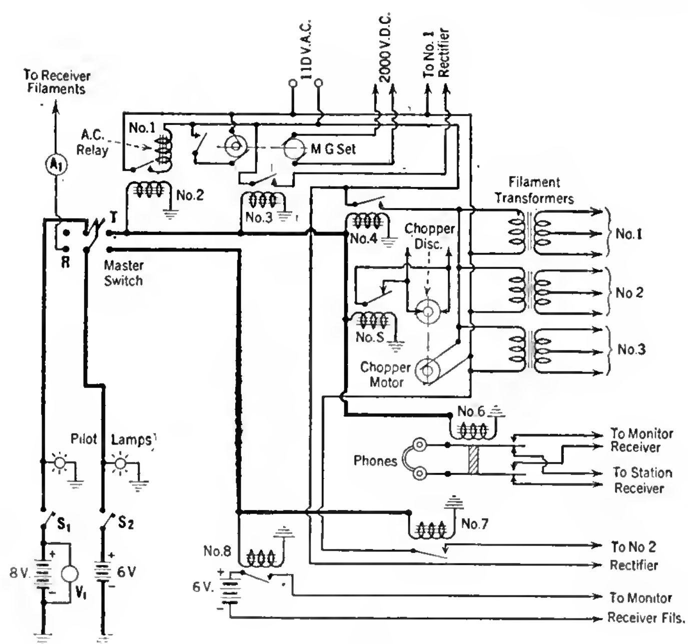


FIG. 6

The control relay system at 2 AG. Filament Transformers: No. 1 supplies filaments of rectifier tubes in No. 2 rectifier for the first intermediate amplifier; No. 2 for filaments of the second intermediate amplifiers (UV-203-A's); No. 3 for filaments of power amplifier tubes (UV-204-A's). The functioning of this control relay system is explained in the text on page 173

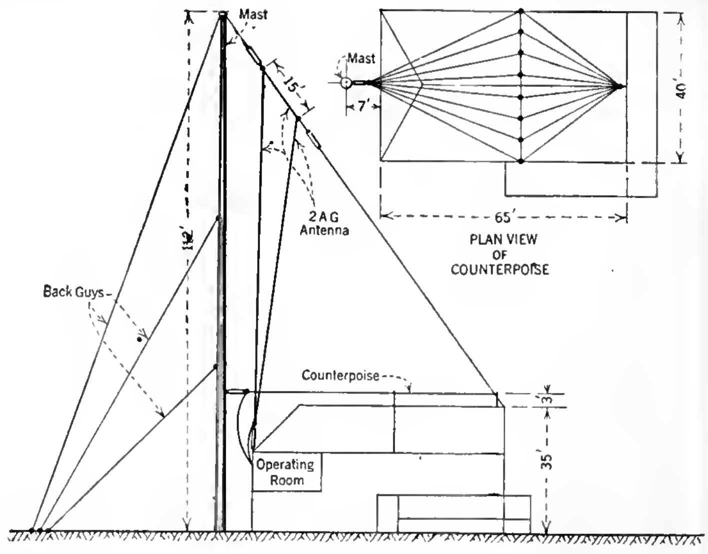


FIG. 7
The antenna system at 2 AG.

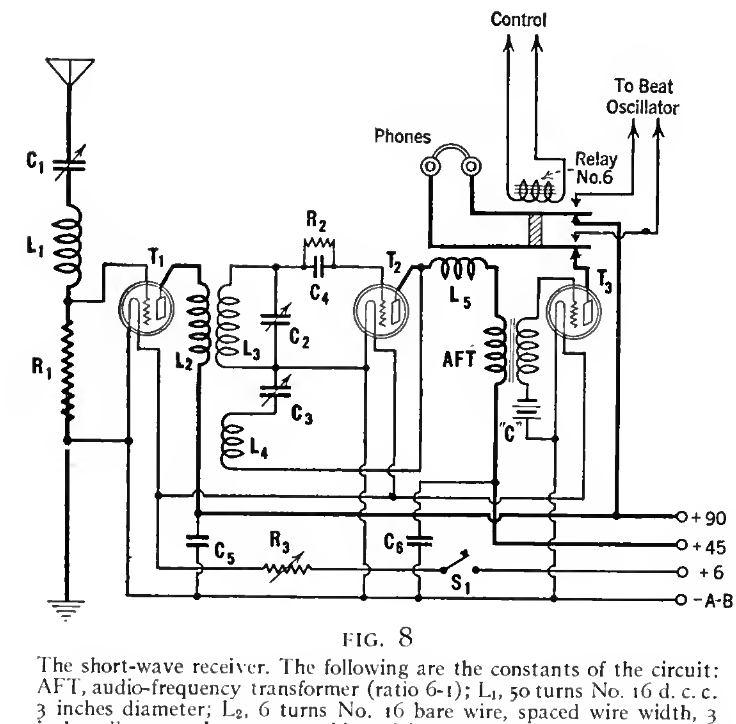


FIG. 8

The short-wave receiver. The following are the constants of the circuit: AFT, audio-frequency transformer (ratio 6-1); L_1, 50 turns No. 16 d. c. c. 3 inches diameter; L_2, 6 turns No. 16 bare wire, spaced wire width, 3 inches diameter; L_3, 23 turns No. 16 bare wire, spaced wire width, 3 inches diameter; L_4, 4 turns No. 16 bare wire, spaced wire width, 3 inches diameter; L_5, 175 turns No. 34 d. s. c. 1 inch diameter; C_1, 0.0005-mfd. variable condenser; C_2, 0.000075-mfd. variable condenser; C_3, 0.00025-mfd. variable condenser; C_4, 0.00025-mfd. fixed condenser; C_5, 0.1 mfd. fixed condenser; C_6, 0.1-mfd. fixed condenser; R_1, 50-ohm fixed resistance; R_2, 3-megohm grid leak; R_3, 6-ohm rheostat; S_1, Filament control switch (on master control switch); relay No. 6, 6-volt, d. p. d. t. The coils given above are for the 80-meter band. Those used for the 40-meter band are as follows: L_3, 10 turns No. 16 bare wire, spaced wire width, 3 inches diameter; L_4, 3 turns No. 6 bare wire, spaced wire width 3 inches diameter.

When the master control switch is thrown to the "receive" position, which is indicated by "R" in Fig. 6, all the control relays, with the exception of relay No. 5, open, and the contacts of this latter relay close, thus shunting the chopper contacts during the period that the chopper motor is coming to a stop. It is well to note that the filaments of the short-wave receiver are turned on by putting the master control switch in the "receive" position, and the headphones are disconnected from the output of the monitor receiver, and connected to the output of the short-wave receiver, this latter action being taken care of by relay No. 6.

THE ANTENNA SYSTEM

A DIAGRAM of the antenna system is shown in Fig. 7. The antenna consists of two verticals which are connected to the extremities of a very short flat-top, the latter being an active part of the antenna system, which is insulated from a guy wire which extends from the top of a 112-foot mast to the top of the roof at the front of the house. The mast itself has three sets of back guys, this mast being about 18" in diameter at the base and 6" in diameter at the top.

The counterpoise is arranged on the top of the roof of the house, as shown in the plan view in the upper right corner of Fig. 7.

SHORT-WAVE RECEIVER

THE schematic diagram of the short-wave receiver used at 2 AG is shown in Fig. 8.

The first tube in this receiver, T_1, is simply a coupling tube. The antenna is connected to the grid of the receiver through the variable 0.0005-mfd. condenser C_1 and the coil L_1. There is a 50-ohm resistor, R_1, between the grid and filament of the coupling tube, and the filament is grounded.

The radio-frequency energy in the output circuit of the coupling tube is passed on to the input circuit of the detector tube through the medium of the inductive coupling between the coils L_2 and L_3, the latter being tuned to the incoming signals by means of the 0.000075-mfd. variable tuning condenser C_2

Regeneration is accomplished by means of the inductive coupling between the feed-back coil L_4 and L_3, and the tuning is effected by the variable condenser C_2. The function of C_3 is to limit the amount of radio-frequency current flowing in the feed-back circuit, hence also limiting the amount of regeneration.

L_5 is a radio-frequency choke and AFT is the first audio-frequency interstage transformer. Only one stage of audio-frequency amplification is shown on the diagram, although in the actual receiver there are two stages.

C_5 is both a radio- and an audio-frequency-bypass condenser, and C_6 is an audio-frequency bypass condenser.

MONITOR RECEIVER

THE monitor receiver is just an ordinary receiver which is tuned so that one of its harmonics beats with the fundamental frequency of the transmitter. In this way it is possible to monitor the outgoing signals by picking up a small amount of signal energy without danger of blocking the tubes in the receiver.

RADIO BROADCAST is the official publication of the Radio Club of America, through whose courtesy, the foregoing paper has been printed here. RADIO BROADCAST does not, of course, assume responsibility for controversial statements made by authors of these papers. Other Radio Club papers will appear in subsequent numbers of this magazine

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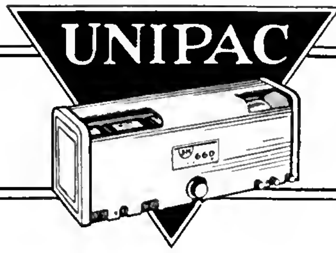

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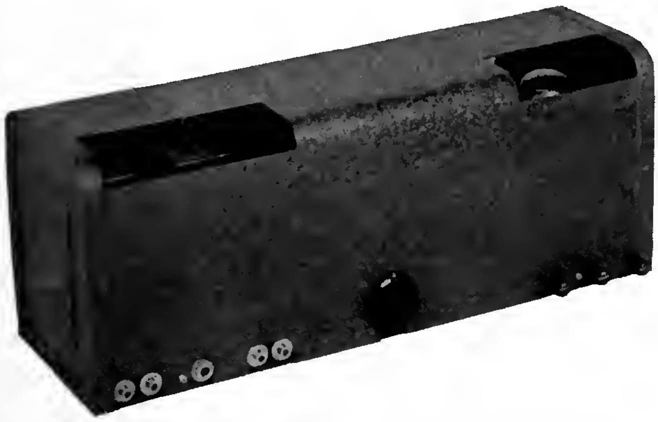


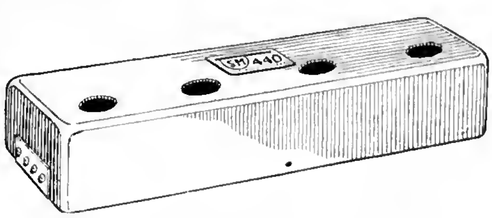
LOOKING back a year to June of 1926, when Silver-Marshall cast a bomb-shell into the field of audio amplification with the now famous 220 and 221 audio transformers, it does not seem surprising that S-M engineering should still lead in A. F. amplification.

Now S-M offers the most powerful power pack yet devised, the amplifier stage of which can develop more undistorted power output than the average 210 power pack. And the Unipac amplifier has the same features of rising low note frequency gain and 5,000 cycle cut-off that have made 220's and 221's the largest selling high-grade audio transformers on the market—two features at first ridiculed by experts, then accepted and next season to be found in the most advanced high-class equipment.

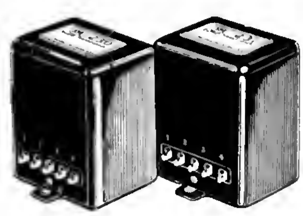
The power supply of the Unipac, unlike average power supplies, gives practically constant output, and is substantially the Reservoir B unit so highly endorsed by Keith Henney of Radio Broadcast Laboratory. It furnishes B supply to any radio set and A, B and C power to the amplifier stage—power constant, unfluctuating and free from "motor-boating" and "putting."

A Unipac added to your set provides it with the finest quality of reproduction, handling capacity to spare, and replaces all B batteries, operating as it does directly from the 105 to 120 volt, 60 cycle, house lighting socket. Even though you may discard your set for a newer model, the Unipac will improve any receiver you ever buy or build—will remain the last word in distortionless power amplification and B power supply for years to come. And its applications are not limited—it may be used as a two stage amplifier, or to electrify any phonograph by means of a standard record pick-up, loud speaker and the Unipac.

The Unipac kit, with all parts including steel chassis and case, is available in two models. Type 660 contains the most powerful of all receiving amplifiers, a push-pull stage with 230 and 231 transformers, and is priced at $62.00. Type 660-B, with a slightly lower output level, includes a standard amplifier stage with 220 and 221 transformers, at $57.00.



The 440 Jewelers' Time Receiver consists of three R. F. amplifier stages and a detector, accurately tuned in the S-M laboratories to exactly 112 K.C., Arlington's wavelength, thus insuring reception of but one station at a time absolutely without interference.



The remarkable tone quality of the Unipac—its tremendous undistorted power output—is made possible only through the use of the S-M push-pull transformers—the new 230 input and 231 output models. You too can enjoy this tone quality by incorporating them in your audio amplifier or power pack. They are priced at $10.00 each.

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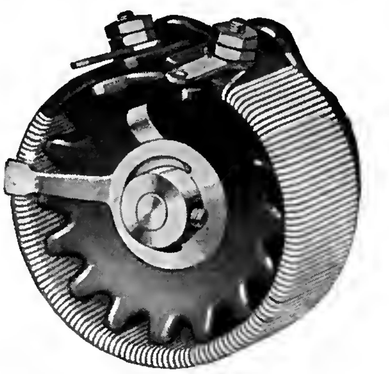

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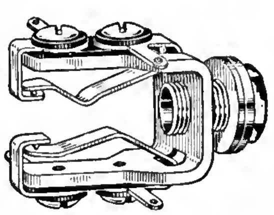

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No. 951 GEM-JAC

This Double Circuit Gem-Jac has genuine Bakelite insulation, sterling silver contacts and occupies but 1 inch of space back of panel. List: **$.50.**

No. 253 Cord Tip Jack

This handy No. 253 Cord Tip Jack has built-in spring clutch from which cord tip cannot be accidentally removed until clutch is released. Two pairs of these are used in the UNI-PAC. List, per pair: **$.30.**

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The *Radio Broadcast* LABORATORY INFORMATION SHEETS

THE RADIO BROADCAST Laboratory Information Sheets are a regular feature of this magazine and have appeared since our June, 1926, issue. They cover a wide range of information of value to the experimenter and to the technical radio man. It is not our purpose always to include new information but to present concise and accurate facts in the most convenient form. The sheets are arranged so that they may be cut from the magazine and preserved for constant reference, and we suggest that each sheet be cut out with a razor blade and pasted on 4" x 6" filing cards, or in a notebook. The cards should be arranged in numerical order. An index appears twice a year dealing with the sheets published during that year. The last index appeared on sheets Nos. 47 and 48, in November, 1926. This month an index to all sheets appearing since that time is printed.

The June, October, November, and December, 1926, issues are out of print. A complete set of Sheets, Nos. 1 to 88, can be secured from the Circulation Department, Doubleday, Page & Company, Garden City, New York, for $1.00. Some readers have asked what provision is made to rectify possible errors in these Sheets. In the unfortunate event that any such errors do appear, a new Laboratory Sheet with the old number will appear.

The Information Service of RADIO BROADCAST is conducted entirely by mail, the coupon on page 191 being used when application is made for technical information. It is the purpose of these Sheets to supply information of original value which often makes it possible for our readers to solve their own problems. —THE EDITOR.

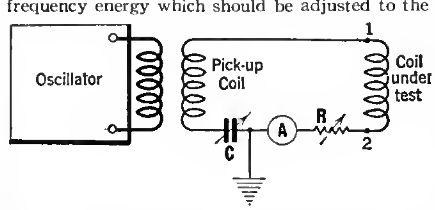
No. 105 RADIO BROADCAST Laboratory Information Sheet July, 1927

Measuring R. F. Resistance of a Coil

NECESSARY EQUIPMENT AND PROCEDURE

THE job of measuring radio-frequency resistance is not an especially difficult one, although it requires considerable apparatus. The circuit diagram of the test circuit is given on this Sheet. The apparatus used should have the following characteristics:

OSCILLATOR—This represents a source of radio-frequency energy which should be adjusted to the



frequency at which the measurements are to be made. It should have plenty of power. In the Laboratory a 210 tube with at least 300 volts on the plate is generally used, but it is doubtlessly possible to use a 201-A as an oscillator with about 100 volts on the plate. The important point is that adjustments in the test circuit should produce no change in the energy delivered by the oscillator.

A—This is a radio-frequency milliammeter with a range of about 200 milliamperes or preferably somewhat less. It may be a hot-wire or thermocouple meter, or an ordinary crystal detector used with a low-range d. c. milliammeter.

C—The condenser should be a very carefully constructed one because it is essential that its resistance be low and constant. It should preferably be a laboratory type instrument although a well made receiving condenser can be used.

R—This resistance must be continuously variable and must be non-inductive. A decade resistance box is well suited for this purpose.

PICK-UP COIL—The pick-up coil functions to pick up energy from the oscillator and feed it into the test circuit. It may consist of just a few turns of wire coupled just close enough to the oscillator so as to give a good deflection on the meter, A.

The procedure in making a test is quite simple. Start with zero resistance at R and once the test has started make no changes at all in the oscillator or in the position of the pick-up coil. The oscillator should be turned on and the condenser varied until the circuit is in *exact* resonance, this condition being indicated by a maximum reading noted on meter A. Points 1 and 2 are now short circuited and the condenser readjusted so as to again bring the circuit into resonance. The reading of the meter will now be greater than before because the resistance of the coil under test is no longer in the circuit. Now add resistance to the circuit at R until the meter reading is decreased to the same value as was noted above, and under such conditions the resistance R is equal to the r. f. resistance of the coil under test.

No. 106 RADIO BROADCAST Laboratory Information Sheet July, 1927

The UX-240 Type Tube

GENERAL CHARACTERISTICS

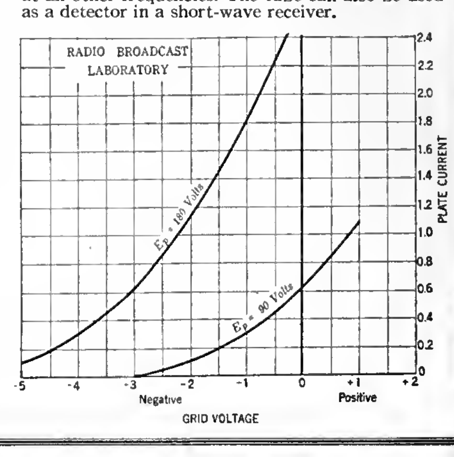
THE UX-240 type tube is designed for use in resistance-coupled amplifiers and under proper conditions will give an effective amplification of about 20 per stage. The plate resistor used with this tube should have a value of 250,000 ohms and the B and C voltages should be 180 volts or 135 volts and 3 or 1.5 volts respectively. The coupling condensers should have a value of 0.05 mfd. and the grid leak resistance should be of 2 megohms. these values are correct when the tube is used as an amplifier. It can also be used as a C-battery type detector in which case the C voltage should be 3 volts for a plate voltage of 135 or 4.5 volts for a plate voltage of 180. The plate resistor, coupling condenser, and grid leak should have the same values as given above.

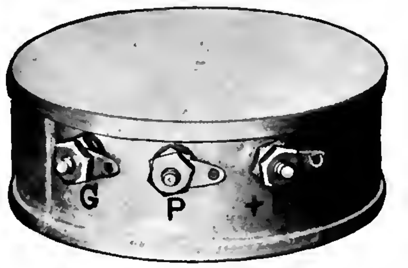
The general characteristics of this tube are as follows:

Filament Voltage	5.0 Volts
Filament Current	0.25 Amperes
Maximum Plate Voltage	180 Volts
Amplification Constant	30
Plate Impedance	150,000 Ohms
Plate Current	0.2 Milliamperes

This tube can be used in any existing resistance-coupled amplifier provided the resistances used are of the proper value and the tubes are supplied with the proper A, B, and C voltages.

It is not possible to use this new tube in a transformer-coupled amplifier because its high plate impedance will cause the transformer to have a rather sharp peak at some frequency. This fact, however, makes the tube very satisfactory as an amplifier for c. w. reception in short-wave receivers where we are interested in obtaining high amplification around 1000 cycles and very poor amplification at all other frequencies. The tube can also be used as a detector in a short-wave receiver.





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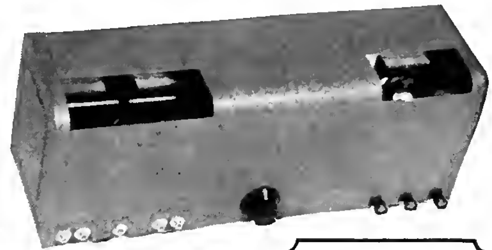
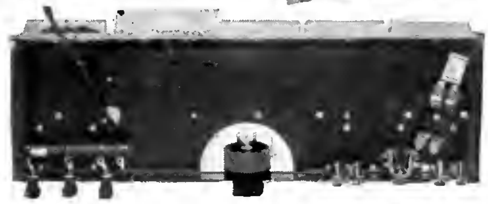


Bottom View



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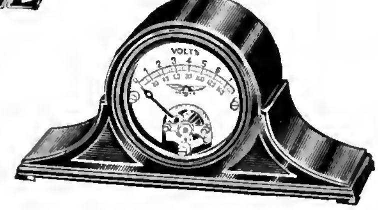

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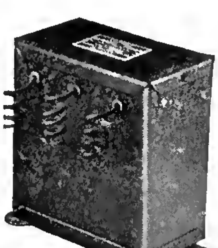

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No. 107 — Radio Broadcast Laboratory Information Sheet — July, 1927

Neutralization

EFFECTS OF MALADJUSTMENT

At the present time there is only one known way whereby a very high-gain high-frequency amplifier can be obtained, and that is by using several well-designed tuned radio-frequency amplifiers with each stage properly neutralized. Manufactured receivers are neutralized at the factory and consequently the problem of neutralizing a receiver or the effect of improper neutralization does not generally concern those who buy their receiver ready made. The home constructor, however, must neutralize his own receiver, and for this reason it is rather important that the effect of improper neutralization be known.

The first and most obvious manifestation of incorrect adjustment of the neutralizing device is oscillation in some or all of the radio-frequency circuits. These oscillations as a general rule become more severe as the frequency is increased, and a loud squeal or whistle will be heard as the tuning controls are adjusted to receive some station that is transmitting.

Such an effect will make it difficult for the user of the receiver to obtain satisfactory reception and the oscillations will be radiated from the antenna attached to the receiver and cause interference on other receivers located in the neighborhood. Such oscillations can be prevented by correct adjustment, and it is essential that the proper setting be determined in order to make it possible to obtain best results from the receiver.

A second detrimental effect of maladjustment of the neutralizers is poor quality, which is generally due to the existence of too much regeneration. The quality under these conditions will generally sound drummy, indicating that the various frequencies in the carrier are being unequally amplified by the radio-frequency amplifiers. To preserve good quality, the radio-frequency amplifiers must amplify without distortion a band of frequencies extending about 5000 cycles above and 5000 cycles below the carrier frequency, and this condition does not exist unless proper neutralization is obtained.

Another effect of improper neutralization is to cause one or more of the tuned circuits in a single-control receiver to be thrown out of synchronism so that the set loses a great deal of its sensitivity, and as a result it is not possible to tune-in distant stations with satisfactory volume.

These three major effects of improper neutralization indicate how essential it is that neutralization be always carefully and completely accomplished. There are several satisfactory methods of neutralizing a receiver, and information regarding them can be found on Laboratory Sheet No. 38, published in the October, 1926, issue.

No. 108 — Radio Broadcast Laboratory Information Sheet — July, 1927

High Voltage Supply for 210 Type Tube

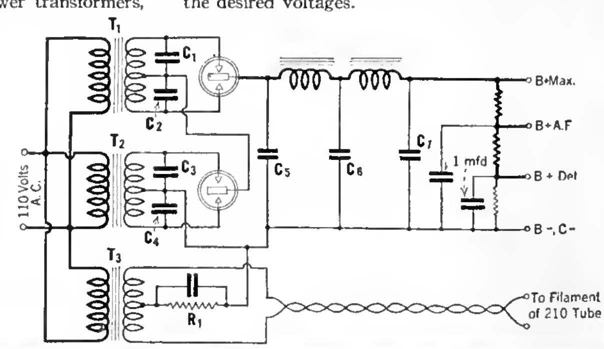
THE DOUBLE TRANSFORMER METHOD

If high voltages up to 400 volts are required for operation of a 210 type power tube, it is generally best to use a B power unit incorporating a 216-B single-wave rectifier tube. This tube is capable of operating satisfactory at the high transformer voltages which must be used. It is possible, however, by using a somewhat complicated arrangement, to obtain the high voltage by using low-voltage rectifiers such as the Raytheon and Q. R. S.

An arrangement whereby 400 to 450 volts can be obtained using two gaseous rectifiers is shown in the drawing on this Sheet. Two power transformers, T_1 and T_2, are necessary, each supplying about 220 volts each side of the center tap. They are connected into the circuit as shown and supply two rectifiers which in turn feed a common filter system. The maximum permissible current drain is 20 milliamperes using Raytheon type B tubes and 35 milliamperes using type BH tubes. Condensers C_1, C_2, C_3, and C_4 each have a capacity of 0.1 mfd; C_5 and C_6 are of 2 mfd. capacity, and C_7, 8 mfd. All the condensers should have a working voltage of 750 volts d. c.

Filament current for the 210 tube should be obtained from a separate filament transformer T_3 capable of supplying 1.25 amperes at 7.5 volts. The transformer should be tapped at the center as shown and a 1500-ohm resistance, R_1, connected between it and the negative B of the filter system. This resistance will supply C bias to the tube. Its bypass condenser should have a value of 2 mfd.

A 50,000- or 100,000-ohm resistance should be connected from B+ to B— if the unit is only to supply B potential to the 210, but if it is also to be used to supply B voltage to other tubes in a receiver the output should be shunted by several fixed resistors with taps at various points to obtain the desired voltages.



No. 109 — Radio Broadcast Laboratory Information Sheet — July, 1927

The Threshold of Hearing and Feeling in the Ear

ENERGY REQUIRED FOR AUDIBILITY

A great many important experiments in sound have been made in the various large laboratories. An interesting experiment is to determine how much energy is required by the ear in order to just hear tones of various frequencies between about 30 and 5000 cycles. Data of this sort can be plotted on a curve, a typical one being given on this Sheet. Such a curve is called a curve of "threshold audibility" because it indicates the amount of sound energy required to just produce an audible sound.

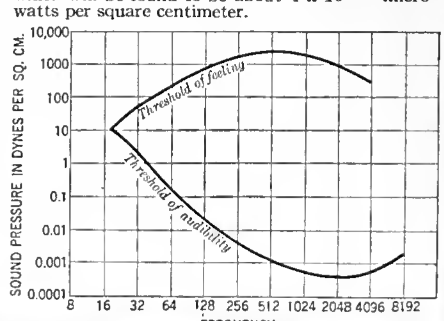
At 32 cycles a sound pressure of somewhat more than one dyne per square centimeter is required to produce an audible response, while at 2000 cycles only about 0.0003 dynes per square centimeter are required to produce an audible sound. The sound pressure required to produce a sound of minimum intensity is fairly constant between about 500 and 5000 cycles. Good speech articulation can be obtained within a frequency range of 250 and 2500 cycles; this band can, in fact, be narrowed to exclude all frequencies below 500 cycles and good articulation will still be retained. In the reproduction of music, however, it is necessary to include a much wider band having an upper limit of 5000 or 6000 cycles and a lower limit of about 32 cycles.

There is also an upper limit of sound pressure at which there is produced a sensation of feeling in the ear and it serves as a practical limit to the range of auditory sensation. At low frequencies the two curves of feeling and hearing meet each other, which indicates that these frequencies give a sensation of feeling which is difficult to distinguish from a sensation of hearing.

The power in microwatts in each square centimeter of the sound wave under average conditions is related to the effective value of the pressure in dynes as follows:

$$\text{Power} = \left(\frac{\text{Pressure in Dynes}}{20.5}\right)^2$$

Using this formula we can calculate the average power required to produce a minimum audible sound at frequencies between 2000 and 4000 cycles, which will be found to be about 4×10^{-10} microwatts per square centimeter.



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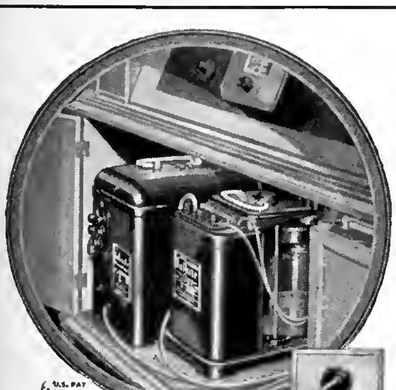

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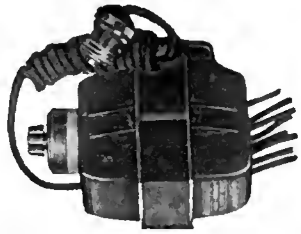

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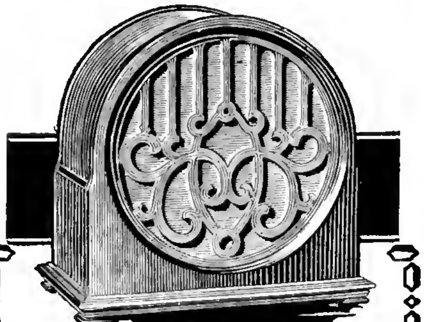

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AMPLION

No. 110 | Radio Broadcast Laboratory Information Sheet | July, 1927

Dry-Cell Tubes

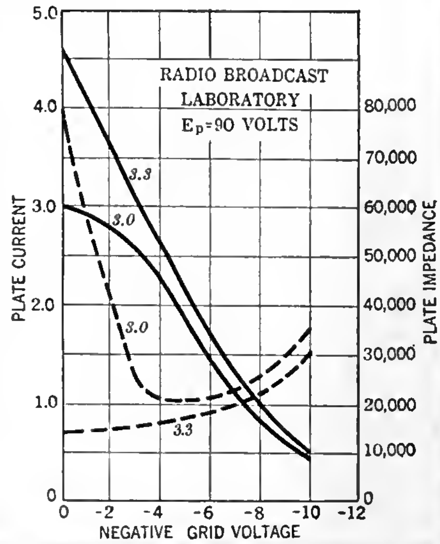
BEST FILAMENT VOLTAGE

Although dry-cell tubes are generally operated with 3 volts on the filament, somewhat better results can be obtained if 3.3 volts is used instead.

The two solid curves on the accompanying diagram are obtained by measuring the plate current at various values of negative grid bias with 3.0 and then 3.3 volts across the filament. If the tube is functioning properly this curve will be a straight line over most of its length. The 3.0-volt curve slopes off at low values of grid bias and this indicates that the filament emission is too low and a signal would be distorted. The 3.3-volt curve, however, is straight over a large portion of its length and therefore this same tube with somewhat higher filament voltage is capable of amplifying without distortion.

The two dotted curves show the plate impedance of the tube first with 3.0 volts and then with 3.3 volts on the filament. With 3.0 volts, and therefore a low filament emission, we obtain an erratic plate impedance curve. which rises to values as high as 80,000 ohms at zero grid voltage. The plate impedance curve taken with 3.3 volts again indicates the value of using this voltage, for it shows the plate impedance to be comparatively constant and low over a greater part of its length, and this is as it should be.

This recommendation that 3.3 volts be used on the filament is the result of many tests made in the Laboratory, and the Cunningham Tube Company has also recommended that this voltage be used.



No. 111 | Radio Broadcast Laboratory Information Sheet | July, 1927

Index

December, 1926, to July, 1927

	Sheet Number	Month
Ampere, What It is	78	March, 1927.
Audio Amplifying Systems		
Double-Impedance Coupled	86, 87	April, 1927.
Dual-Impedance Coupled	93	May, 1927.
Push-Pull Amplification	71	February, 1927.
Resistance-Coupled	74	March, 1927.
" "	98	June, 1927.
Transformer-Coupled	88	April, 1927.
Amplification Constants, Calculation of	80	March, 1927.
Amplifying Systems, Efficiency of	102	June, 1927.
Antenna		
Loop	90	May, 1927
Power Dissipation	62	January, 1927.
Tuning the Antenna	55	December, 1926.
Arc, The	97	June, 1927.
Audio Transformers	103	June, 1927.
Batteries, Storage	95	May, 1927.
C Voltages	85	April, 1927.
Chargers, Trickle	49	December, 1926.
Coils, Short-Wave	89	May, 1927.
Coils, Measuring Radio-Frequency Resistance	105	July, 1927.
Condensers, Gang	64	January, 1927.
Detector, C-battery	54	December, 1926.
Ear, Threshold Sensitivity	109	July, 1927.
Electrons, Sources of	69	February, 1927.
Filter Circuit Data	60	January, 1927.
Frequency Ranges of Musical Instruments	52	December, 1926.
Harmonics		
What They Are	59	January, 1927.
Importance of	51	December, 1926.
Interference		
Elimination	77	March, 1927.
Finder	75, 76	March, 1927.
Intermediate-Frequency Amplifier	61	January, 1927.
Lightning Arrestors	101	June, 1927.
Line Power-Supply Devices	63	January, 1927.
Loop Antennas	90	May, 1927.
Musical Instruments, The Frequency Range of	52	December, 1926.
Mutual Conductance, Calculation of	83	April, 1927.
Neutralization, Importance of	107	July, 1927.
Ohm's Law	81	April, 1927.
Ohm, What It Is	78	March, 1927.

No. 112 | Radio Broadcast Laboratory Information Sheet | July, 1927

Index

December, 1926, to July, 1927

	Sheet Number	Month
Oscillation Control	82	April, 1927.
Oscillator, Radio Frequency	66	February, 1927.
Overtones (Harmonics)	51	December, 1926.
Plate Impedance, How It Is Calculated	67	February, 1927.
Power Amplifier, A. C. Operated	73	March, 1927.
Power-Supply Devices		
Calculation of Resistance Values	63	January, 1927.
High Voltage Unit for 210	000	July, 1927.
Output Curves	101	June, 1927.
Regulating voltage	79	March, 1927.
Trouble Shooting	72	February, 1927.
Push-pull Amplification	71	February, 1927.
Radio Telegraph Transmission	56	December, 1926.
Receivers		
Portable	75, 76	March, 1927.
"Universal"	99, 100	June, 1927.
Reflexing, The Principle of	94	May, 1927.
Regulating Voltage on B Power-Supply Device	79	March, 1927.
Resistance-Coupled Amplifiers	74	March, 1927.
Resonance, What It Is	57	January, 1927.
Short Wave Coils	89	May, 1927.
Shunts	53	December, 1926.
Soldering	70	February, 1927.
Storage Batteries	95	May, 1927.
Transformer Coupled Amplifiers	88	April, 1927.
Transformers, Audio	103	June, 1927.
Trickle Chargers	49	December, 1926.
Tubes		
Characteristics General	80	March, 1927.
Characteristics, 240	106	July, 1927.
Characteristic Curve, 120	84	April, 1927.
Comparison of 171 and 210	58	January, 1927.
Curves for the 171	68	February, 1927.
Filament Voltage, Dry Cell Tubes	110	July, 1927.
Hard and Soft Tubes	50	December, 1926.
171 Characteristics	67, 68	February, 1927.
Tube Tester	91, 92	May, 1927.
Tuning the Antenna Circuit	55	December, 1926.
"Universal" Receiver	99, 100	June, 1927.
Vacuum-Tube Voltmeter	65	February, 1927.
Voice Frequencies, Analysis of	96	May, 1927.
Volt, What It Is	78	March, 1927.

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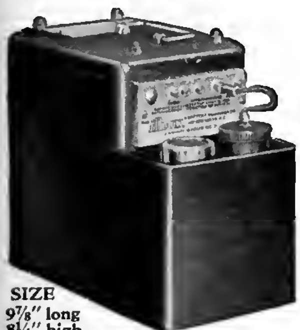

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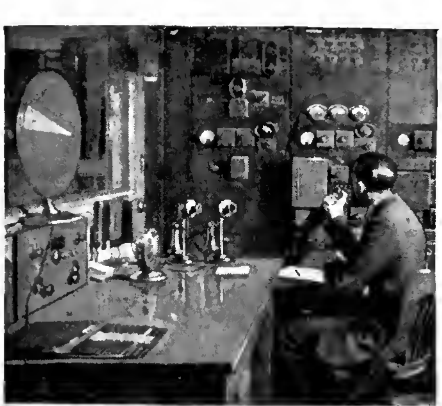

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TAYLOR RESONANCE INDICATOR

THE design of a receiver in which several of the tuning condensers are actuated by a single control is a somewhat difficult job because it is essential that each of the tuned circuits be in exact resonance with each other to prevent loss in selectivity and sensitivity.

The coils and condensers used in such a receiver must be as electrically similar as possible, and it is generally advisable to check each coil-condenser combination separately to make certain that it tunes, throughout the entire frequency range of the receiver, exactly the same as the other tuned circuits. A simple and satisfactory method of making a test of this sort is possible with the use of the new Taylor resonance indicator, shown in a photograph on this page.

The circuit diagram is given in Fig. 1. Two 201-A type tubes are necessary to operate the

THE TAYLOR RESONANCE INDICATOR

device. One of them is placed in socket A and acts as an oscillator, the oscillatory circuit consisting of C_1, L_1, and L_2; the frequency range of the oscillator is 500 to 1500 kc. The other tube is placed in socket B, and it acts as a rectifier of the current flowing through the galvanometer, "G." In the following paragraphs we will describe the procedure in testing a single-control receiver for synchronism.

Suppose that we have such a receiver consisting of three tuned circuits A, B, and C, all of them operated from a single dial. If the receiver is to give satisfaction these three circuits must tune to exactly the same frequency at exactly the same point, and the problem is to determine if such is the case. In making the test no batteries at all should be connected to the receiver. The resonance indicator itself, however, requires for its operation a 45-volt B battery and a 6-volt storage battery for filament supply.

There are two leads attached to the resonance indicator, one red, the other green, and these leads should be connected, respectively, to the stator and rotor of the first variable condenser in the receiver. Now set the dial on condenser C_1 at some medium frequency, say 1000 kilocycles, which corresponds to 17 on the dial (See Fig. 2), and then turn the instrument on. The oscillations in tube A are fed through the small coupling condenser, C_2, to the tuned circuit of the receiver to which the leads are connected, and as a result, a voltage will be developed across the tuned circuit. This voltage will be a maximum when the tuned circuit in the receiver is in exact resonance with

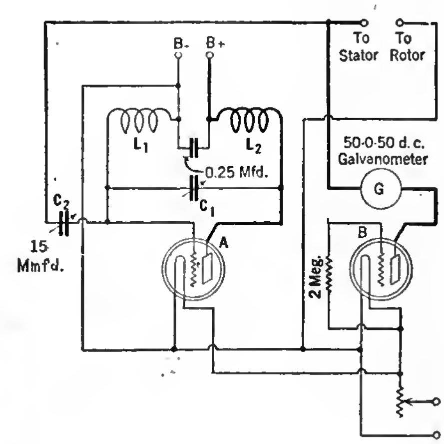

FIG. 1

the oscillations produced by tube A. This voltage across the tuned circuit, will cause a current to flow through the galvanometer and the tube B connected in series with it, and the current flowing through the galvanometer will be proportional to the voltage. It is evident that maximum galvanometer deflection means maximum voltage and, therefore, that the circuit is in resonance. The dial reading of the receiver at resonance should be noted down as accurately as possible.

Without in any way changing any of the settings on the resonance indicator, the two connections are moved over to the next stage in the receiver and connected to circuit B. The condenser in this circuit is then adjusted for maximum deflection as was done with the condenser

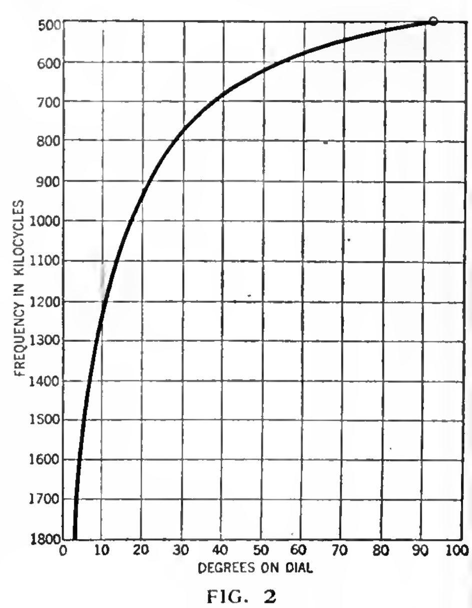

FIG. 2

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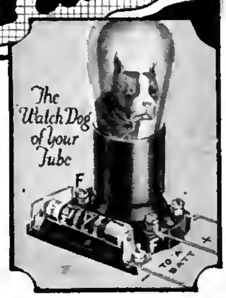

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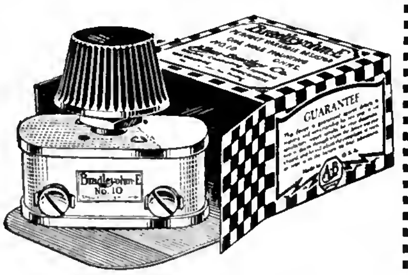

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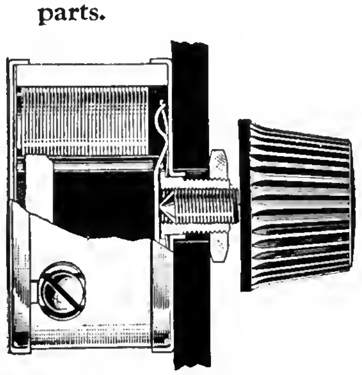

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in circuit A, and the dial reading noted. The same test is then made with the leads connected across the condenser in tuned circuit C. If it is found that the dial on the receiver must be tuned to exactly the same point in all three cases, we have a good indication that the three circuits are in synchronism. If, on the other hand, one of the condensers gives a different reading than the other two it must be readjusted so as to give exactly the same reading.

Usually only one test for alignment is necessary at some medium frequency. The set may be checked at three or more points if it is deemed necessary, by simply placing the condenser dial of the tester at a different setting and repeating the test outlined above. A precaution which must be observed is to keep the leads from the oscillator to the receiver well separated and well away from metallic parts, otherwise untrue results will be experienced. This is particularly true with short wavelength (high-frequency) readings.

This tester may also be used as a source of high-frequency oscillations for many different tests by simply attaching a short piece of wire to the "stator" binding post for an antenna and connecting the "rotor" binding post to ground. Manufactured by the Taylor Electric Company, Madison, Wisconsin. Price $32.50.

RADIO SET TESTER

WHEN a service man or a radio experimenter has to diagnose trouble in a radio receiver, he needs certain instruments and meters for the purpose. If these instruments and meters are individual pieces of apparatus, he will need a number of them. They are bulky and a good deal of time is wasted in making connections. The new Weston No. 519 set tester gives a combination of instruments in a compact form, which permits of easy operation and a considerable saving of time. All routine tests can be made on sets, tubes, and other accessories, with very little effort and a minimum number of connections.

Only one meter is used in the test kit, as shown in the accompanying photograph. This one meter, however, by means of an ingenious switch and a combination of meter scales, can be made to read A, B, and C voltages, and plate current, besides being able to check open or closed circuits. For testing tubes a socket is provided, and connections are made directly to the set by means of a cable and a plug arrangement which, by means of adapters, can be plugged into any type socket in the receiving set.

By simply placing the plug in one of the receiver sockets and manipulating the switch, all of the A, B, and C voltages may be read. This switch is of the double-contact type; that is, for each connection, both sides of the line are opened or closed, as the case may be. This prevents interconnections which might possibly cause some trouble. The switch is marked in the following manner:

(1) "OPEN." The meter is entirely disconnected from the cable or binding posts and is in the starting position.

(2) "VM. B.P." There are three binding posts at the right-hand side. With the switch in this position the meter is not connected with the cable but may be used by placing leads on the binding posts. By connecting between the minus binding post and the center one of the three, voltages up to 8 may be measured, while, by connecting between the minus post and the top one, voltages up to 200 may be read, thus giving the operator a simple double-range voltmeter.

(3) "C A-REV." This point on the switch gives the C-battery voltage (with plug in receiver) on a reversed socket. Some receivers have the filament connections on the socket reversed. While this condition does not affect the operation of the receiver it would make the d.c. meter read backward unless provision was made for it. The voltage as read on the 8-volt scale should be multiplied by 10.

(4) "C." This point on the switch gives the C-voltage reading when the socket is connected in the standard manner.

(5) "B." This point gives the voltage of the B battery at the socket and is read on the 200-volt scale.

(6) "PLATE MA." With a tube inserted in the socket of the tester and the cable connected to the receiver, the meter will read the plate current taken by the tube on the 200-volt scale. The reading on this scale should be divided by 10. That is, if the meter read 80, it would really indicate 8 mA.

(7) "A." This point on the switch connects the meter to the filament connections on the socket and gives A voltage on the 8-volt scale.

(8) "A-REV." Gives the A voltage if the socket happens to be reversed as mentioned above.

(9) "OPEN." This is the same as the "open" position in No. 1. The switch may be placed in either No. 1 or No. 9 position thus making it immaterial in which direction the switch is turned in starting a test.

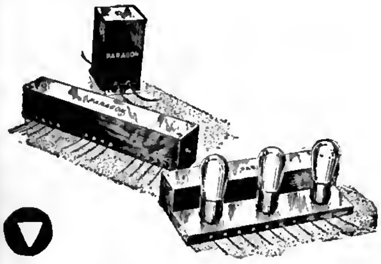
In making tests, the plug is placed in one of the sockets of the receiver, the rest of the tubes remaining in their respective places. The batteries are left connected. The switch is then manipulated and the A, B, and C battery voltages read. If no reading is obtained, an open circuit is indicated. The tube may then be placed in the tester socket and its plate current determined.

A simple test is provided for tubes. A small button at the center bottom of the test panel is pressed. This places a zero grid bias on the tube. The difference in plate current reading with the button up or down indicates the worth of the tube. The difference can be compared directly with a table accompanying the tester.

All in all, any test on tubes, batteries, or receivers can be made quickly and definitely without loss of time with this instrument and it should recommend itself strongly to those who have to handle radio receivers in trouble. Manufactured by the Weston Electrical Instrument Corporation, of Newark, New Jersey. Price $75.00

RADIO BROADCAST Photograph

WESTON RADIO SET TESTER



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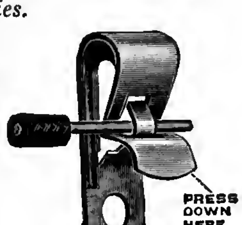

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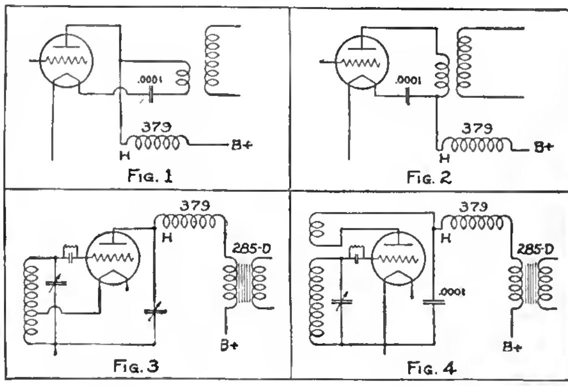

The figures in the above diagram show the more common uses for the Type 379 Radio Frequency Choke.

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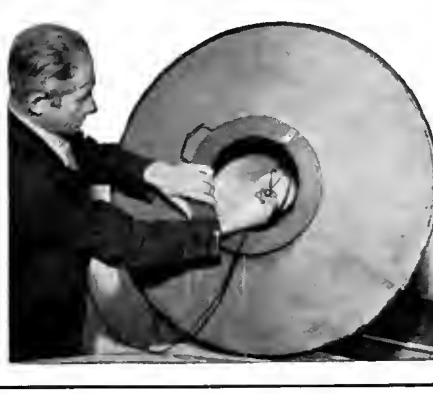

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11. RESISTANCE COUPLING—Resistors and their application to audio amplification, with circuit diagrams. DEJUR PRODUCTS COMPANY.

12. DISTORTION AND WHAT CAUSES IT—Hook-ups of resistance-coupled amplifiers with standard circuits. ALLEN-BRADLEY COMPANY.

15. B-ELIMINATOR AND POWER AMPLIFIER—Instructions for assembly and operation using Raytheon tube. GENERAL RADIO COMPANY.

15a. B-ELIMINATOR AND POWER AMPLIFIER—Instructions for assembly and operation using an R. C. A. rectifier. GENERAL RADIO COMPANY.

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17. BAKELITE—A description of various uses of bakelite in radio, its manufacture, and its properties. BAKELITE CORPORATION.

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20. AUDIO AMPLIFICATION—A booklet containing data on audio amplification together with hints for the constructor. ALL AMERICAN RADIO CORPORATION.

21. HIGH-FREQUENCY DRIVER AND SHORT-WAVE WAVEMETER—Constructional data and application. BURGESS BATTERY COMPANY.

46. AUDIO-FREQUENCY CHOKES—A pamphlet showing positions in the circuit where audio-frequency chokes may be used. SAMSON ELECTRIC COMPANY

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49. BYPASS CONDENSERS—A description of the manufacture of bypass and filter condensers. LESLIE F. MUTER COMPANY.

50. AUDIO MANUAL—Fifty questions which are often asked regarding audio amplification, and their answers. AMERTRAN SALES COMPANY, INCORPORATED.

51. SHORT-WAVE RECEIVER—Constructional data on a receiver which, by the substitution of various coils, may be made to tune from a frequency of 16,660 kc. (18 meters) to 1999 kc. (150 meters). SILVER-MARSHALL, INCORPORATED.

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62. RADIO-FREQUENCY AMPLIFICATION—Constructional details of a five-tube receiver using a special design of radio-frequency transformer. CAMFIELD RADIO MANUFACTURING COMPANY.

63. FIVE-TUBE RECEIVER—Constructional data on building a receiver. AERO PRODUCTS, INCORPORATED.

64. AMPLIFICATION WITHOUT DISTORTION—Data and curves illustrating the use of various methods of amplification. ACME APPARATUS COMPANY.

65. RADIO HANDBOOK—A helpful booklet on the functions, selection, and use of radio apparatus for better reception. BENJAMIN ELECTRIC MANUFACTURING COMPANY.

66. SUPER-HETERODYNE—Constructional details of a seven-tube set. G. C. EVANS COMPANY.

70. IMPROVING THE AUDIO AMPLIFIER—Data on the characteristics of audio transformers, with a circuit diagram showing where chokes, resistors, and condensers can be used. AMERICAN TRANSFORMER COMPANY.

71. DISTORTIONLESS AMPLIFICATION—A discussion of the resistance-coupled amplifier used in conjunction with a transformer, impedance, or resistance input stage. Amplifier circuit diagrams and constants are given in detail for the constructor. AMSCO PRODUCTS INCORPORATED.

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86. SHORT-WAVE RECEIVER—A booklet containing data on a short-wave receiver as constructed for experimental purposes. THE ALLEN D. CARDWELL MANUFACTURING CORPORATION.

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93. B-SOCKET POWER—A booklet giving constructional details of a socket-power device using either the BH or 313 type rectifier. NATIONAL COMPANY, INCORPORATED.

94 POWER AMPLIFIER—Constructional data and wiring diagrams of a power amplifier combined with a B-supply unit are given. NATIONAL COMPANY, INCORPORATED.

ACCESSORIES

22. A PRIMER OF ELECTRICITY—Fundamentals of electricity with special reference to the application of dry cells to radio and other uses. Constructional data on buzzers, automatic switches, alarms, etc. NATIONAL CARBON COMPANY.

23. AUTOMATIC RELAY CONNECTIONS—A data sheet showing how a relay may be used to control A and B circuits. YAXLEY MANUFACTURING COMPANY.

25. ELECTROLYTIC RECTIFIER—Technical data on a new type of rectifier with operating curves. KODEL RADIO CORPORATION.

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27. DRY-CELL BATTERY CAPACITIES FOR RADIO TRANSMITTERS—Characteristic curves and data on discharge tests. BURGESS BATTERY COMPANY.

28. B BATTERY LIFE—Battery life curves with general curves on tube characteristics. BURGESS BATTERY COMPANY.

29. HOW TO MAKE YOUR SET WORK BETTER—A non-technical discussion of general radio subjects with hints on how reception may be bettered by using the right tubes. UNITED RADIO AND ELECTRIC CORPORATION.

30. TUBE CHARACTERISTICS—A data sheet giving constants of tubes. C. E. MANUFACTURING COMPANY.

31. FUNCTIONS OF THE LOUD SPEAKER—A short, non-technical general article on loud speakers. AMPLION CORPORATION OF AMERICA.

32. METERS FOR RADIO—A catalogue of meters used in radio, with connecting diagrams. BURTON-ROGERS COMPANY.

33. SWITCHBOARD AND PORTABLE METERS—A booklet giving dimensions, specifications, and shunts used with various meters. BURTON-ROGERS COMPANY.

34. COST OF B BATTERIES—An interesting discussion of the relative merits of various sources of B supply. HARTFORD BATTERY MANUFACTURING COMPANY.

35. STORAGE BATTERY OPERATION—An illustrated booklet on the care and operation of the storage battery. GENERAL LEAD BATTERIES COMPANY.

36. CHARGING A AND B BATTERIES—Various ways of connecting up batteries for charging purposes. WESTINGHOUSE UNION BATTERY COMPANY.

37. CHOOSING THE RIGHT RADIO BATTERY—Advice on what dry cell battery to use; their application to radio, with wiring diagrams. NATIONAL CARBON COMPANY.

53. TUBE REACTIVATOR—Information on the care of vacuum tubes, with notes on how and when they should be reactivated. THE STERLING MANUFACTURING COMPANY.

54. ARRESTERS—Mechanical details and principles of the vacuum type of arrester. NATIONAL ELECTRIC SPECIALTY COMPANY.

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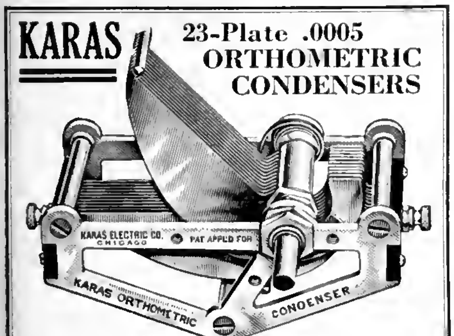

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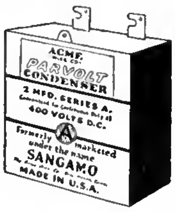

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68. Chemical Rectifier—Details of assembly, with wiring diagrams, showing how to use a chemical rectifier for charging batteries. Cleveland Engineering Laboratories Company.
69. Vacuum Tubes—A booklet giving the characteristics of the various tube types with a short description of where they may be used in the circuit. Radio Corporation of America.
77. Tubes—A booklet for the beginner who is interested in vacuum tubes. A non-technical consideration of the various elements in the tube as well as their position in the receiver. Cleartron Vacuum Tube Company.
87. Tube Tester—A complete description of how to build and how to operate a tube tester. Burton-Rogers Company.
91. Vacuum Tubes—A booklet giving the characteristics and uses of various types of tubes. This booklet may be obtained in English, Spanish, or Portuguese. DeForest Radio Company.
92. Resistors for A. C. Operated Receivers—A booklet giving circuit suggestions for building a. c. operated receivers, together with a diagram of the circuit used with the new 400-millampere rectifier tube. Carter Radio Company.
97. High-Resistance Voltmeters—A folder giving information on how to use a high-resistance voltmeter, special consideration being given the voltage measurement of socket-power devices. Westinghouse Electric & Manufacturing Company.

Miscellaneous

38. Log Sheet—A list of broadcasting stations with columns for marking down dial settings. U. S. L. Radio, Incorporated.
41. Baby Radio Transmitter of 9xh-9ek—Description and circuit diagrams of dry-cell operated transmitter. Burgess Battery Company.
42. Arctic Radio Equipment—Description and circuit details of short-wave receiver and transmitter used in Arctic exploration. Burgess Battery Company.
43. Short-Wave Receiver of 9xh-9ek—Complete directions for assembly and operation of the receiver. Burgess Battery Company.
44. Aluminum for Radio—A booklet containing much radio information with hook-ups of basic circuits, with inductance-capacity tables and other pertinent data. Aluminum Company of America.
45. Shielding—A discussion of the application of shielding in radio circuits with special data on aluminum shields. Aluminum Company of America.
58. How to Select a Receiver—A commonsense booklet describing what a radio set is, and what you should expect from it, in language that any one can understand. Day-Fan Electric Company.
67. Weather for Radio—A very interesting booklet on the relationship between weather and radio reception, with maps and data on forecasting the probable results. Taylor Instrument Companies.
73. Radio Simplified—A non-technical booklet giving pertinent data on various radio subjects. Of especial interest to the beginner and set owner. Crosley Radio Corporation.
74. The Experimenter—A monthly publication which gives technical facts, valuable tables, and pertinent information on various radio subjects. Interesting to the experimenter and to the technical radio man. General Radio Company.
75. For the Listener—General suggestions for the selecting, and the care of radio receivers. Valley Electric Company.
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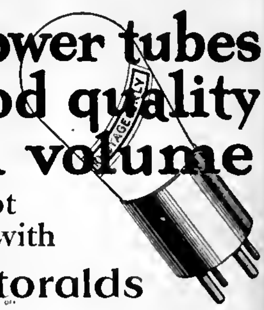

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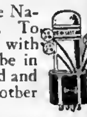

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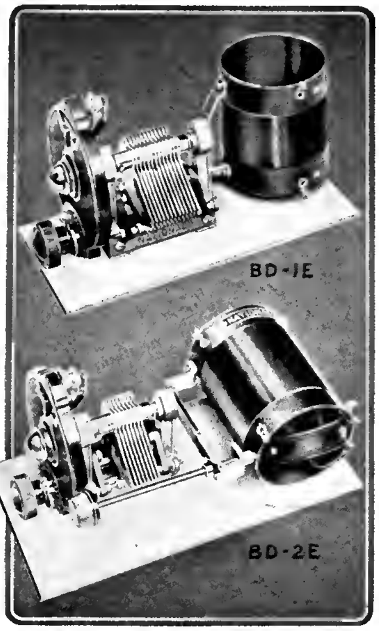

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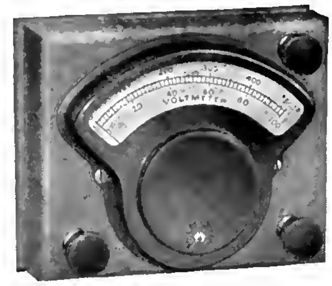

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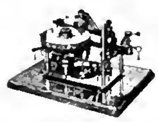

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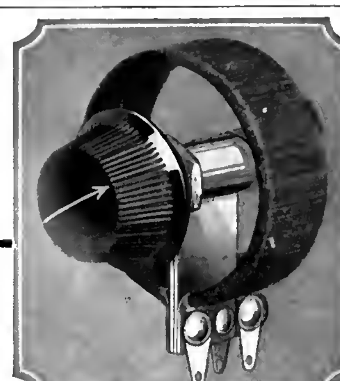

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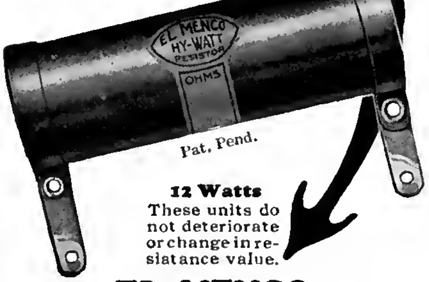

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What Kit Shall I Buy?

THE list of kits herewith is printed as an extension of the scope of the Service Department of Radio Broadcast. *It is our purpose to list here the technical data about kits on which information is available. In some cases, the kit can be purchased from your dealer complete; in others, the descriptive booklet is supplied for a small charge and the parts can be purchased as the buyer likes. The Service Department will not undertake to handle cash remittances for parts, but when the coupon on page 191 is filled out, all the information requested will be forwarded.*

201. SC Four-Tube Receiver—Single control. One stage of tuned radio frequency, regenerative detector, and two stages of transformer-coupled audio amplification. Regeneration control is accomplished by means of a variable resistor across the tickler coil. Standard parts; cost approximately $58.85.

202. SC-II Five-Tube Receiver—Two stages of tuned radio frequency, detector, and two stages of transformer-coupled audio. Two tuning controls. Volume control consists of potentiometer grid bias on r.f. tubes. Standard parts cost approximately $60.35.

203. "HI-Q" Kit—A five-tube tuned radio-frequency set having two radio stages, a detector, and two transformer-coupled audio stages. A special method of coupling in the r.f. stages tends to make the amplification more nearly equal over the entire band. Price $63.05 without cabinet.

204. R. G. S. Kit—A four-tube inverse reflex circuit, having the equivalent of two tuned radio-frequency stages, detector, and three audio stages. Two controls. Price $69.70 without cabinet.

205. Pierce Airo Kit—A six-tube single-dial receiver; two stages of radio-frequency amplification, detector, and three stages of resistance-coupled audio. Volume control accomplished by variation of filament brilliancy of r.f. tubes or by adjusting compensating condensers. Complete chassis assembled but not wired costs $42.50.

206. H & H-T. r. f. Assembly—A five-tube set; three tuning dials, two steps of radio frequency, detector, and 2 transformer-coupled audio stages. Complete except for baseboard, panel, screws, wires, and accessories. Price $35.00.

207. Premier Five-Tube Ensemble—Two stages of tuned radio frequency, detector, and two steps of transformer-coupled audio. Three dials. Parts assembled but not wired. Price complete, except for cabinet, $35.00.

208. "Quadraformer VI"—A six-tube set with two tuning controls. Two stages of tuned radio frequency using specially designed shielded coils, a detector, one stage of transformer-coupled audio, and two stages of resistance-coupled audio. Gain control by means of tapped primaries on the r.f. transformers. Essential kit consists of three shielded double-range "Quadraformer" coils, a selectivity control, and an "Ampitrol," price $17.50. Complete parts $70.15.

209. Gen-Ral Five-Tube Set—Two stages of tuned radio frequency, detector, and two transformer-coupled audio stages. Volume is controlled by a resistor in the plate circuit of the r.f. tubes. Uses a special r.f. coil ("Duo-Former") with figure eight winding. Parts mounted but not wired, price $37.50.

210. Bremer-Tully Power-Six—A six-tube, dual-control set: three stages of neutralized tuned radio frequency, detector, and two transformer-coupled audio stages. Resistances in the grid circuit together with a phase shifting arrangement are used to prevent oscillation. Volume control accomplished by variation of B potential on r.f. tube. Essential kit consists of four r.f. transformers, two dual condensers, three small condensers, three choke coils, one 500,000-ohm resistor, three 1500-ohm resistors, and a set of color charts and diagrams. Price $41.50.

211. Bruno Drum Control Receivers—How to apply a drum tuning unit to such circuits as the three-tube regenerative receiver, four-tube Browning-Drake, five-tube Diamond-of-the-Air, and the "Grand" 6.

212. Infradyne Amplifier—A three-tube intermediate-frequency amplifier for the super-heterodyne and other special receivers, tuned to 3490 kc. (86 meters). Price $25.00.

213. Radio Broadcast "Lab" Receiver—A four-tube dual-control receiver with one stage of Rice neutralized tuned-radio frequency, regenerative detector (capacity controlled), and two stages of transformer-coupled audio. Approximate price, $78.15.

214. LC-27—A five-tube set with two stages of tuned-radio frequency, a detector, and two stages of transformer-coupled audio. Special coils and special means of neutralizing are employed. Output device. Price $85.20 without cabinet.

215. Loftin-White—A five-tube set with two stages of radio frequency, especially designed to give equal amplification at all frequencies, a detector, and two stages of transformer-coupled audio. Two controls. Output device. Price $85.10.

216. K.H.-27—A six-tube receiver with two stages of neutralized tuned radio frequency, a detector, three stages of choke-coupled audio, and an output device. Two controls. Price $86.00 without cabinet.

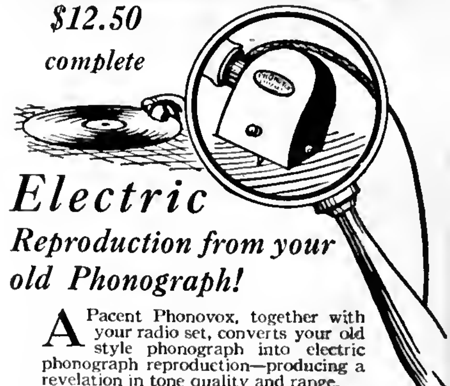
217. Aero Short-Wave Kit—Three plug-in coils designed to operate with a regenerative detector circuit and having a frequency range of from 19,990 to 2306 kc. (15 to 130 meters). Coils and plug only, price $12.50.

218. Diamond-of-the-Air—A five-tube set having one stage of tuned-radio frequency, a regenerative detector, one stage of transformer-coupled audio, and two stages of resistance-coupled audio. Volume control through regeneration. Two tuning dials.

219. Norden-Hauck Super 10—Ten tubes; five stages of tuned radio frequency, detector, and four stages of choke- and transformer-coupled audio frequency. Two controls. Price $291.40.

220. Browning-Drake—Five tubes; one stage tuned radio frequency (Rice neutralization), regenerative detector (tickler control), three stages of audio (special combination of resistance- and impedance-coupled audio). Two controls.

$12.50 complete



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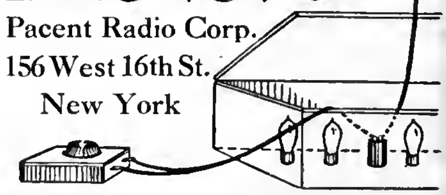

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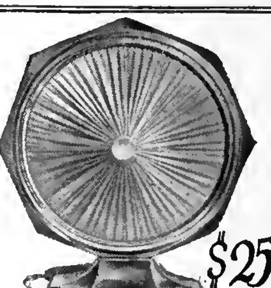

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TECHNICAL INFORMATION INQUIRY BLANK

Technical Service,
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GENTLEMEN:

Please give me fullest information on the attached questions. I enclose a stamped addressed envelope.

☐ I am a subscriber to RADIO BROADCAST, and therefore will receive this information free of charge.

☐ I am not a subscriber and enclose $1 to cover cost of the answer.

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Sterling

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Sterling indicator makes this unit adjustable to point of highest operating efficiency and lowest power cost.

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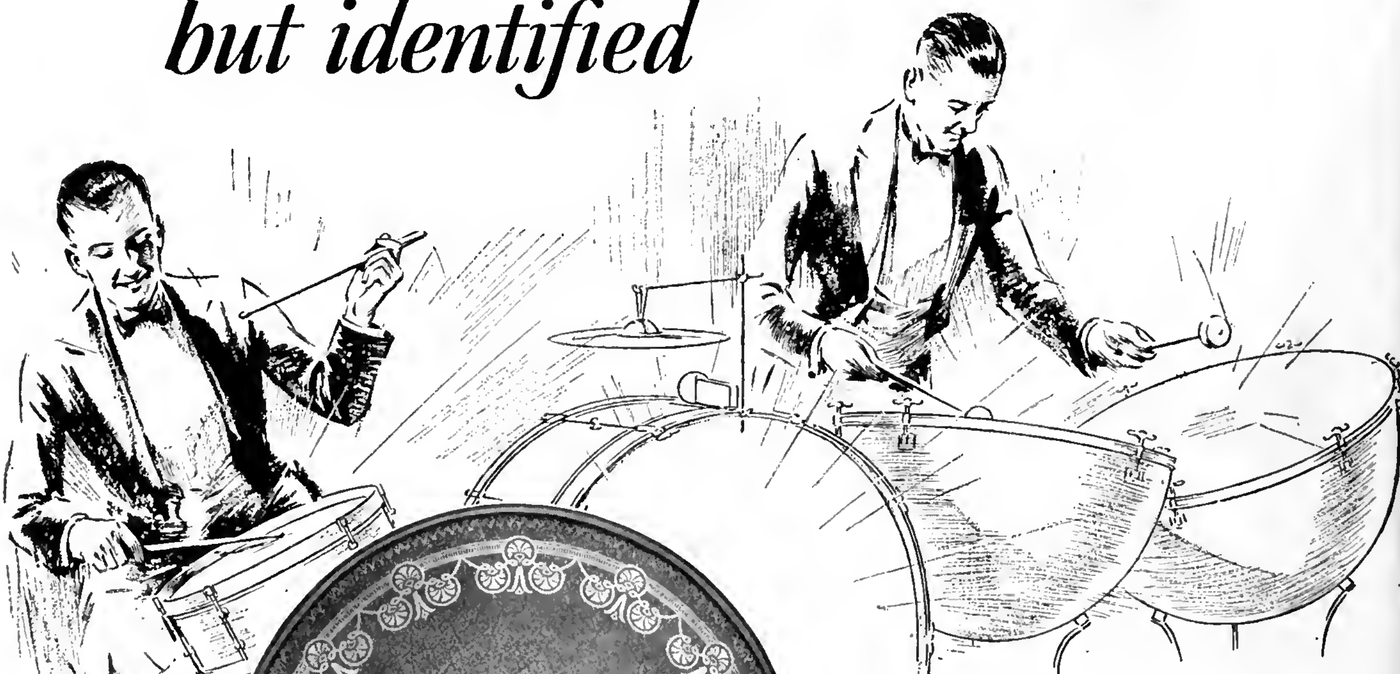

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Recent court decisions now greatly clarify radio patent situation

Ever since Crosley entered the radio field their methods and developments have created a leading place for Crosley radio receivers.

And now—completely available to Crosley—and amplifying Crosley supremacy in fullest measure, are the enormous resources, discoveries and ideas, embodied in patents of the Radio Corporation of America, The Westinghouse Co., The General Electric Co., and The American Telephone and Telegraph Co.—under which Crosley is now licensed to manufacture.

No wonder the new Crosley receivers are in the forefront, their amazing efficiency acknowledged and demanded by that section of the radio trade which insists on the latest and best at all times.

THE "BANDBOX"

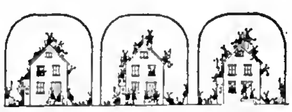
It is a new 6-tube set of astonishing sensitiveness.

Many exceptional features commend the "Bandbox."

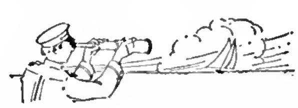
The metal outside case, 'tho keeping out strong local signals effectually enough, did not fully satisfy Crosley ideals of fine radio reception. Signals must be kept in order *inside the set.*

Coils and condensers are like families living in a row of houses with no fences between. The children run around the yards; they meet, mix it up, quarrel and squabble. No harmony.

Magnetic and electric fields are the offspring of coils and condensers. With no fence between, they, too, run around the house, mix it up, quarrel and squabble. Howls and squeals result.



So, to keep each "family" or field of individual coils and condensers separated, metal fences are erected (copper fences for the coils) and the individual parts of the Bandbox are shielded as only found in the highest priced sets.



For fans who love to go cruising for faint, far-away signals the "Acuminators" intensify weak signals like powerful lens revealing distant scenes.

The "Bandbox" employs completely balanced or neutralized radio frequency stages, instead of the common or losser method of preventing oscillation. In presenting this important feature Crosley is exclusive in the field of moderate price radio.

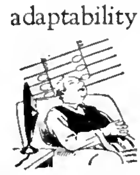
Volume for dancing

Volume control is another big "Bandbox" feature. Signals from powerful local stations can be cut from room filling volume to a whisper.

Each "Bandbox" is fitted with a brown cable containing colored rubber covered leads for power and other connections.

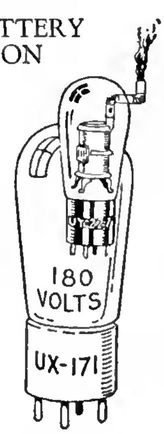
The frosted brown crystaline finish harmonizes with the finest furniture and matches the frames of Musicones and the casing of the power unit. The bronze escutcheon creates an artistic control panel.

Withal, in the beautiful appearance and modest size of the "Bandbox" is the utmost in adaptability to requirements of interior arrangement or decoration. The outside case is easily and quickly removed for installation in console cabinets.



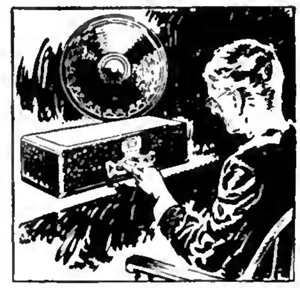
Soft and low thru volume control

AC AND BATTERY OPERATION



The "Bandbox" is built both for battery and AC operation. The new R. C. A.—AC tubes make the operation of the set directly from house current both practical and efficient.

In the AC set the radio stages and the first audio stage use the new R.C.A.—AC—UX-226 tubes. Filaments in these tubes are heated with raw AC current at proper voltage.

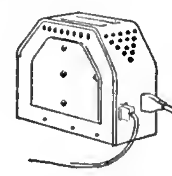


A Master Station Selector, with illuminated dial for shadowy corners, enables tuning for ordinary reception with a single tuning knob.

The UY-227, with indirectly heated emitter, is used with the detector. Power tube UX-171 at 180 volts plate.

There is no AC hum. The new R.C.A. Radiotrons do the work.

The power supply unit is a marvel of radio engineering ingenuity. Half the size of an ordinary "A" storage battery, it supplies A, B and C current direct from lamp socket to tubes.



Models for 25 and 60 cycles. Snap switch shuts down set and power unit completely.

TILT-TABLE MUSICONE
$27.50

Although Musicones improve the reception of almost any radio set they are perfect affinities in finish, beauty and reproductive effectiveness for Crosley Radios. A new model built in the form of a Colonial Tilt-table and finished in brown mahogany stands 3 feet high.

12-inch Ultra Musicone	16-inch Super Musicone
$9.75	$12.75

Write Dept. 20 for Descriptive Literature.

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Crosley Radio is licensed only for Radio Amateur, Experimental and Broadcast Reception.

RCA Radiotrons are supplied at standard prices with each Crosley Receiver. Prices slightly higher west of Rocky Mountains.

THE CROSLEY RADIO CORPORATION

Cincinnati, Ohio — Powel Crosley, Jr., Pres.

RADIO BROADCAST

AUGUST, 1927

WILLIS KINGSLEY WING, Editor

KEITH HENNEY, Director of the Laboratory

EDGAR H. FELIX, Contributing Editor

Vol. XI, No. 4

CONTENTS

Cover Design - - - - - *From a Design by Harvey Hopkins Dunn*

Frontispiece - - - - *The Broadcasting Station at Warsaw* 198

Saving Paper! - - - - - - - - - - - - - *James Millen* 199

The March of Radio - - - - - - *An Editorial Interpretation* 203
- Revolutionary Methods Which Fail to Materialize
- The Commission Regulates Broadcasting for the Broadcasters Not the Listener
- What Commissioner Bellows Thinks About DX Listening
- Never Again Without Radio
- Why We Need More Listeners
- Unsnarling the Patent Tangle
- "Canned" Programs, Good and Bad
- The Month in Radio

Have You a Roberts Reflex? - - - - - - - *John B. Brennan* 208

The Balsa Wood Loud Speaker - - - - *The Laboratory Staff* 211

A Flexible Short-Wave Transmitter - - - *Howard E. Rhodes* 213

The Listeners' Point of View - - - - - - - - *John Wallace* 218
- Radio Is Doing a Good Job in Music
- The "Continuity" Program
- Tolerating Jazz
- Thumb Nail Reviews
- Broadcast Miscellany
- Correspondence

"Strays" from the Laboratory - - - - - - - - - - - - 222
- The "Myracycle"
- The Use of Exponents
- The Telephone Transmission Unit
- Colored Sockets and Bases
- New A. C. Tubes
- New Apparatus Received

Judging Tone Quality - - - - - - - - - - *Edgar H. Felix* 224

Condenser, Coil, Antenna Measurements - - *Keith Henney* 227

A Super-Sensitive Shielded Five-Tube Receiver *Herbert J. Reich, M. S.* 229

Constructing a Five-Tube Neutrodyne - - *Howard E. Rhodes* 232

As the Broadcaster Sees It - - - - - - - - - - *Carl Dreher* 235
- The Future of Television
- Another Broadcast Fatality
- Local Regulation of Broadcasting
- Memoirs of a Radio Engineer, No. XIX

Use of Tubes Having High Amplification - - *A. V. Loughren* 238

"Radio Broadcast's" Laboratory Information Sheets - - - - - 242
- No. 113 Output Circuits
- No. 114 The Transmission Unit
- No. 115 Wave Traps
- No. 116 Static
- No. 117 Super-Heterodynes
- No. 118 Audio Amplifiers
- No. 119 Radio-Frequency Choke Coils
- No. 120 A-Battery Chargers

Manufacturers' Booklets Available - - - - - - - - - - - 248

"Radio Broadcast's" Directory of Manufactured Receivers - - 250

What Kit Shall I Buy? - - - - - - - - - - - - - - - - 254

A Key to Recent Radio Articles - - - - *E. G. Shalkhauser* 255

AMONG OTHER THINGS. . .

RADIO, or at least, its basic principles, be it known, is gradually influencing other fields, and one of the most interesting examples of this is told by James Millen in our leading article this month which describes the ingenious weightmeter developed by Albert Allen of Boston. While the theory of operation of this remarkable device is not complicated, many seemingly insurmountable problems were encountered and conquered before the instrument was practical enough for the strict requirements of commercial use.

A WORD about some of the authors in this issue may be of interest. Herbert G. Reich, whose shielded neutrodyne is described in these pages, is a member of the Department of Physics at Cornell University. A. V. Loughren, whose paper on vacuum tubes appears in this issue, is in the research laboratories of the General Electric Company at Schenectady.

THE Directory of Manufactured Receivers which appears in this number, beginning on page 250, should prove of wide interest. Tabulated data on receiving sets have appeared before, of course, but the information has been sketchy while our Directory is as complete in detail as it is possible to make it. From this listing, it is possible to determine much about the circuit of any receiver listed, how its volume is controlled, how many and what sort of tubes there are and how much current they take, what accessories are supplied and, important enough, the size of the cabinet. What is more, by using the Service Department coupon, more complete or additional information will be forwarded each inquirer with a minimum of trouble to him. The Directory will appear regularly and will be improved each month with additions and corrections. Naturally it has not been possible to include even nearly all the receivers on the market, but we believe that, with the monthly additions, the list will prove an adequate source of information to such as may find it necessary to refer to it.

WE SHALL soon publish a paper by B. F. Miessner, whose work with 2-amp. a.c. tubes has become so well known. There is wide interest in the characteristics and use of these tubes and Mr. Miessner has prepared a very interesting paper indeed. . . . The Laboratory has designed an inexpensive and extremely simple tube tester which for some time has been put to good use out here at Garden City. Complete constructional and operating information about this tester will appear soon.

—WILLIS KINGSLEY WING.

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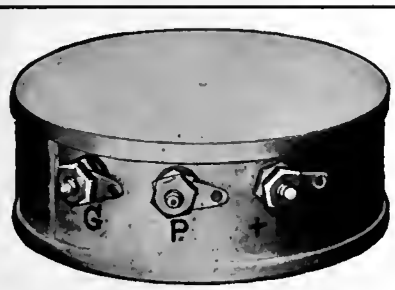

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SICKLES

Diamond-Weave Coils

THE new Sickles Shielded Tuned Radio Transformer prevents both outside and local interference. It is remarkably compact, sharp tuning, sturdy.

Sickles Diamond-weave coils have established an enviable reputation for low distributed capacity, low dielectric losses, and large range of frequency with small variable capacity.

The ideal coil for the Naald Localized Control Tuning Unit and for the Truphonic Catacomb Assembly.

There are Sickles Diamond Weave Coils for all Leading Circuits.

The F. W. Sickles Co.

132 Union Street

SPRINGFIELD, MASS.

COIL PRICES

No. 30	Shielded Transformer	$2.00 each
No. 24	Browning-Drake	7.50 Set
No. 18A	Roberts Circuit	8.00 "
No. 25	Aristocrat Circuit	8.00 "

AmerTran DeLuxe audio transformers are guaranteed to amplify at 80% of their peak at 40 cycles, and their peak is above 10,000 cycles. Made for first and second stages, either type $10.00.

The AmerTran power transformer type PF52, $18.00, and the AmerChoke type 854, $6.00, (illustrated) are designed for use in the construction of power amplifiers to operate with UX-216B and UX-210 tubes at their correct voltages, supplying A, B and C to the last audio, and B and C to the other tubes.

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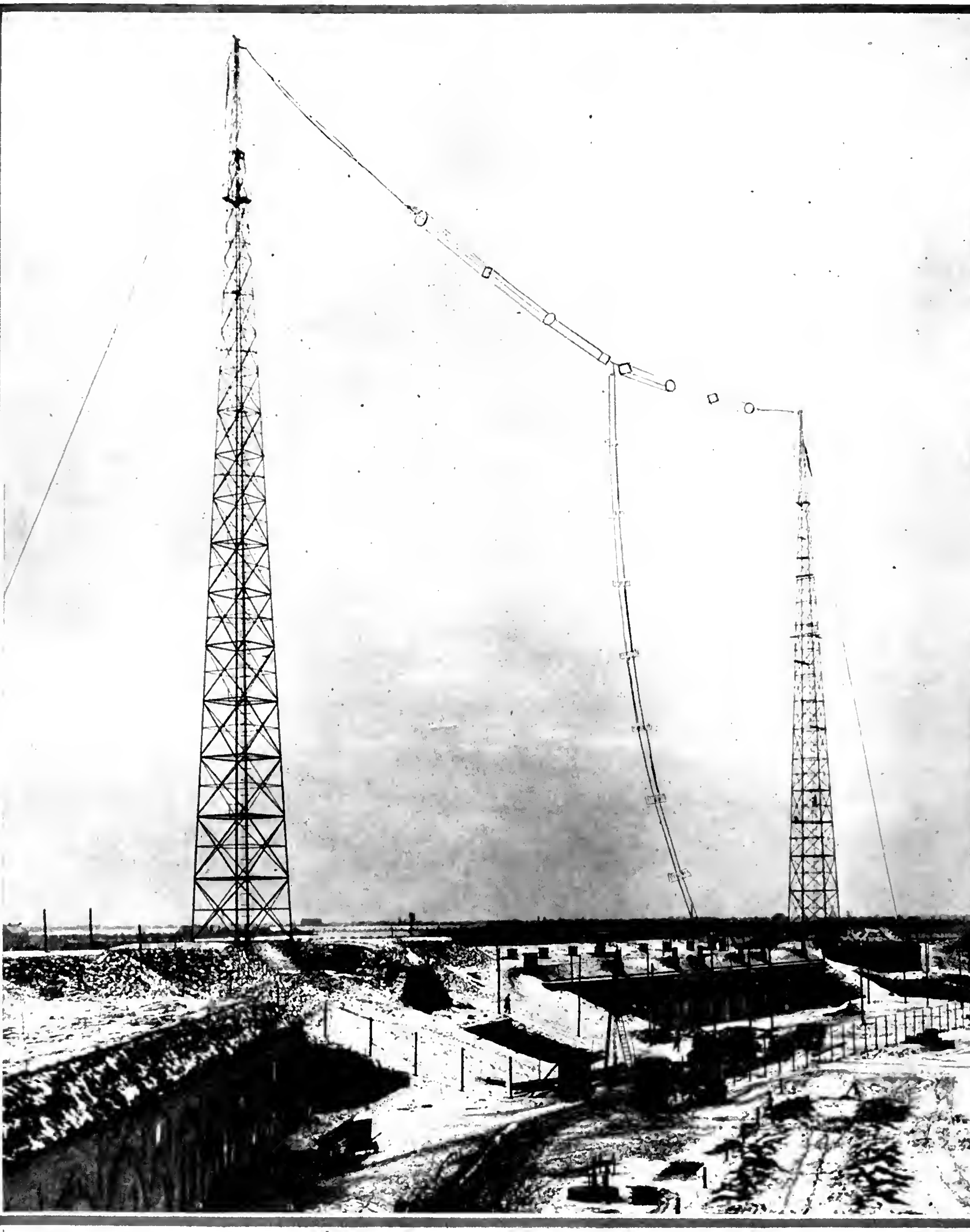


THE BROADCASTING STATION AT WARSAW

Located seven kilometers from Warsaw, this station is installed at Fort Mokotow. The Fort was built twenty-five years ago by the Russians, but has not been used for its original purpose for some years. The power is 8-kw. to the plates of the tubes. The antenna current is 30 amperes on a frequency of 269 kc. (1111.5 meters). The crystal range of the station is said to be 75 miles

RADIO BROADCAST

VOLUME XI — NUMBER 4

AUGUST, 1927

Saving Paper!

Millions of Dollars are Saved Annually in the Paper and Rubber Industries by the Use of a Magic Device Operating With Radio Principles

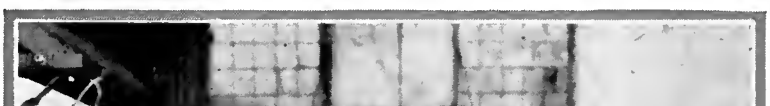
By JAMES MILLEN

WHILE rapidly assuming a deserving place as a separate science in itself, radio is fundamentally a branch of electrical engineering. During the last few years, in which such great strides have been made toward the present-day ideas of perfection, many new scientific theories have been developed. Instead of these developments coming from the parent science, they have come from the engineers and other workers primarily interested in radio. At first, many electrical engineers were wont to consider radio as a mere toy or public plaything not worthy of their attention. Then, as time passed and startling progress in the new field became apparent, well-known electrical engineers began to devote their skill to the furtherance of development in the new field. Where "cut and try" ruled before, calculus and electrical engineering theory began to come to the front. Thus resulted the neutrodyne and many other genuine developments.

But, no sooner had these fatherly gentlemen begun to aid their offsprings in the perfection of a new "toy," than they began to realize that much of the theory involved was not only new and unique, but that it might be applied to their own established science as a panacea for long-endured ills.

Perhaps the first indication the public had of progress along such lines was the press reports of a year or two ago regarding the use made of radio by large electric light and power companies to forewarn them, by means of static disturbances, of approaching thunder showers so that they might be prepared in advance for a sudden increased demand for power for lighting.

But while many such applications of radio principles to industrial use have been and are yet to be made, few indeed are as vitally important and yet seemingly impossible as that conceived some two or three years ago by a Maine man, then working as a cadet engineer in a large paper mill. To-day his devices are in use in paper and rubber mills throughout the country, automatically regulating the uniformity of the mills' sheet products.



THE "RADIO SCALES" IN OPERATION

Albert Allen, inventor of an instrument known as the weightmeter, shows a foreman in the paper mills of the Eastern Manufacturing Company at Bangor, Maine, how to weigh a strip of moving paper without actually touching it. Formerly it was necessary to tear a sample piece for weighing, with an ordinary pair of scales, from the edge of the moving paper

Several years ago, Albert Allen, like many other electrical engineers, realized that maybe there was something practical and worth while to this radio stuff after all.

He constructed a number of receiving sets and did much experimental work with them. One night, while his set was tuned to one of the local broadcasting stations, he took a piece of paper and inserted it between a pair of the plates in one of the tuning condensers that seemed on the point of short-circuiting. The result was that he immediately heard a different station from his loud speaker. Being a true electrical engineer, he realized that such was as might be expected. The paper, because of its different dielectric properties than air, had changed the electrical capacity of the condenser, and likewise the wavelength to which his set was tuned, bringing in a new station.

Later, when at his work in the mill, he stopped to watch the long sheet of new paper passing through numerous rollers and machines in an endless strip. Every little while, the foreman would tear a piece of paper from the strip, mark it, and send it off to the laboratory. Then a report would come back and he would readjust his machine. The purpose of this act was

TESTING THE EFFICACY OF THE WEIGHTMETER

The inventor of this remarkable device, Albert Allen, is to the right of this group in the laboratory. To the left is William Ready, of the National Company, while the author is in the center

to determine the weight per given area of the paper—whether it was up to the required standard, or overweight. If overweight, the company was losing money; if underweight, the customer might refuse to accept.

But just imagine how crude and costly such a process was? The piece torn out might not be representative. The strip was damaged, much time was wasted, and most important of all, all sorts of variations might take place between tests without anyone being any wiser.

Young Allen recalled his experience with his radio set and the piece of paper. Why not, thought he, apply the same principle to providing a continuous, instantaneous, check on the paper conditions. For two years, he devoted his entire time to the problem. At first he experimented alone, then, as success seemed certain, and as the president of the paper mill realized the tremendous value of his idea, he joined with a staff of competent research engineers in the engineering laboratories at Harvard University.

Finally, finished working models were developed to the point where they were considered reliable and practical enough to be installed in the paper mills of the Eastern Manufacturing Company, at Bangor, Maine.

Then came necessary re-design as a result of the information gained under operating conditions. Trouble with dust accumulation, trouble due to variations in temperature causing greater variations in instrument readings than variations in paper weight, trouble due to the tremendous variations in the line voltage from which the instruments were operated—all had to be overcome. Troubles of all kinds were encountered, but even so, the new method was far better than the old.

But every cloud has its silver lining, and it was not long before the difficulties were overcome and the initial idea carried a step further, so that the "weightmeter," as the new instrument was called, not only recorded the variation in weight of the stock being passed through it, but, by means of suitable relays, automatically controlled the paper machines so as to keep the stock at any desired weight.

HOW THE WEIGHTMETER WORKS

SOME may be interested in a more explicit explanation of just how the weightmeter functions—how a minute change in the capacity of an electrostatic condenser can result in the control of a several-horsepower motor operating the calenders in a rubber mill, for instance.

The fundamental principle by which a very minute variation in the electrostatic capacity of a condenser may result in a readily measurable change of current, is illustrated in Fig. 1. Here we have an oscillator, "A," coupled, by means of the coils "B" and "C," to a tuned circuit "D." Tuning the circuit "D" to resonance with the oscillator "A" results in a deflection of the thermal meter "E." By properly arranging the circuit constants, the sensitivity of the weightmeter, or in this case, the response of the thermal meter, to minute capacity changes, can be any desired amount, from the condition illustrated by the peaked curve, "A," in Fig. 2, where even the very slightest capacity change results in a marked current change, to the other extreme condition illustrated by the low broad curve, "B," Fig. 2.

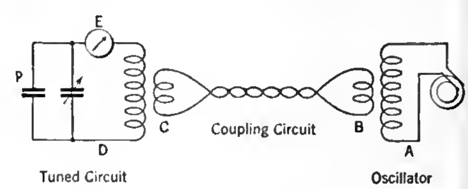


FIG. 1

The radio fan will readily recognize the elementary circuit of the weightmeter to consist of nothing more than an oscillator, wavemeter, and coupling circuit

Now compare the elementary circuit diagram, Fig. 1, with the actual apparatus illustrated in the photograph on page 201. The oscillator "A," coupling circuit "B" and "C," and the tuned circuit "D," are located in the same case. The precision condenser, shown more clearly in a photograph on page 202, is used to tune the circuit

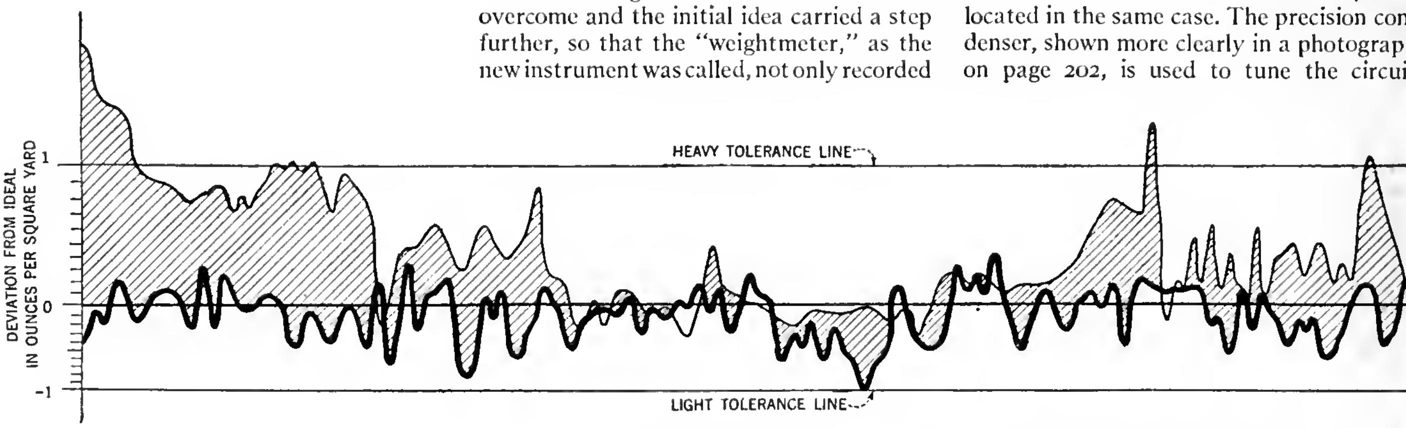


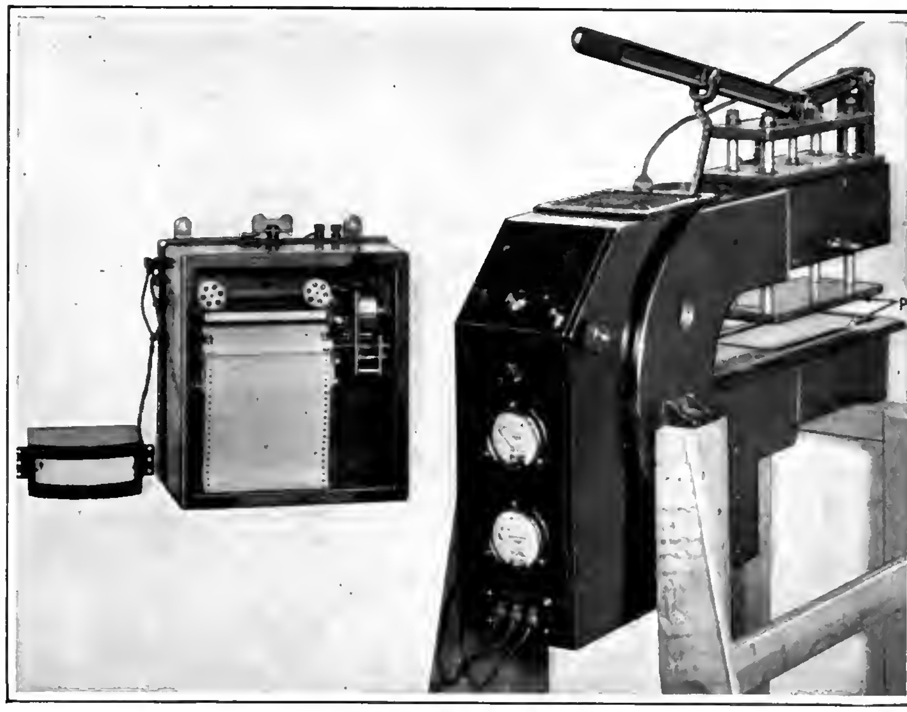
FIG. 3. A VISUAL INDICATION OF THE SAVINGS ACCOMPLISHED—

The straight center line shows the desired thickness of rubber, most economical production resulting from keeping the thickness as closely as possible—be tolerated. The heavy curve was made at a rubber mill when the weightmeter was in use, while the lighter one was made when no weightmeter—

"D" (Fig. 1) into a condition just off resonance. This condition is indicated by the arrow on the side of the curve "A" in Fig. 2. In actual practice, either side of the resonance curve may be employed.

In parallel with the precision variable condenser are two mechanically adjustable plates forming a condenser. These are indicated by the lettering "P," in the photograph and Fig. 1. If the capacitance of this condenser should change, due to a variation in the weight of the paper or other material passing through it, the tuned circuit "D" Fig. 1, either comes more closely into or further out of resonance, depending upon which side of the resonance curve is being used and whether the capacity change is positive or negative, thus changing the reading of the thermal ammeter.

By employing the recording type meter shown alongside the weightmeter in the photograph, a continuous curve may be traced, showing variations in weight of the material with time. A sample curve is shown in Fig. 3. The straight center line indicates the weight desired to be maintained. The light curve shows a rather wide discrepancy between the weight desired and the results obtained by hand feeding and the old method of actual weighing. The heavy curve indicates the results obtained when using a weight meter control. The shaded area between the two sets of curves illustrates the saving in material effected by the new control method. In addition to the actual saving in material, the product is ever so much more uniform. It will be noticed that the "light" tolerance line is nearer the "ideal" line than the "heavy" tolerance line. This variation in the two linear distances, however, does not represent a difference in upper and lower tolerance weights, but is the result of the changing slope of the resonance curve in either direction.



RECORDING METER AND WEIGHTMETER

The recording meter to the left is used to make curves similar to that of Fig. 3. The smaller instrument to the extreme left is an indicating meter, calibrated to read weight in desired units. The material to be weighed passes between the two horizontal invar plates marked "P," to the right. The upper invar plate may be varied when desired by the long handle atop the instrument

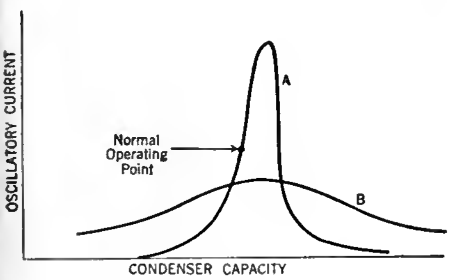


FIG. 2

The sensitivity of the weightmeter may be varied by changing the shape of the resonance curve. With a steep curve, a very minute change in weight of material (and thus condenser capacity) will cause a fairly large change in meter reading

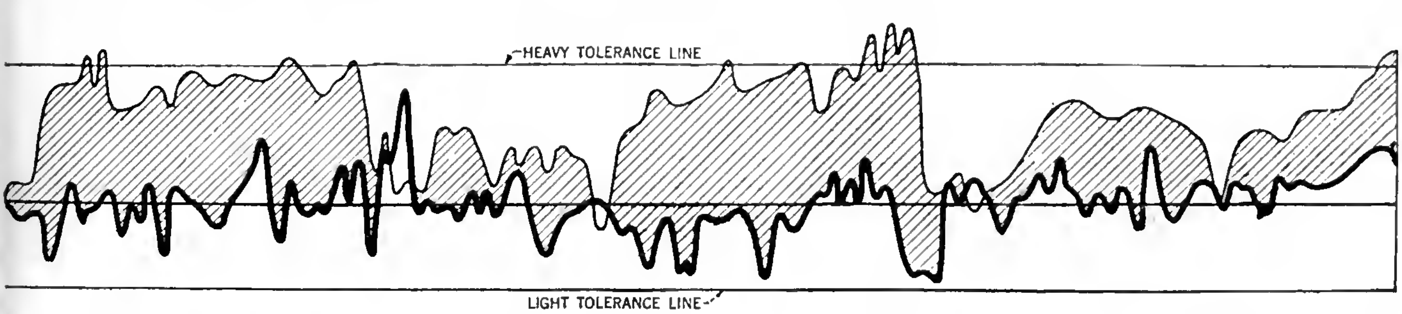
The many irregularities in the two curves in Fig. 3, are due to "feeding." Every time more rubber is fed, the stock tends to gain in weight, even though the calendar adjustments remain unchanged.

The absolute necessity for precision built apparatus cannot be over emphasized. Apparatus so substantial in design, and expertly made, as to hold its calibration under all kinds of abuse, in all kinds of climate and conditions of service, is absolutely essential if any appreciable saving is to accrue from its use.

Hence the massive cast iron frame for the fixed condenser, and also the invar steel rods and supports. If some other metal were to be substituted for the expensive invar, the least variation in temperature of the condenser would change its capacity far more than a little change in weight of the stock being measured. In the earlier weightmeters, compensating thermostatic condensers were used to correct any changes in temperature of the main condenser. Such a system was found, in practice, to be excessively complicated. The result was the design of the present invar steel unit which is not affected by temperature variations.

Another seemingly overwhelming difficulty encountered with the first commercial installation was the tremendous variations in the line voltage from which the oscillator received its power. Fluctuations of as much as 40 or 50 volts were not at all uncommon.

Ballast tubes, separate alternators, line transformers, and many other complicated and expensive remedies were tried. The final solution arrived at, however, was not only superior in performance to the other methods, but required no additional equipment of any type.



—BY THE USE OF THE WEIGHTMETER AT A RUBBER MILL

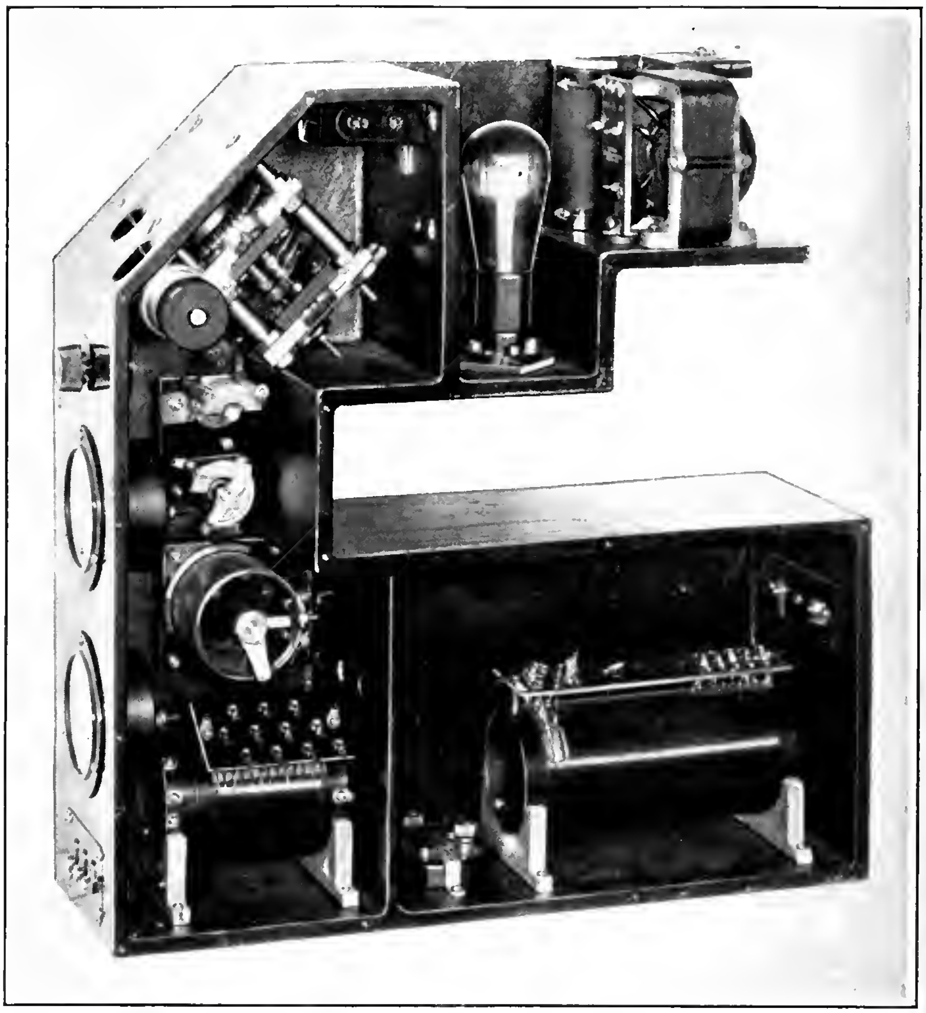
—to this value. The upper and lower horizontal lines show respectively the maximum and minimum deviation in ounces per square yard that can

—was used. The shaded portions represent material saved by the use of the weightmeter. This curve represents 5950 yards of rubber $\frac{1}{20}$" thick

As a power oscillator of the type used in the weightmeter is in reality a miniature radio transmitting station, one might imagine that radio reception in the vicinity of a mill in which the weightmeters are employed would not be all that could be desired. This apparatus, however, in no way interferes with radio reception. The oscillator is tuned to a wavelength slightly in excess of 600 meters so as to be outside of the broadcasting frequency band and, also, the oscillator is so completely shielded that an exceedingly sensitive super-heterodyne located but a hundred yards away is unable to pick up the carrier. The often long exposed leads to the indicating meters do not carry radio-frequency current as the thermal-junction, belonging to each meter, is located within the shielded oscillator cabinet.

Just what the saving amounts to in dollars and cents when the weightmeter is used depends greatly upon the quality and quantity of material being manufactured. Thus, in the production of a low grade of newsprint stock in a low-speed paper making machine, the saving effected per year per machine might be as low as $10,000 or so. On the other hand, where a highly priced stock is being manufactured in a rubber factory, such as tire tread for automobiles, the saving brought about as a result of automatic weightmeter control may be ten times as great.

In one automobile tire factory, the average last year saving per weightmeter employed was approximately $80,000. As this particular rubber company employed many machines, it will be seen that automatic control was of considerable financial benefit, aside from its fundamental purpose of aiding in the making of a uniform product.

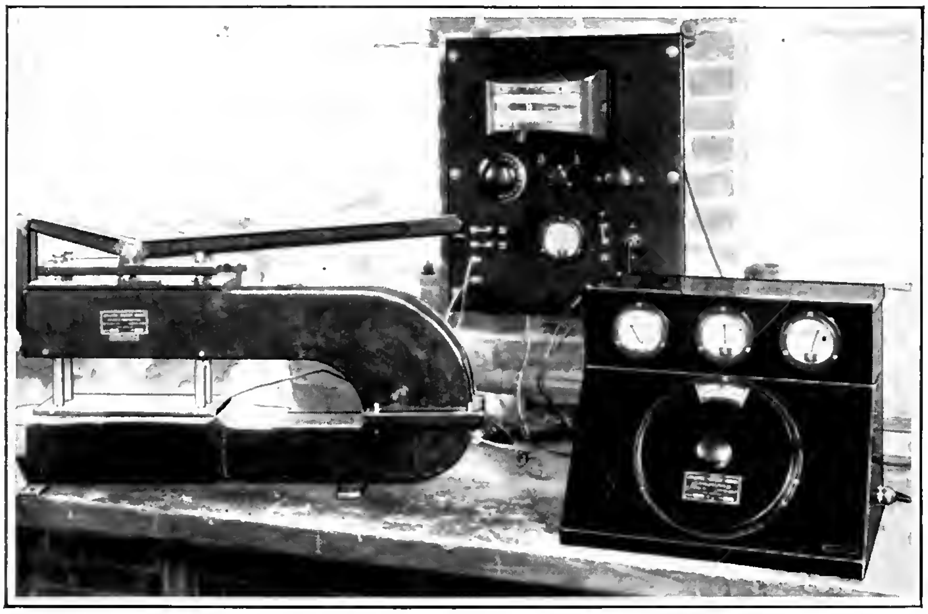


THE INTERIOR OF THE OSCILLATOR BEFORE WIRING

The case is of cast aluminum. The transformer at the upper right supplies A and B power for the UX-210 tube. The precision variable condenser is connected in parallel with the measuring plates and used to bring the tuned circuit to the desired point on the resonance curve

The weightmeter is but one of many applications of radio principles to industrial purposes—principles which, before the advent and recognition of radio broadcasting as a major art, were, perhaps, little understood. That the development of this instrument is not an isolated instance of such progress, we have only to consult our journals for adequate and frequent proof.

The ideas obtained from the radio industry by Albert Allen and so successfully applied toward the elimination of a seemingly almost unsurmountable handicap encountered in the manufacture of paper and rubber—the difficulty of accurately weighing moving objects—is but a vivid example of such progress.



A DIFFERENT SET-UP OF APPARATUS

The equipment is basically the same as that shown in the photograph on the preceding page. The oscillator is the instrument to the right

The March of Radio
News and Interpretation of Current Radio Events

Revolutionary Methods Which Fail to Materialize

ILL-CONSIDERED publicity statements are the bane of the radio industry and the despair of newspaper and magazine publishers. Receiving, as we do, numbers of poorly prepared and inaccurate statements from radio manufacturers in every mail, we plead for mercy, not only to spare our weary eyes but to discourage their harmful influence on the well-being of radio.

Almost each week, a revolutionary invention is heralded in the press to disturb the confidence of the hesitant radio buyer. Many of these inventions are promises never performed; others announce hoary practices and inventions as new discoveries; all of them conspire to discourage the non-technically informed from purchasing his radio to-day in order that he may have the advantages of these doubtful but glorified inventions to-morrow.

In the pile of material before the writer are three announcements from one of the largest manufacturers in the radio and electrical industry. Considering the source of these statements, they would certainly be regarded as authoritative by any newspaper editor who did not possess an extensive background of technical knowledge and an intimate familiarity with the history and progress of the radio art. Since most newspaper men quite properly lack such detailed knowledge of radio, they naturally make much of these extravagant statements, although they belong only in the editor's waste basket.

The first of these statements announces the exponential horn as "a new invention," which received "its first public test" on May 12, 1927. Then follows a glamorous account of the magnificent improvements in tone quality which the "discovery" brings to the world. The statement totally overlooks the fact that the exponential horn, developed ten years ago, has been used in some public address systems long before the first broadcasting station went on the air; that the merits of the exponential horn have been discussed before technical societies time and again; that exponential horns are in use in thousands of homes as a part of the orthophonic phonograph and of certain power loud speakers. But how many potential loud speaker buyers decided, upon reading that statement in the press, to postpone buying a radio or a reproducer until they might have this new horn, said to "broadcast the natural human voice or tones of musical instruments without distortion for the greater part of a mile?"

The second statement deals with the transmission of radio-frequency energy, heralding a new era of wireless transmission of power. It discloses nothing, however, which any amateur having a suitable wavemeter, cannot perform in his own home for the delectation of his friends.

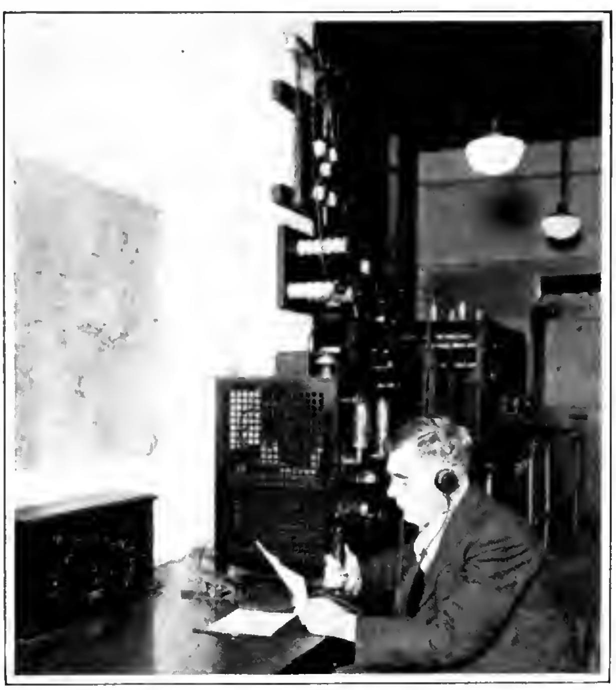
The third effusion by this eminent manufacturer concerns itself with a new system of frequency modulation for broadcasting stations which enables one-half-kc. separation. Approximately 1900 broadcasters can operate simultaneously without sharing waves or splitting time. It is pointed out that this will solve the congestion problem which the Federal Radio Commission is now trying to overcome.

Extraordinary, absurd, and unwarranted claim! The statement entirely neglects the fact that this invention, before it can have any bearing on the work of the Radio Commission, must undergo the following tedious processes:

(1) Laboratory research and development; (2) standardization of transmitters and receivers utilizing the new principle and suited to quantity production; (3) remodeling of every existing broadcast transmitter to one using the new system and (4) the probable replacement or alteration of every existing receiving set for one of the new type receivers at a cost to the listening public of perhaps a billion dollars or so.

Each one of these problems has its share of hazards and pitfalls which those who issued the statement have reason to know as well as anyone. To state that the invention of frequency modulation has any bearing on the solution of present-day broadcasting problems is both absurd and well-nigh malicious, since it encourages small broadcasters, now gradually dying from neglect by the listener, to redouble their expiring efforts to remain on the air.

Some day, the radio industry will learn to restrain its blabbing tongue until it has the goods, ready to sell, on the dealers' shelves. The automobile industry does not announce a new type of car until every dealer all over the country has his demonstrator on hand. Thereby, motor car manufacturers capitalize public interest, aroused



TELEPHONING TO SHIPS AT VANCOUVER, B. C.

The installation in the Vancouver Merchants' Exchange Building, with J. E. Harker, chief operator. More than forty British Columbian tug boats are equipped with 50-watt telephone sets, operating on 1507 kc. (199 meters). Any one aboard ship can operate the sets, the average range of which is from 60 to 150 miles, giving loud speaker volume at the receiving station. The sets are used to facilitate the delivery of lumber being towed down the waterways. Much of this is sold while enroute. It is the only service of its kind in the world and is operated by the radio branch, Department of Marine and Fisheries by their announcements, and convert that interest directly into cash sales. The radio industry, on the other hand, childishly chooses to make its announcements prematurely, thus bringing to an immediate stop any buying activity which may be manifest at the time. Then, months or years later, when it finally has its new product ready for sale, it cannot again stimulate any real public interest because the publicity men have already done their croaking.

The publicity disease has gone too far to be quickly remedied. Some encouragement might be given by a more conservative attitude on the part of newspapers. Instead of accepting as gospel truth the publicity statements offered them, they might first check with their own radio staffs or, in absence of a competent radio staff, take advantage of high-grade radio feature syndicate services which offer them the protection of expert and conservative censorship.

The Commission Regulates Broadcasting for the Broadcasters Not the Listener

THE Federal Radio Commission, still occupying the center of the radio stage, has made its first comprehensive re-allocation, effective June 15. In the congested areas, stations are now separated by at least fifty kc.; time-sharing is enforced upon the lesser stations and some interesting power reductions have been made. These power reductions are announced by the Commission as experimental. We hope that the experiment may soon be concluded and plenty of power be permitted to all our outstanding stations—which is not now altogether the case.

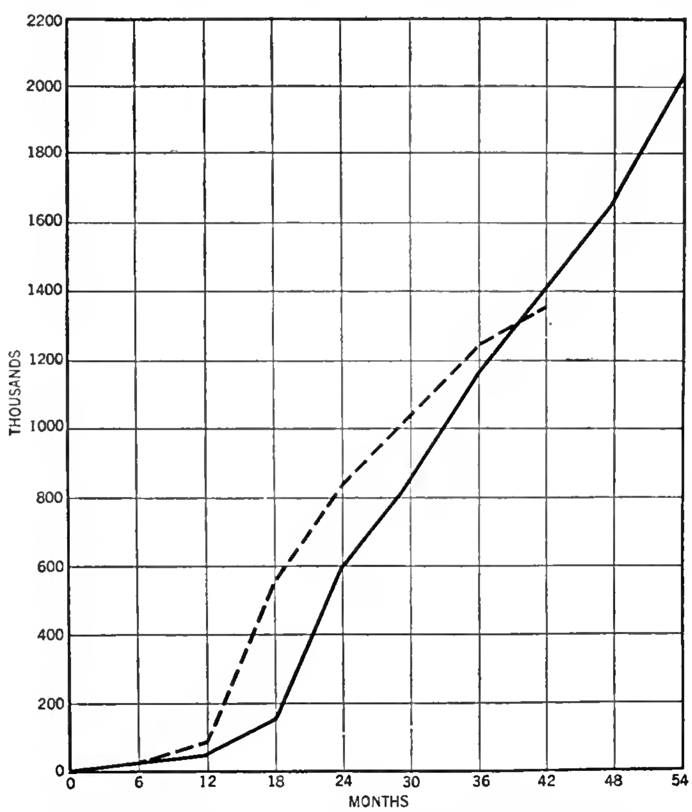
The enforced curtailment of the activities of the lesser stations has transferred much howling from the broadcast listener's receiver to the crowded doors of the Radio Commission. In deciding upon the case of individual stations, service to the public, as determined by program standards, quality of transmission, length of service, and orderly conduct through the late chaos, have been taken into consideration. Clean channels have been given to recognized old-timers and we are pleased to see the principle of priority of service, urged in these columns for more than a year, actually put into practice.

The New York allocation, for example, gives WNYC, WEAF, WJZ, WOR, WHN (with WQAO operating only on Sundays), WMCA (sharing with WEBJ which uses only six hours a week), and WABC (sharing with its own transmitter, WBOQ) practically undivided time. The most popular stations are therefore given a full opportunity to serve their respective audiences which, combined, probably include 90 per cent. of all listeners in the area. In the questionnaire which so many of our readers filled out, considerably more than half the New York listeners expressed themselves identically as to their favorite stations, placing WEAF first, WJZ second, and WOR third, while more than 96 per cent. of the replies included at least one of these three stations among their first, second, and third choices. Only WNYC, which ranked eleventh in popularity, seems to have received curiously favored consideration on the part of the Commission in being included in the list of seven stations with virtually exclusive channels.

A point brought out with striking emphasis by our questionnaire, regarding the stations which have been compelled to divide time four or five ways on the less desirable channels, is that they are nobody's favorites. Some of our readers listed as many as ten "favorite" stations, yet 21 New York stations were not mentioned as favorites by a single listener. These same 21 insignificant stations are most prominent in the listings of stations which the listener wished eliminated, receiving 25 per cent. of the demands for a "permanent signing off." And, mind you, this 25 per cent. does not include such widely disliked stations as WHAP, WKBQ, and WLWL, which three stations alone polled 20 per cent. of the demands for elimination. Hence, the Commission's judgment, in giving the two National Broadcasting chain stations, WEAF and WJZ, and the five independents, WNYC, WOR, WHN, WMCA, and WABC, virtually exclusive channels, is fully justified.

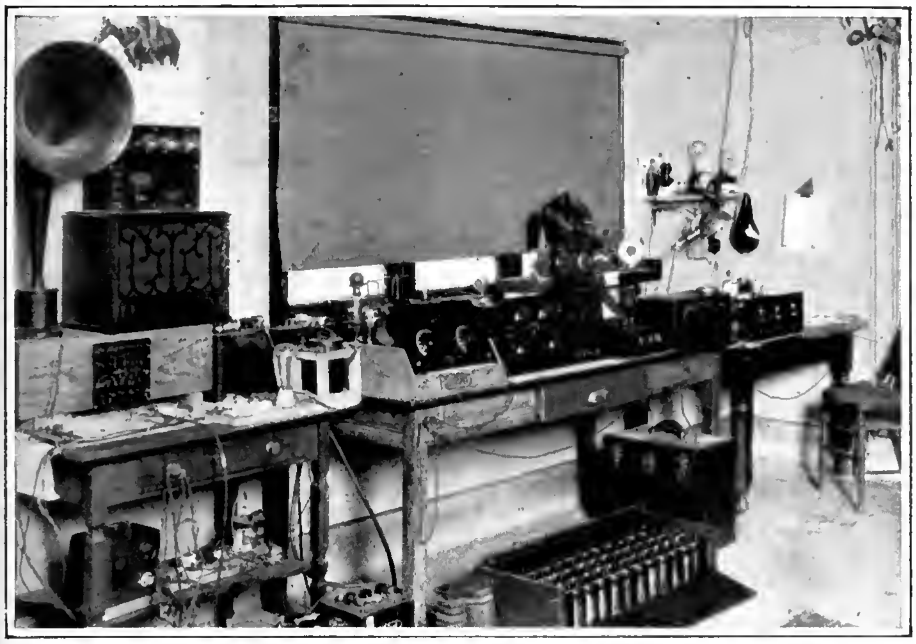
In the Chicago area, KYW is the only station favored with an exclusive channel. Our Chicago readers divided their first choices between KYW and WGN almost to the exclusion of other stations. Station WMAQ is the strongest second choice and WEBH the strongest third, while, strangely enough, neither of these latter two polled a substantial number of first choices. The superior standing of these four stations over all the others in the Chicago area is not, however, recognized by the Commission as in the case of the New York favorites. These four are treated no better than such wholly unpopular stations as WCFL, which is practically tied for first place with WGES in the demands for stations to be eliminated, and WJAZ, running a strong third in the unpopularity contest because of the prejudices aroused by its leadership in upsetting broadcasting conditions. It seems that the only discrimination made in the Chicago area, in deciding whether a station should divide time two, three, or more ways, is power and not service to the listener.

Considering the national situation as a whole, many assignments have been made which are impossible. Let us examine a few frequencies. The first on the list is 550 kc., shared by KSD and WMAK, the latter's 750-watt carrier certainly being sufficiently strong to cause serious interference with the former, at least in winter. The next channel, 560 kc., finds WNYC in the same bed with WHO, 5000 watts, which very likely will cause a steady whistle in New York. At 580 kc., we find an untenable assignment, WMC, Memphis, Tennessee, and WCAE, Pittsburgh, both 500-watt stations. The popular Philadelphia stations, WOO and WIP, must contend with a thousand-watt station, WOW, in Omaha, Nebraska, which probably limits the range of the former stations to their limited high-grade service area only. Two Baltimore stations, WCAO and WCBM, will not find WMBF's carrier, which pumps strongly into their locality, any improvement on their programs; nor will WCSH, the principal reliance of a large New England area, find its programs favorably affected by WSAI's powerful carrier. Unless WEW is sharing time with WOC, we cannot understand how either St. Louis, Missouri, or Davenport, Iowa, can be expected to enjoy its best local station with another powerful and nearby station sharing the 850-kc. channel. Nor can a listener enjoy WKRC's program in Cincinnati with WBZ, only six hundred miles to the east, sending its 15,000-watt carrier out on the same frequency. Station KMOX will



GROWTH OF LISTENERS IN ENGLAND AND GERMANY

The two curves, the plain one representing England and the dotted one Germany, show how licenses were issued for the reception of broadcast matter in those countries. A period of four and a half years is considered



A CORNER OF THE BUTTE, MONTANA, RADIO CLUB ROOMS

Among the complete equipment there is a broadcast receiver, a long-wave Reinatz receiver, a 50-watt short-wave transmitter using the call 7NT, and several short-wave receivers. The president of the Club is Judge W. E. Carroll; C. J. Trauerman is publicity director, M. E. Cooper, secretary, and J. R. Bartlett is vice president

probably sound like old times with WBAK in Harrisburg, Pennsylvania, on the air at the same time on the same frequency.

But, enough of this; all *local* heterodyning and cross-talk have been eliminated. Heterodyning carriers from distant stations will not cause serious annoyance during the summer, because of attenuation of the carrier. But these June 15 assignments leave us far from a solution of the broadcasting problem.

One might conclude that the Radio Commission has failed in its duty of regulating broadcasting in the interests of the listener because, on the face of things, it has fallen far short of eliminating the heterodyne squeal entirely. The Radio Commission has done the best possible job of trying to put a carload of apples into a bushel basket. No matter how you juggle some 600 stations, many of considerable power, they cannot be accommodated on the broadcast band without heterodyning. We have preached the doctrine of station elimination consistently because it is the only practicable answer to the problem. The number of stations must be reduced to 200 or 225 so that the listener may have clear programs no matter where he is located. The only alternative is to cut the power of 400 to 450 stations to 50 watts and allocate only 75 or 100 stations to favored channels.

The Commission has elected to avoid the closing of any station, presumably because it does not care to have its prerogatives tested in the courts. It realizes that one successful injunction would bring chaos even worse than that of the last season and, with it, the actual bankruptcy of the entire industry. The broadcasters have already shown that they act like small boys when the teacher is away—if the slightest fetters are placed upon the regulatory power. So the Commission is proceeding to do the impossible, namely, to accommodate the host of broadcasting stations in a frequency band which cannot hope to accommodate half of them properly; in effect, it is ruling broadcasting for the benefit of the broadcasting stations rather than for the broadcast listener.

If the Radio Commission must wear gloves, we wish they would choose boxing gloves and hand out a few knockout blows.

What Commissioner Bellows Thinks About DX Listening

COMMISSIONER Bellows is credited with saying that DX listening must be abandoned. The DX listener is frequently scored by the radio engineers, particularly those who have an appreciation of good tonal quality. They realize, as does everyone who secures really good quality, that the range limit of high-quality reception for a 500-watt station is some thirty miles and, for a 50,000-watt station, one hundred miles. Anything beyond this distance the engineer considers DX reception and frowns upon as unnecessary.

It is not generally realized, however, that these frowns shadow nearly 80 per cent. of the area of the United States! Only about 20 per cent. of our area lies within the high-quality reception range of any broadcasting station! If the radio business and the radio listeners of 80 per cent. of the United States are of no account, it is fair to set down DX listening as of no value.

Fortunately, the engineers do not rule the world. Some listeners are willing to listen to a station three or four hundred miles distant in spite of them. Indeed, a great many are compelled to listen to

A REPLICA OF MARCONI'S FIRST EXPERIMENTAL APPARATUS

With similar apparatus, Senatore Marconi demonstrated in 1895 the possibilities of "beam" transmission and reception, and later confirmed his results officially before representatives of the British Postoffice and the military on Salisbury Plains, in September, 1896, when he communicated over a distance of $1\frac{3}{4}$ miles. The transmitter is at the left, and the receiver, at the right

stations at such "great" distances because the nearest high-grade broadcasting is at least that far away. In our recent questionnaire, we asked our readers to list the favorite out-of-town stations which they wish retained. More than 60 per cent. of New York listeners asked for the continuation of KDKA; well over 50 per cent. cast votes for WGY. Preferences continued in the following order: WBZ, WSB, WTAM, WLW, WOC, WLS, WPG, KYW, WMBF, WSAI, WEBH, WGN, and WBAL. The lowest of these were mentioned by more than 15 per cent. of our readers as "long-distance" favorites.

And still they say DX listening is of no importance!

Never Again Without Radio!

TWO continents waited breathlessly for news of the hero-aviator, Charles A. Lindbergh, as he braved the immense solitude of the transatlantic sky. But a few days before, that same sky had conquered Nungesser, that great fighting aviator, enveloping him in a blanket of complete mystery. There would have been neither suspense nor mystery had these intrepid fliers carried a radio transmitter.

Radio has repeatedly demonstrated its service to long-distance flying from the day, more than ten years ago, that Irwin's SOS saved the crew of Vaniman's dirigible on the first transatlantic flight attempt. Lack of radio equipment nearly lost us the crew of the *Pn-9*. Radio made the whole world a by-stander as the *Norge* swept across the North Pole last summer. Where men venture into danger—whether it be transatlantic flight, polar expedition, or the conquest of equatorial jungle—radio has saved lives and removed isolation; without radio, they have vanished into heroic oblivion.

Why not profit from experience? We hope that never again will a transatlantic flight be undertaken without the protection which a radio transmitter affords. We cannot recall a single case in which a suitable radio transmitter has failed to bring prompt rescue to a plane which has made a safe forced landing on the sea.

Why We Need More Listeners

A NEWSPAPER report states that "one chain" of broadcasting stations will spend two million dollars for talent in the coming year. The cost for talent for a commercial hour ranges, on an average, between five hundred and two thousand dollars. Top-notch entertainers are said to receive from a thousand to two thousand dollars for a single studio appearance, while one jazz orchestra is booked for $1500 an hour. Still, one of the problems of radio is how the standard of programs may be improved. Commercial broadcasters cannot be expected to spend larger sums and to present better programs unless the numbers of the radio audience increase proportionately to their increased expenditures.

A most important problem of the radio industry is to make better known what it offers as an inducement to the purchase of a radio set. The sales barrage on the public has been concentrated upon selling the radio receiver as a perfected electrical instrument. The important work of making the big programs on the air better known has been more or less neglected. Broadcasting needs more listeners in order that programs may be improved and programs cannot improve unless there are more listeners. Advertising and sales effort, directed to the non-radio user, should stress the variety and quality of radio education and entertainment. On the other hand, the radio expert complains of the glittering generalities in the advertisements which are spread before him in the radio magazines. Why not recognize the distinction between radio users and non-radio users and plan advertising which appeals specifically to the radio user in the radio magazines and to non-radio users in the consumer magazines?

Unsnarling the Patent Tangle

THE National Electric Manufacturers' Association has appointed a committee to investigate the patent situation in the electric industry. Undoubtedly, this committee will deal with the radio situation, the branch of the industry now most seriously involved in the meshes of patent complication. Included in the membership of the committee are A. G. Davis of the General Electric Company, A. Atwater Kent of the Atwater Kent Manufacturing Company, and M. C. Rypinski of Federal-Brandes. It is unlikely that much progress can be made until certain important patent cases are adjudicated. Considering the tremendous cost of research and litigation and the long period before the various basic patents have become royalty producing, it is likely that there may be difficulty in restraining patent holders to sufficiently moderate royalties. In this respect, the committee can be very useful because the industry cannot suffer such burdens as 10 per cent. of the sales price of the receiver, which was once collected by one important patent holder. Considering that it would be difficult to make a radio set which does not infringe from twenty to thirty patents, the ultimate cost to the consumer may become prohibitive unless an agency, such as the N. E. M. A. committee, takes the situation in hand.

John V. L. Hogan has set an excellent example by charging only a modest royalty for the use of his single-control patent, which covers the combination of several interdependent resonant circuits, having an element which changes their respective electrical period equally and simultaneously. Thereby it covers every type of single-control receiver. In spite of its wide scope, evasions of royalty payment and legal costs have been reduced to a minimum because few, if any, manufacturers have attempted to evade Mr. Hogan's modest license fees. One of the principal reasons why radio patents are litigated to the bitter end and every obstacle is raised to avoid payment of royalties is because licensing has been restricted wherever possible to a few manufacturers, and royalties have been exceedingly high. It is likely that, if a modest scale of royalties is established for all radio patents, few manufacturers will be unwilling to give the inventor his just due.

"Canned" Programs Good and Bad

JAMES C. PETRILLO, President of the Chicago Federation of Musicians, has started a crusade against Station WCRW of that city because it has been broadcasting dance music programs with the aid of a phonograph rather than with paid union musicians. A diet of phonograph records, so long as standard commercial records are used, is an imposition upon the listening audience. It would be unfortunate, however, if this crusade should result in a regulation against the use of any phonograph records in broadcasting. A suggestion made in Edgar H. Felix's new book, *Using Radio in Sales Promotion*, points out that special broadcasting programs may be rendered in recording studios and "assembled" and "cut" in the same way that motion picture films are perfected in the film laboratories. Every part of the program, by this recording process, may be rehearsed and fitted together to make the most perfect broadcasting performance. Numbers may be shortened or lengthened, re-rendered for more perfect reproduction, and worked over until the program is worked out to the utmost satisfaction. If such a carefully rehearsed and perfectly balanced program wins popular acceptance, it can be repeated at any time through any station or stations merely by running off the records again. The use of phonograph records as a program source in this manner is quite different, however, from broadcasting ordinary four- or six-minute commercial records. A station indulging in this practice is simply giving evidence of its incompetence in securing artists, and a way should be found to cancel its broadcasting license.

The Month In Radio

P. S. HILL, Vice-President of Herbert H. Frost, Inc., parts manufacturers, makes pertinent observations as to the value of the parts business, which indicate a larger total volume than is generally conceded to that branch of the industry. During 1926, the aggregate sale of complete receivers was $225,000,000 and of parts, $75,000,000. Accessories amounted to $230,000,000. Since the cost of parts of a home-built receiver, is, in general, less than that of a manufactured receiver, it is only reasonable to assume, says Mr. Hill, that half of the accessories, which include tubes, batteries, loud speakers, and power supply devices, were used in connection with home-built receivers. Making this division in accessory sales, the total business in manufactured sets, with the necessary auxiliaries, totalled $340,000,000 in 1926, while that of parts and their associated accessories was $190,000,000. In other words, reasons Mr. Hill, the sale of parts and their accessories was slightly more than 50 per cent. of the total sale of complete sets. This accounts for the prosperity of those dealers who learn to sell parts intelligently and concentrate upon that phase of the business.

THE appointment of distinguished music leaders to executive positions in broadcasting program direction, on both sides of the Atlantic almost simultaneously, is a striking recognition of radio as a force in the music world. In England, Sir Henry Wood, perhaps the foremost conductor of Great Britain, was retained by the British Broadcasting Company to develop its musical programs. On almost the same day, it was announced that Walter Damrosch had accepted the position of music counsel for the National Broadcasting Company. The two largest broadcasting organizations in the world called upon distinguished musical leaders and entrusted them with the guidance of the now most potent force in musical education.

LEGAL representatives of the American Radio Relay League successfully attacked the municipal regulation established by Portland, Oregon, which attempted to control federally licensed amateur radio stations. The municipality revised its ordinance so as to except amateur stations from its jurisdiction and the matter did not therefore become a test case in the courts.

ALTHOUGH New Zealand's two broadcasting stations are privately owned, the Government exercises close supervision over the broadcast listener. Before any make of radio set can be placed on the market, government inspectors test and pass upon its radiating qualities. If it fails in these tests, it cannot be sold without subjecting the dealer to penalties of the law.

THE Fourth Radio World's Fair will be held at the New Madison Square Garden in New York, September 19 to 24, under the direction of G. Clayton Irwin, Jr. In addition to an impressive collection of manufacturer's exhibits, many of the newest developments of the radio art will be featured, including, it is rumored, the first general public demonstration of telephotography. Last year, a quarter of a million people attended the exposition. Many favorite broadcasting artists will appear at the glass-enclosed studio, which will be the program source for the principal New York stations during show week.

THE opening of a 1000-watt broadcasting station in São Paulo, Brazil, has greatly stimulated the radio business in that country. The 55 per cent. ad valorem duty is a serious barrier to complete set sales, but the parts business is flourishing. While German and British headsets are selling in large quantities, other parts, such as rheostats, condensers, sockets, and binding posts, are largely imported from the United States.

A FEATURE of the Citizens' Military Training Camps, being conducted at Plattsburg, Fort Niagara, and Fort Ethan Allen, in the Second Corps Area this summer, will be a special evening course on advanced commercial radio

ALFRED E. WALLER

New York

Managing Director, National Electrical Manufacturers Association. A statement especially prepared for RADIO BROADCAST:

"Constant vigilance is essential if the radio industry is to keep its own house in order. As I see it, there are immediately required: (1.) A cleaning of the air; (2.) an organization of our manufacturing and distributing effort to level out buying and production; (3.) time, money, brains, and courage to provide for improved programs and their reception.

"The last-mentioned need is dependent upon the first two. The second point can be achieved most effectively through group action and constant, steady development of the product by the manufacturer, and by more competent selling and maintenance.

"The Federal Radio Commission has already worked marvels in clearing the air of what I have called 'electrostatic katy-dids.' The power company, the manufacturer, and the owner of noisy wave-generating equipment will be equally interested in a cleaning up process if we have sold him a good set, and provided him with continuously attractive programs."

practice, thus fitting those attending for the attainment of first-grade commercial radio licenses. Consequently, enrollment in the Signal Corps course at the Citizens' Military Training Camps will offer, in addition to the usual advantages, an opportunity to become a commercial radio operator.

ANNOUNCEMENT has at last been made of the much-rumored broadcasting chain, promoted by the Paramount-Famous-Lasky Corporation. It is understood that the network, which is to comprise about a dozen stations, will be known as the Keystone Chain. Most of the stations are to be in cities already served by the National Broadcasting chain. It is understood that KMOX, WHT, and WMAK are included in the chain, while several New York stations have been named as possible key stations.

Nothing would be better for radio than a real rival to the National Broadcasting chain. The fact that the new organization is sponsored by a motion picture group, and probably by other companies, rather than by an independent company seeking to establish a commercial broadcasting business on a profitable basis, may cause it to concentrate so much on motion picture publicity that it will fail to offer real competition. But we hope for the best.

THE Circuit Court of Appeals reversed the decision of the District Court, unfavorable to the Radio Corporation, in its action to restrain the Twentieth Century Radio Company from further infringements of the Hartley and Rice patents. The decision affects the Hazeltine patents, the Twentieth Century Corporation being a distributor of Garod sets.

THE Indianapolis Broadcast Listeners' Association has been giving a series of twenty talks through WFBM on the general subject of radio interferences and how to identify, locate, prevent, and remedy them. A printed copy of one of these addresses reveals a most constructive attitude, urging the coöperation of listeners with power companies through the medium of listener organizations. Instead of wholesale abuse and fanatical antagonism to power companies and public pressure to bring about restricting municipal regulation of interference noises, the Indianapolis Association urges more effective measures, *i.e.*, the employment of experts, remunerated by the contributions of broadcast listeners, to locate interference. Since radio listeners are their best customers, the power companies welcome their intelligent and helpful coöperation.

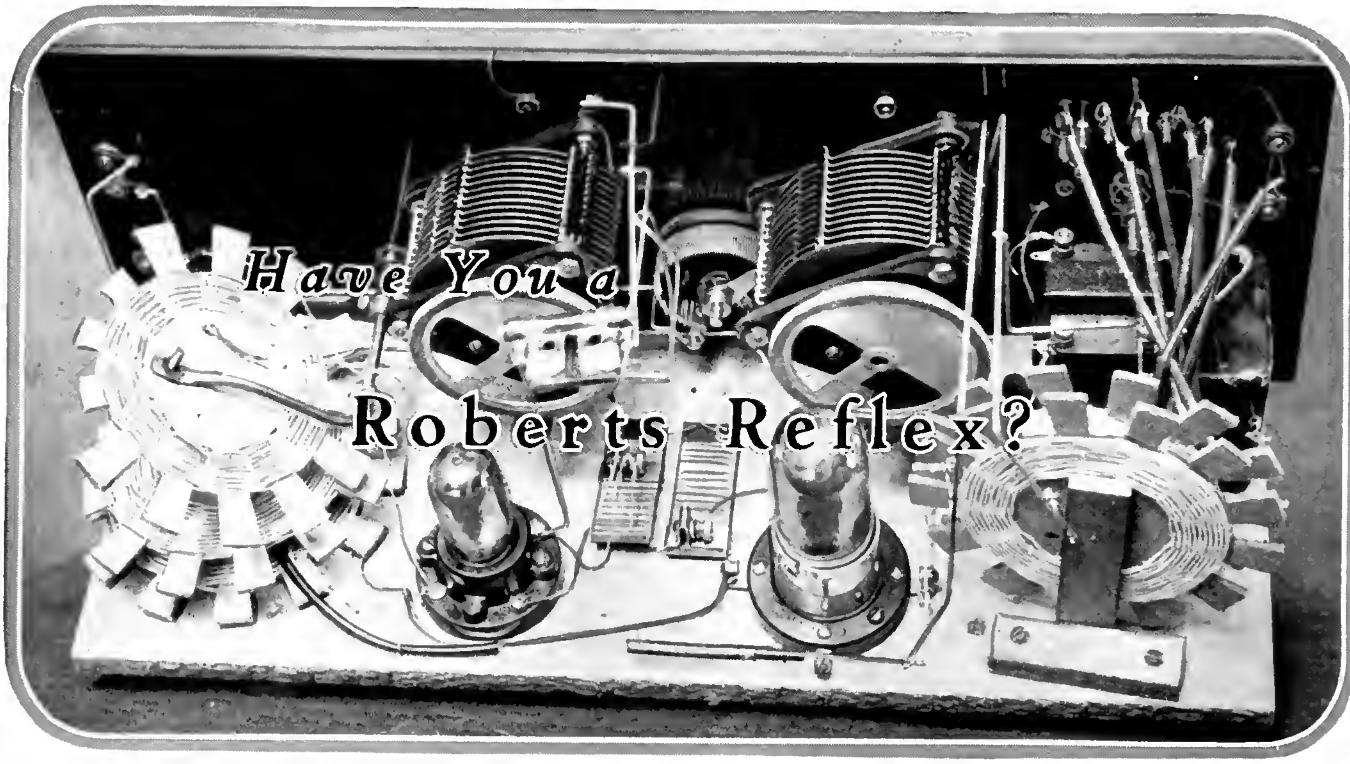
It has been frequently demonstrated that 90 per cent. of the noisy reception in any city can be eliminated or reduced to an unimportant minimum by an expenditure of less than $100 per square mile for an engineering investigation. In some instances, the broadcast listeners themselves, through a local radio club, have made this expenditure; in others, radio dealers have combined to do the work; and, in other instances, the power companies themselves have sought and cured the trouble. Any city troubled by notably poor reception, due to "man-made" interference, can, by coöperative means, eliminate most of it.

TEX RICKARD, who, not so long ago, was rated as an opponent of broadcasting, has become converted. "I have found," he says, "that the radio has done more to create new fans for sporting events than any amount of advertising could possibly do."

Accordingly, he has made arrangements to use the red and blue networks for important events, still maintaining WMSG for minor fistic combats. A tribute to the popularity of fight broadcasts was found in many of our questionnaire returns. Practically all of those who favored the continuance of WMSG qualified their approval by the statement "for prize fight programs only."

THE National Electric Manufacturers' Association has issued the second Nema Handbook of Radio Standards This covers such items as tests and necessary tolerances for cords, plugs, jacks, cable terminals, rheostats, variable condenser mountings, shaft extensions, standard tests for audio coupling devices, color codes for outside connections to set, battery dimensions and tests, socket power device markings, vacuum tube sockets, and constants for standard tubes. It establishes the frequency range of broadcast receivers from 550 to 1500 kilocycles, a most important requirement which many manufacturers are not yet regarding.

Have You a Roberts Reflex?



Radio Broadcast Photograph

AS IT WAS IN THE BEGINNING!

We would blush to introduce our friends to a receiver such as that depicted above in these days of low-loss apparatus. Yet this is a very typical example of pre-contemporary days. The Robert reflex, for it is none other, created quite a sensation at the time of its introduction a few years ago. The picture shows a two-tube model, a more popular one consisting of an identical circuit arrangement but with the addition of a push-pull audio stage

Modern Apparatus, Simple Changes, and Latest Tubes Will Rejuvenate This One-Time Most Popular of Receivers

By JOHN B. BRENNAN

To COUNT up the number of circuits which have remained in the public's eye over a lengthy period of time does not require many fingers. Such familiar names as Browning-Drake, Roberts, Haynes Super, Knockout Reflex, are all indelibly fixed in the minds of Radio Broadcast readers.

The most outstanding of these, at least to Radio Broadcast readers, is the Roberts circuit in its several forms. It was first brought to the attention of receiving set builders through a modest article by Dr. Walter Van B. Roberts in the April, 1924, issue of this magazine. Since then, the circuit has attained such prominence that those who have built it are numbered in the tens of thousands and, according to some estimations, approach the hundred-thousand mark. The most popular form of this circuit has probably been the Knockout four-tube Roberts reflex, a circuit diagram of which is shown in Fig. 1. Now, since April, 1924, considerable refinement has taken place in radio apparatus. Selectivity, sensitivity, volume, and ease of operation have all improved since that date and the thought has probably occurred to many owners of a Roberts receiver of the vintage of 1924, that some modern improvements might be made to bring the receiver more or less up to date. The questions the owner should ask himself are these:

(1.) Is my Roberts receiver sensitive and selective enough?
(2.) Does it tune sharply enough?
(3.) How is the quality compared with receivers of to-day?
(4.) Do I secure sufficient volume from it?
(5.) Is it stable on the shorter wavelengths?
(6.) Is it difficult to operate compared to more modern receivers?

If the answers to these questions indicate to the reader and owner of the receiver that he is perfectly satisfied, there is no necessity for him to read further in the present article. On the other hand, if his receiver seems to suffer somewhat compared to what he is led to expect is the best of present-day development, then the suggestions to follow may be useful. Boiled down to a simple, straightforward statement, this means that the owner of a Roberts receiver, if he desires, can bring it up to date in every respect so that it will be on a par with the latest receivers described, and incorporate all the niceties and refinements of present-day receiver design. It is possible that the answers to these questions indicate that the receiver in question needs a general overhauling. It is also possible that only one or more of the respective units need attention.

The sensitivity and selectivity of a receiver using the Roberts circuit go hand in hand; that is, a sensitive receiver will probably be selective and on the other hand, if it tunes broadly so that the signals desired have as a background signals from several other stations, it is probable that the receiver suffers on the side of sensitiveness as well. The old Roberts receiver used spiderweb coils, and these quite often were wound with wire having enamel insulation. Frequently the enamel wears off the wire at a point where it bends around the spiderweb form and if another adjacent turn is bared, a short-circuited turn results. As soon

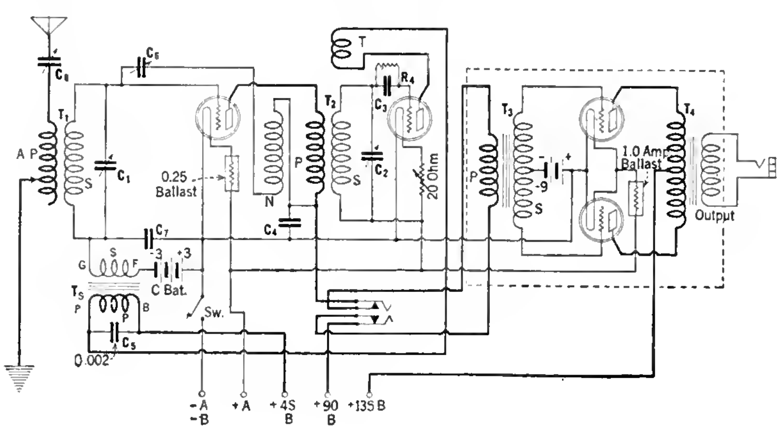


FIG. 1

as this happens, the set begins to tune broadly and signals are not as loud as they might be.

In the Roberts receiver there are two tuning controls, one on the antenna or radio-frequency stage, and the other on the detector. If either of the condensers seem to tune broadly, the coil should be looked at to see whether short-circuited turns are present on it. Sometimes it is impossible to determine definitely whether this is the cause of broad tuning or not and it is well, under such conditions, to remove the wire and either wind new coils or to substitute a more modern type of winding, such as a good solenoid inductance.

The antenna coil consists of 40 turns of No. 24 double cotton-covered wire with taps taken off about every 10 turns. The two secondary coils consist of 45 turns of the same size wire. The NP coil is wound with No. 26 double cotton-covered wire for 40 turns with a tap taken off at the 20th turn. This tap connects, via a jack, to the plate post of the primary of the input transformer of the push-pull unit and thence through that primary to the B battery. One end of the NP coil connects to the neutralizing condenser while the other connects to the plate of the radio-frequency tube. The tickler consists of 20 turns of No. 26 double cotton-covered wire. Incidentally, these same specifications will hold true whether the coils are to be wound in spiderweb, basketweave, or solenoid fashion. For the solenoid type of coil, the diameter of the form should be approximately 3 inches.

NEW COILS FOR THE ROBERTS

AMONG the manufactured coils which have been successfully used in the antenna stage of the Roberts receiver are those of Hammarlund, Sickles, Aero, General Radio, Bruno, and Silver-Marshall. Undoubtedly there are others which have the same characteristics and which may be employed in the antenna stage satisfactorily. The substitution of more up-to-date inductances for the interstage spiderweb coil will also be a step toward modernization. The F. W. Sickles Company and the Hammarlund Manufacturing Company make coils intended specifically for the Roberts Circuit while the Silver-Marshall and Bruno coils consisting of primary, secondary, and tickler, may be used after the primary coil on the form has been removed and a new one wound according to the specifications given above. All of these coils have carefully been tried in a model of the receiver built in RADIO BROADCAST Laboratory according to the specifications contained in the September, 1924, issue of RADIO BROADCAST. No difficulty was experienced in substituting these coils for the original spiderwebs.

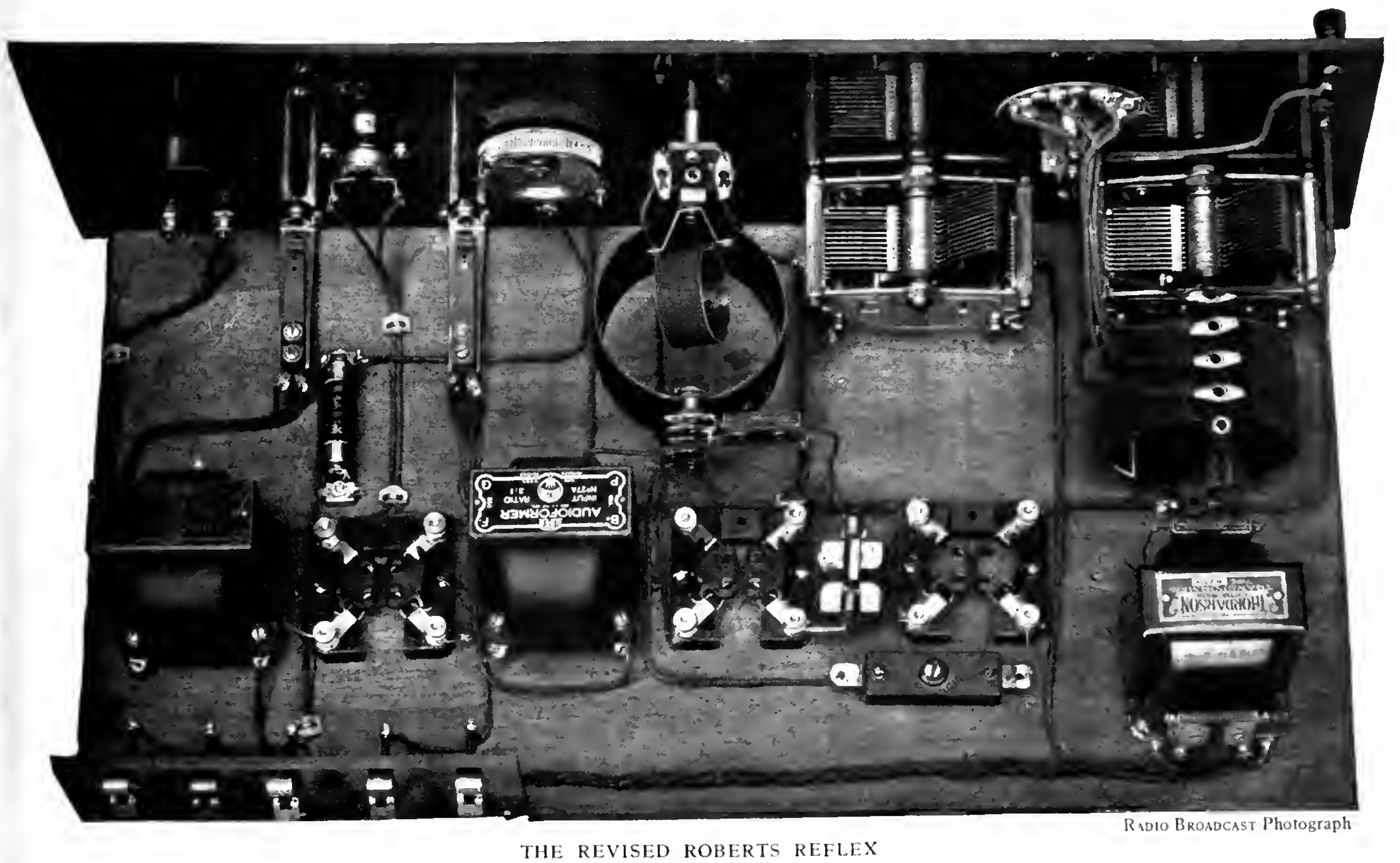
Broadness of tuning may be caused by poor connection between wires which are supposed to be making perfect contact. It is always advisable to solder such wires and even in soldering occasionally there exists high-resistance joints due to the failure of the constructor to clean properly the wires which are to be joined together. A good soldering flux, together with a soft wire solder, is a definite necessity in the wiring of a radio receiver.

It has been demonstrated since the early days of the Roberts receiver that no coil is more efficient than the solenoid of the proper dimensions. Efficiency with regard to coils means high inductance, low resistance, and low distributed capacity. These factors, in turn, mean high sensitivity and selective tuning circuits, and the owner of a Roberts receiver using old style spiderweb coils cannot make a better move than to substitute a highly efficient solenoid winding. This is especially true of the antenna stage where every bit of voltage amplification is useful. In the interstage coils, resistance is not so important and a coil of somewhat lower efficiency will not have the same importance as it would in the case of the radio-frequency amplifier. In other words, the first coil changed is the antenna coil and if the set's sensitivity and selectivity are still to be improved, the detector coil should follow the antenna coil into the scrap basket and a new one be substituted.

Another remedy for broadness in tuning lies in the use of an antenna series tuning condenser as shown in Fig. 1. This condenser should preferably be of the variable type and have a value of about 0.0001 mfd. However, if a variable type condenser of this value is not available, it will be found quite satisfactory to use a good make of fixed condenser of about the same value, such as those manufactured by Dubilier, Sangamo, Aerovox, Electrad, Tobe, etc.

There are other causes of broad tuning. As Fig. 1 shows, the input coil to the radio-frequency amplifier has between it and the tube a high-resistance winding—the secondary of the audio reflex transformer. This transformer secondary, unless properly bypassed, broadens the tuning of the antenna stage and it has been found in practice that it is advisable to shunt this secondary with a 0.0001-mfd. fixed condenser. It will be noticed that, when this shunt condenser is connected in the circuit as explained, the radio-frequency amplifier usually oscillates, particularly on the higher frequencies, and therefore it is more difficult to neutralize.

It will be found that the possibility of erratic action of the regeneration control is quite remote if coils such as those listed or manufactured specifically for use in the Roberts circuit are used. On the other hand, if the constructor is still employing his spiderweb type of coil and modern tubes, and cannot obtain smooth regeneration, he may experiment with the detector plate voltage and decrease the number of turns on the tickler coil one by one until the desired smoothness of regeneration is obtained. It was found in the receiver experimented upon in the Laboratory that 22½ volts was ouite satisfac-



RADIO BROADCAST Photograph

THE REVISED ROBERTS REFLEX

The layout of parts for the three-tube arrangement. The circuit differs from Fig. 1 in that the push-pull audio arrangement has been omitted in favor of a straight audio stage tory and about 6 turns had to be removed from the old 20-turn spiderweb tickler coil before the circuit was really satisfactory. Under these conditions the detector could be made to oscillate easily on 500 kilocycles, and be thrown out of oscillation on 1500 kilocycles. Experiments should be made with various sizes of grid leaks to obtain smooth control of regeneration. Grid leaks of a value of from 1 to 8 megs. may be used, smoother regeneration resulting from the use of higher valued leaks. The quality of reproduction, however, improves as lower grid leak values are used.

Where there is something wrong with the reflex part of the receiver it manifests itself in a number of ways. Perhaps the loud speaker will still continue to blare forth even though the detector tube is removed from its socket. Or perhaps reception is accompanied by a raucous squawk or howl when tuning-in to a station. Low volume is a good indication of trouble in the reflex stage and is often caused by the use of a cheap transformer in the circuit.

Besides having a good make of transformer in the reflex stage, it is essential that both the primary and secondary be bypassed intelligently. A 0.002-mfd. condenser across the primary and a 0.0001-mfd. one across the secondary will suffice, although other neighboring values should be tried and one selected which produces most satisfactory results, as it is always probable that no two similar circuits will require exactly the same condenser values to make them work properly.

THE AUDIO CHANNEL

IN THE few years since the appearance of the Roberts circuit, audio transformers have been developed which have much greater primary impedance than was necessary a few years ago. The reflex transformer may be one of the high grade units now on the market, such as Ferranti, Amertran Deluxe, Pacent 27-A, Samson, Thordarson, Silver-Marshall, or General Radio. The push-pull stage may be eliminated in favor of a straight stage employing one of the transformers used in the reflex stage, or a new push-pull amplifier may be used utilizing special Silver-Marshall or Samson transformers. Two 112 tubes in parallel, as shown in Fig. 2, will give somewhat greater output than a single tube

In a push-pull amplifier, the quality can be materially improved by substituting semi-power tubes of the 112 type for the two 201-A tubes. When this substitution is made, it is necessary that the plate voltage applied be 135 with 9 volts of C battery. The 171 type may be employed, but the volume will not be as great as with the 112 because the 171 has an amplification factor of 3 whereas the 112 has an amplification factor of 8. However, the 171 type tube has much greater handling capacity.

To determine whether the quality of the output from the reflex stage in your present Roberts receiver is everything that it should be, connect a pair of phones in series with the primary of the first push-pull transformer, or connect the phone tips in place of the terminals of the primary of this transformer. If the signal quality is not good here, then it is evident that the audio reflex transformer is at fault and the simplest way to improve the quality is to substitute another transformer of a better type.

If the tickler coil is adjusted up to the point where the detector is just about to spill over, it cannot be expected that the quality of the signal in the loud speaker will be everything that is desired and the tickler should always be backed off to prevent this condition.

Tubes offer a fertile field for the investigation of poor quality. A poor tube in the radio-frequency reflex stage may affect the tone quality and volume appreciably and the builder should switch around the tubes in the various sockets until the most satisfactory position for all tubes is found.

There are a number of unit amplifiers on the market which may be readily substituted for the second stage audio originally employed. Such units as the Pacent "Powerformer," the Silver-Marshall "Unipack," those of Receptrad and General Radio, and several resistance amplifiers such as the DeJur, Heath, Daven, etc., will be satisfactory for this purpose.

Fig. 2 shows two audio amplifier systems which may be constructed and also an output device to

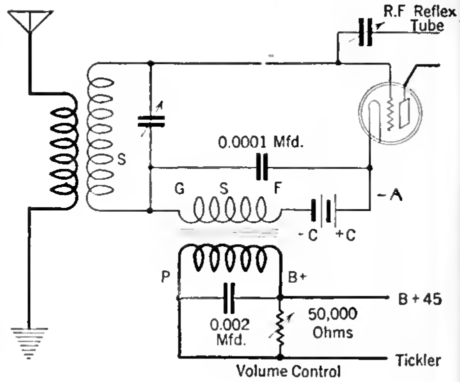


FIG. 3

couple an ordinary transformer stage to the loud speaker.

VOLUME CONTROL

THE volume of the receiver may be controlled by shunting the primary of the reflex audio transformer with a variable resistance of the value of 50,000 ohms, as shown in Fig. 3. The compression type of variable resistor, such as the Clarostat, may successfully be employed here.

In making the change to power tubes, it is not necessary to control the filaments with a rheostat since a fixed filament ballast will suffice. This, therefore, leaves one hole on the panel vacant by the removal of the rheostat which controls the tubes in the push-pull amplifier. In this hole may be mounted the volume control. Since no adjustment of the filament of the tube in the radio-frequency reflex stage is required, the rheostat originally provided may be dispensed with and a filament ballast substituted for it, thus making vacant another hole on the main panel. It is suggested that the rheostat for the detector tube be transferred to the hole formerly occupied by the rheostat for the radio-frequency reflex tube and in the hole made vacant by the rheostat on the detector tube, a filament switch be mounted. This switch should be connected in series with the minus A lead to the various tubes.

There are a number of neutralizing condensers now available which may take the place of the home-made tubular neutralizing condenser originally specified in the construction of the Roberts reflex receiver. These new condensers are of the variable plate or screw type and are much easier to adjust and to maintain adjusted than the tubular type. The primary requisite in neutralizing is to keep the connecting leads between the coil, neutralizing condenser, and tube, as short and direct as possible and not let these leads parallel any other leads. Satisfactory neutralizing condensers are those manufactured by Precise, Hammarlund, Cardwell, and XL Laboratories.

The changes as outlined here have centered mainly around the original popular Knockout four-tube reflex receiver and deal particularly with the substitution of new and improved parts for old ones, with one or two circuit changes. In its revamped form, it is a very fine receiver, worth the efforts of any home constructor.

It will give good quality and if the changes suggested are carefully made the receiver should equal, in sensitivity and selectivity, any of the more recent receivers which have been described. For best results the receiver should be used with some good cone-type loud speaker.

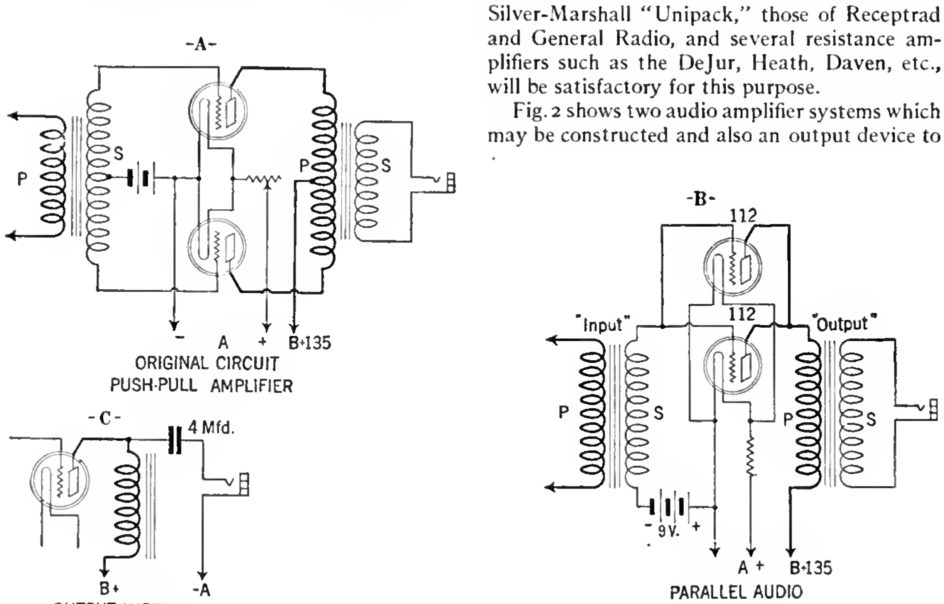


FIG. 2

In this figure are shown three arrangements of the power stage that can be satisfactorily used. At "A" is shown the original push-pull amplifier that was used in the old Roberts receiver. New push-pull transformers are now available and can be used with excellent results in this circuit. At "B" is an output arrangement consisting of two 112 tubes connected in parallel, both of them feeding into an output transformer. At "C" is an arrangement using a single 171 type power tube. In the plate circuit is a choke-condenser combination used to eliminate the direct current from the windings of the loud speaker.

The Balsa Wood Loud Speaker

A NEW LOUD SPEAKER
The Balsa wood loud speaker is now obtainable in fully assembled form. The picture to the right shows a typical example

Constructional Hints on a New Loud Speaker Which Was Found in the Laboratory to Give Very Excellent Quality

By THE LABORATORY STAFF

IT IS generally conceded that the loud speaker is the present weak link in broadcast receiving systems. It is possible to build excellent amplifiers both for transmitters and for receivers, and from the pick-up device in the radio broadcasting studio to the output of the final amplifier there is little to be desired as far as true reproduction of various frequencies is concerned. It is true that programs are still compressed somewhat as regards volume, partly because of the limited carrying capacity of the telephone lines connecting pick-up and transmitter, partly because of the limited power range of the transmitter, and partly because of the limited volume range of receivers; but the ear will stand for a great deal of distortion due to these causes without rebelling. The loud speaker, however, is far from perfect.

For this reason, when anything new in the way of loud speakers develops, the average radio engineer registers considerable interest. The latest idea in this realm is the Balsa wood loud speaker. The story goes that the Western Electric engineers, in whose laboratories have developed some of the best known translating devices of the present time, "played" for some time with Balsa wood and, like all good things the Western Electric engineers "play" with, sooner or later the idea got about. It is now possible to purchase in kit form the necessary Balsa wood, hardware, driving mechanism, and frame to put together a very excellent loud speaker.

Balsa is the lightest known wood, averaging about six or seven pounds per cubic foot, while cork averages about fourteen pounds. It grows in Panama and other tropical countries, and is used widely in the airplane industry. Because it is 92 per cent. air, it makes an excellent insulating medium against heat.

The Balsa wood slats in the kits for loud speaker construction come in three sizes ready to be assembled as diaphragms of one by two feet, two by three feet, or two by four feet, approximately. The middle sized one is the one most people build, and, in fact, is the best of the three. The smallest is too small; the largest is too awkward. Photographs of the medium sized one are shown here.

Heretofore, the best loud speaker that could be made was an elliptical cone with about four feet as its longest dimension. This, driven with a Western Electric 540 AW unit, seemingly left little to be desired. It was, in many peoples' estimation, better than the 540 AW loud speaker purchased on the open market. The new Balsa loud speaker, if carefully made, is on a par with the elliptical cone.

Balsa wood is useful for loud speaker construction because of its extreme lightness and because it is possible to make the radiating part of the loud speaker extremely rigid. Lightness contributes toward the efficiency of the loud speaker, which means that a greater percentage of the input power is radiated as sound energy and not wasted in friction. Rigidity is necessary in order that considerable energy can be fed into the device before anything begins to rattle or to fall apart. When it is considered that the best loud speaker now obtainable is less than five per cent. efficient, it may be seen that anything contributing toward greater efficiency is worth while.

The Balsa loud speaker consists of three boards or slats which are held together mechanically by smaller strips, as shown in the photographs. These strips should be stuck on with Ambroid cement. Glue is bad since it is hard, brittle, and heavy. In practice, the slats may be placed either with their edges flush or not. If they touch, they must be firmly cemented together. The strips may radiate from the center of the loud speaker, they may be placed at right angles to the long dimension of the speaker, or they may be curved as shown in one of the accompanying photographs. In the Laboratory, little difference was noted whichever way they were placed as long as everything was rigid and light.

Radio Broadcast Photograph

ONE OF THE BALSA LOUD SPEAKERS CONSTRUCTED IN THE LABORATORY
With several units in front of it. The Western Electric 540 AW unit was found to give most satifaction. "A" in the photograph is the top of the bushing arrangement which grips the pin of the driving unit. The complete bushing unit is shown in Fig. 1. "B" is a piece of cedar shingle, afterwards replaced with a piece of Balsa wood. Since the Laboratory made tests on the Balsa loud speaker, a driving unit specially designed for it has been announced by the Balsa Corporation

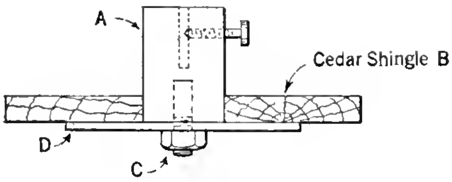


FIG. 1

The bushing arrangement, or "gadget," which grips the pin of the driving unit employed. "A" is the shank into which the pin is placed and held by the set screw; "D" is a very thin piece of copper or aluminum sheet; "C" is a hex nut to hold "A" to "D." "B" should preferably be of Balsa wood and not cedar

Some Balsa loud speakers have been found to give better results than the 540 AW cone while others with the same unit and with the same care in construction are not so good, for some unknown reason. Reports have come to the Laboratory to the effect that not everyone is satisfied with the Balsa loud speaker after it is constructed. In our opinion, however, there is nothing better at the present time than a carefully constructed Balsa loud speaker, rigidly put together with Ambroid, and driven with a 540 AW unit. The following experience will reveal some of the difficulties.

A Balsa loud speaker of the familiar two-by-three-foot size was constructed of standard material consisting of slats, strips, and the "gadget," or bushing arrangement, which holds the drive rod of the unit, glue being used in the assembly. This "gadget" is shown diagrammatically in Fig. 1, and also at "A" in the photograph on page 211. In practice it varies somewhat in size and appearance. It was glued to the center of the diagonally radiating strips which were in turn glued to the slats, as shown in the photograph. A piece of cedar shingle, "B" in the same photograph, about two inches square, was also glued onto the strips with the shank and set screw of the "gadget" protruding through a hole in it. The purpose of the shingle is to hold the bushing arrangement rigidly to the diagonal strips.

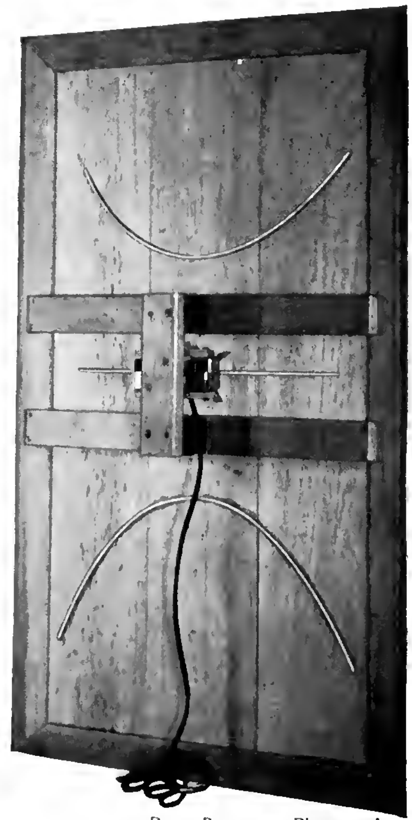
The loud speaker was very fine until a certain power input, which was not very high, was exceeded, and then the thing rattled unmercifully. The first point of attack was the glued strips, which seemed to have a habit of breaking loose when certain frequencies were placed on the loud speaker. These glued strips were ripped off and re-cemented with Ambroid which not only stuck better than glue but was lighter. It formed a homogenous connection between slat and strip. Then the bushing which held the 540 AW unit drive rod to the Balsa wood was removed, the cedar shingle thrown away, and part "D" (see Fig. 1) of the bushing assembly cut down to its smallest possible dimensions, until it was about the size of a dime but thinner. Then a small piece of Balsa was placed over this dime dimensioned piece of thin copper sheet, to take the place of the cedar shingle, and the driving unit was replaced. This process seemed to release a great load from the unit for the high frequencies (which before had been about equal to the 540 AW 18-inch cone) were now much better, and the low frequencies, which before had been much better than the cone, were not changed. It was possible to put the full output of an amplifier using a 210 type tube into it.

SOME SUGGESTIONS

THERE are several kinks that may be tried on this loud speaker. One is to drive the Balsa not at the center, but somewhere between the center and one end. Another idea is to place felt strips between the ends of the Balsa slats and the frame, insuring good contact and preventing any possible rattles.

In constructing a Balsa loud speaker from the standard kit, the procedure is as follows. The slats are first firmly fixed to the frame with Ambroid and then the moulding that is furnished is cemented in place. Next, the strips are cemented to the slats, again using Ambroid in sufficient quantities to insure perfect connection but not enough to run over the slats and increase the weight or spoil the appearance. At the center of the two diagonal strips, if they are arranged as shown in the photograph on page 211, and if the unit is to be placed there, a small depression will have to be cut in the strips in which the hexagonal nut, "C" in Fig. 1, is to fit; then the bushing assembly of Fig. 1 is cemented to the strips. Some means of mounting the driving unit must be provided, and since there are no two units that have the same dimensions, the constructor will have to exercise his own ingenuity at this point. The photograph on this page gives an idea of how it was done in one case in the Laboratory. The Balsa Corporation has an aluminum bracket that simplifies this problem considerably. Weights may be balanced on the strips, etc., while the Ambroid is drying to insure firm contact.

The loud speaker should not be tried until several hours after the final cementing has been completed. Then the weights, if these are used, should be removed from the strips, and the whole instrument looked over carefully for places where the strips might not be securely fixed to the slats.



Radio Broadcast Photograph

ANOTHER ASSEMBLY

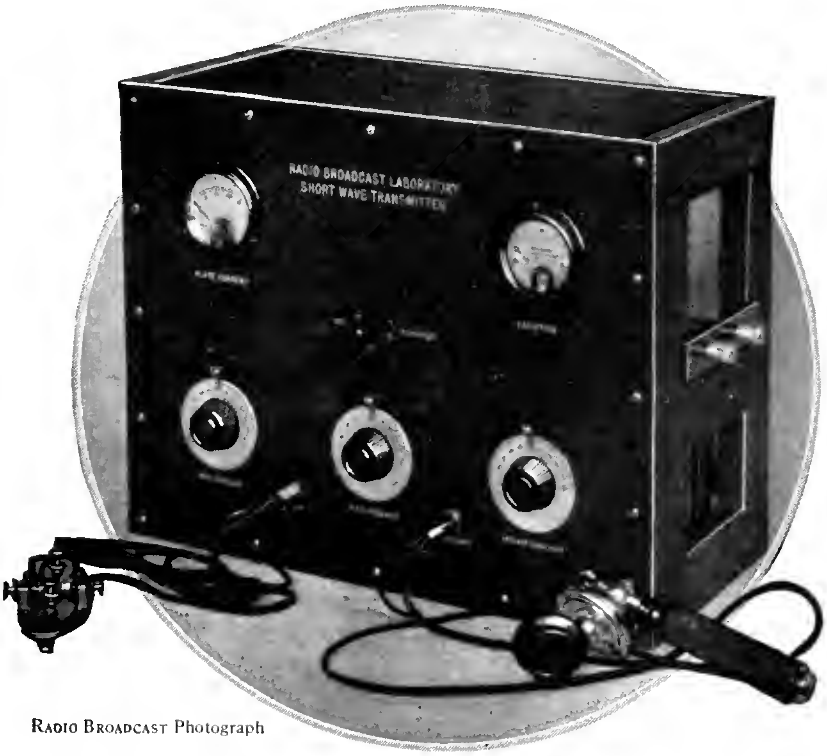
The mounting of the unit is clearly shown in this illustration. This loud speaker differs in detail from that shown on the previous page

Radio Broadcast Photograph

PREPARING TO REMOVE THE 540 AW UNIT

The matter of units is an important one. Several have been tried in the Laboratory, some of which are probably not representative of the best on the market. None so far tried can compare with the 540 AW, but as soon as the unit field has been covered by the Staff, the results of the investigation will be made known. Anyone who has a 540 AW loud speaker can experiment with the Balsa wood loud speaker for five dollars, which is the price of the Balsa wood. Unfortunately, the Western Electric 540 AW unit is not obtainable except in the complete cone loud speaker form. The Balsa material can be procured in New York from the Balsawood Reproducer Corporation, 331 Madison Avenue. Ambroid liquid cement is a product of the Ambroid Company, 1227 Miller Avenue, Brooklyn, and a 35-cent can is plenty.

In building a Balsa wood loud speaker, one should spend not less than three or four hours cementing slats to strips, and must bear in mind that the Balsa wood is easily broken or punctured. A moment's lack of care may cost a beautiful loud speaker. It should be remembered that it takes a very good power amplifier, and a very good program from a very good station to enable the average ear to tell the difference between the 18-inch 540 AW cone loud speaker and the Balsa wood loud speaker. Completely assembled Balsa loud speakers, attractively decorated and containing a specially constructed unit, are now on the market.



Radio Broadcast Photograph

Operating Characteristics and Constructional Details of a 38- to 113- Meter Transmitter

Either Battery or A. C. Operation Possible—Transmits C. W. Signals or Phone at Option

A FRONT VIEW

Of the short-wave transmitter described in this article. It can be used to transmit either c.w. or telephone signals, the changeover from one to the other being accomplished by merelv throwing the switch in the center of the panel

A Flexible Short-Wave Transmitter

By HOWARD E. RHODES

THIS article describes the construction and operation of a low-power short-wave transmitter, designed for use on either c.w. or phone. The transmitter, which is illustrated in various photographs in this article, was designed and constructed in the Radio Broadcast Laboratory.

It uses the tuned-plate tuned-grid circuit, a type of oscillatory circuit which is very likely one of the easiest to adjust. The three dials on the front of the transmitter are used to tune the grid, plate, and antenna circuits, and properly setting these three condensers is all that is necessary in adjusting the transmitter. In this article considerable data will be given regarding the general characteristics of this type of circuit.

The transmitter is designed so that, by merely throwing a multiple-pole switch, it can be connected for use on either phone or c.w. On c.w. work this switch, located at the center of the panel, is thrown to the left, and then one of the $7\frac{1}{2}$ watt tubes functions as an oscillator and the other two tubes are turned off. The set is keyed by connecting a pair of leads between a telegraph key and the two telephone tip jacks on the front of the panel (the photographs show an ordinary jack for this purpose but in practice it was found that the voltages were high enough to break down the insulation on the jack, and therefore two pin jacks, one above the other, were substituted for the telephone jack).

When the control switch is thrown to the right, or "microphone," position, one tube functions as an oscillator and the other two tubes function as modulators in a Heising modulation system. The grids of the two modulator tubes are fed from the secondary of a General Radio modulation transformer, in the primary circuit of which is the microphone in series with two dry cells. The microphone is connected in the circuit through a telephone jack on the front of the panel. When the control switch is thrown to the "off" position it not only turns off the filaments of the tubes, but also opens the microphone circuit so that the microphone telephone plug can be left in the telephone jack without any danger of exhausting the two dry cells.

An accompanying photograph shows a group of microphones that are satisfactory for use with this transmitter. In all cases very good quality signals were transmitted using these microphones powered from two dry cells, although somewhat higher modulation can be obtained using three dry cells instead of two.

Facts About This Transmitter

Circuit: Tuned-plate, tuned-grid
The set can be used on either phone or c.w.
Tubes: One 210 oscillator and two 210 modulators
Wavelength Range: 39 meters (7900 kc.) to 112 meters (2500 kc.)
Power Input to Oscillator: 40 Watts

This transmitter can be operated from batteries or from a compact a.c. power unit also described in this article. The set is entirely controlled by a single master switch. The transmitter is not difficult to construct and is easily adjusted for efficient operation.

Radio Broadcast Photograph

THREE EXCELLENT MICROPHONES

To use on phone work. The Federal unit (price $7.00) is at the left. The Globe type E microphone (price $15.00) is the center one, and the microphone at the right hand is made by Kellog (price $8.90). The latter unit is equipped with a push button which is used to open and close the microphone circuit

When the transmitter was first constructed, the control switch was arranged so that in the "key" position all three tubes worked as oscillators. It was found, however, that with this arrangement, a considerable change in frequency took place on throwing the switch to microphone, and the circuit was then revised so as to have only one oscillator with the control switch in either position. With this latter circuit no change in frequency takes place on switching from microphone to key. It is therefore possible with this set to call an amateur on c.w. and then talk to him on phone without making him change his receiver adjustment except to take it out of oscillation, as modulated signals, unlike c.w. signals, cannot be satisfactorily received with an oscillating detector.

The transmitter is so wired that it can be operated from batteries or from a compact a.c. power unit, also described in this article, which will supply it with all the necessary filament, plate, and grid voltages. The circuit diagram of the transmitter is given in Fig. 1, and the connections for battery operation are given in Fig. 2. Fig. 3 is the circuit diagram of the power unit. No changes in the transmitter itself are necessary in changing from battery operation to a.c. operation; it is merely necessary to connect the various binding posts somewhat differently so as to obtain proper operation.

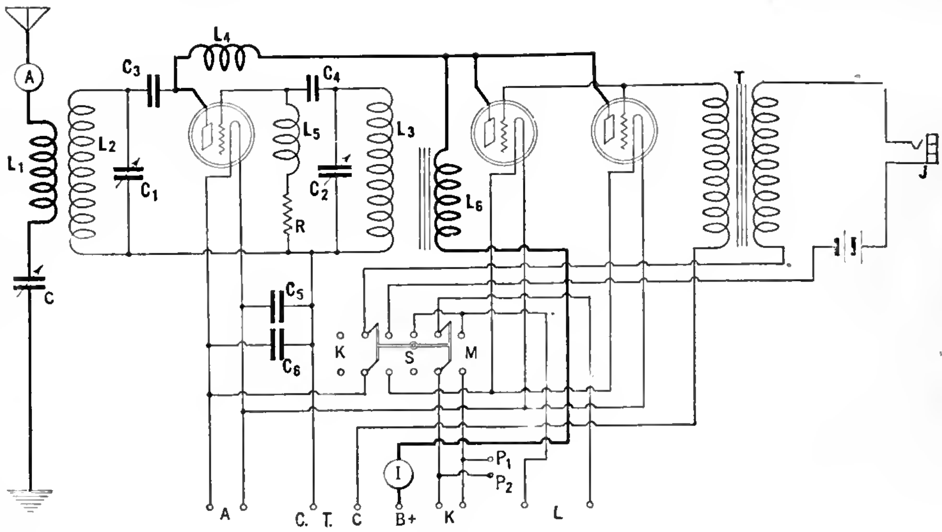


FIG. 1

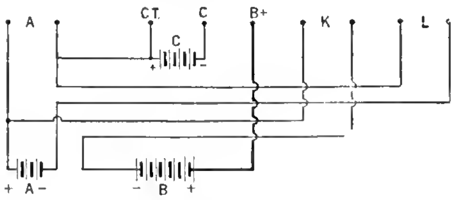


FIG. 2

The transmitter can be operated on any wavelength between 38 and 113 meters (7900 kc. and 2650 kc.). The tuning chart shown in Fig. 4 was obtained by plotting wavelength against the settings of the grid (left-hand) tuning condenser dial. In adjusting the set, the grid-circuit tuning condenser is set at the desired reading, and the plate and antenna condensers are then adjusted for maximum efficiency as indicated by the plate milliammeter and antenna ammeter.

The transmitter has been carefully constructed so as to present a good appearance and its size and weight are such as to make it readily portable. It measures 18 inches long, 14 inches high, and 8 inches deep, and only weighs about 28 lbs. The a.c. power unit in its container measures 16 inches long, 8 inches high, and 8 inches deep, and also weighs about 28 lbs.

The entire transmitter can be duplicated at a cost of about $90.00 without tubes. If the set is to be operated from a.c., it will be necessary to build the power unit, which costs about $50.00.

Before the final model of the transmitter was laid out and constructed, a temporary affair was put together on a large baseboard and a series of tests made to determine the characteristics of the circuit. Specifically, it was desired to determine: (a) The effect of varying the grid leak resistance; (b) the effect of varying the resistance of either the tuned grid or plate circuit; (c) the effect of varying the coupling between the plate and antenna coils; and (d) the effect of variations in plate voltage. Data were also obtained which showed how the plate current, antenna current, and the frequency, vary as the plate condenser is adjusted.

In all of the tests a single DeForest type DL9 tube was used, this tube being similar to a 210 type tube. The circuit used in making these tests was exactly the same as that given in Fig. 1 and all the data were taken at a frequency of 3750 kc. (80 meters). The plate potential was 385 volts, obtained from a bank of Exide storage batteries. A non-inductive resistance was used to represent the antenna. The coils and r.f. chokes used were those made by the Aero Products Company. The inductance of coils L_2 and L_3 is about 7.5 microhenrys each at 3750 kc. (80 meters). Fig. 5 shows how the inductance of either L_2 or L_3 varies with the wavelength.

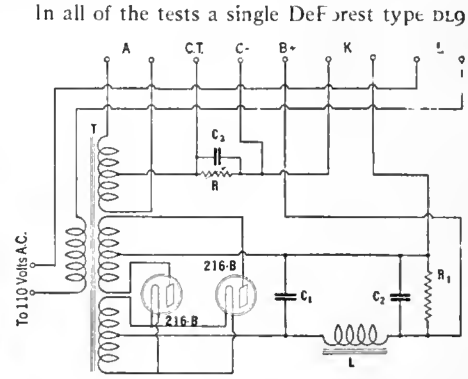


FIG. 3


Radio Broadcast Photograph

THE SHORT-WAVE TRANSMITTER

As viewed from the rear. The upper and lower compartments into which the set has been divided makes possible a very compact arrangement. The Heising choke coil, modulation transformer, variable condensers, and microphone batteries, are all placed beneath the shelf

RESISTANCE VARIATIONS OF THE GRID LEAK

When a vacuum tube breaks into oscillation, it operates over its entire characteristic, and during part of each cycle the grid draws current. This current flowing through the grid leak resistance develops a voltage which impresses a negative bias on the grid of the tube. The group of curves given in Fig. 6 show the effect of using different values of grid leak resistance. Curve No. 1 shows how the average voltage across the grid-bias resistance varies

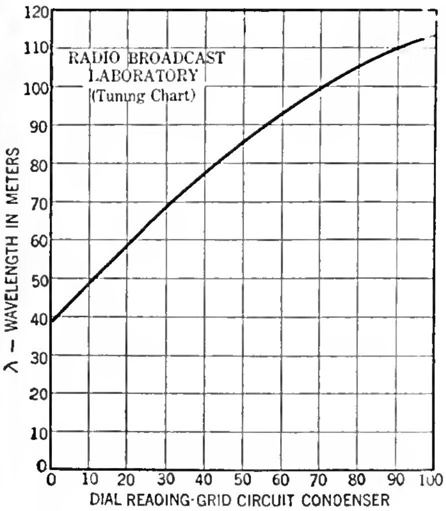


FIG. 4

with different values of resistance. At low resistance values the grid current is large but because of the small resistance only a low voltage is developed. With increasing resistance the voltage Eg also increases and reaches values as high as 124 volts when the grid leak resistance is 26,000 ohms. The plate-current, curve No. 2, is very large with low values of resistance but gradually decreases with increased resistance and reaches a minimum value with a grid leak resistance of about 16,000 ohms and then increases again. The current in the antenna circuit reaches a maximum with a grid leak resistance of about 9000 ohms although there is little change in antenna current between 4000 and 14,000 ohms.

The power input, Pi, is equal to the plate voltage times the plate current, and the power output is proportional to the square of the antenna current. The efficiency can therefore be expressed as:

$$\text{Efficiency} = \frac{\text{Power Output}}{\text{Power Input}} \times 100$$

$$= \frac{I_A^2}{Pi} \times 100 = \frac{I_A^2}{Eb \times Ip} \times 100$$

This expression is plotted in curve No. 4, Fig. 6, and shows a maximum with a grid leak resistance of between 12,000 and 14,000 ohms. It appears evident, then, that most efficient operation can be obtained with a grid leak resistance of about 13,000 ohms.

RESISTANCE IN THE GRID AND PLATE CIRCUITS

IN ORDER to obtain the most efficient operation from a tuned-plate, tuned-grid transmitter, it is essential that the coils used be carefully constructed so as to reduce to a minimum all losses. The curve in Fig. 7 shows the effect of increasing the resistance of either the tuned-plate or tuned-grid circuit, and it indicates the quite rapid decrease in efficiency that occurs when resistance is added to either of these circuits. In a tuned-plate, tuned-grid transmitter, the tuned-grid circuit is coupled capacitively to the plate circuit through the inter-electrode capacity of the tube, the grid circuit acting more or less as a driver to keep the tube oscillating. It might appear, at first thought, that some loss in the grid circuit could be tolerated without any great decrease in efficiency. It appears likely, from the tests made, that increasing the resistance in the grid circuit is practically as effective in reducing the efficiency, as is resistance in the plate circuit. The test was made by connecting small straight pieces of high-resistance manganin wire in series with the tuned circuit. The resistance of the small pieces of wire was measured on a d.c. bridge and their r.f. resistance was considered to be the same as their d.c. resistance. This procedure was followed because it is difficult to make accurate resistance measurements at very high radio frequencies.

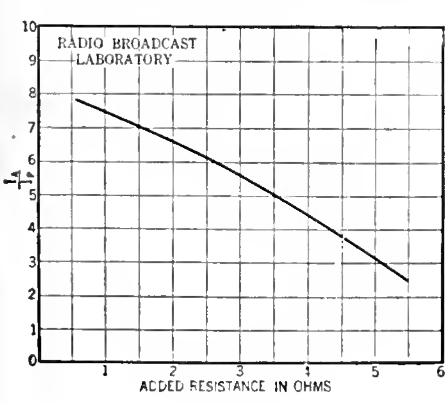


FIG. 7

VARYING ANTENNA AND PLATE COIL COUPLING

IN FIG. 8 are curves showing the effect of varying the coupling between the plate coil and the antenna-coupling coil. In the Aero coils the antenna coil is hinged at the bottom and in measuring the coupling merely the distance between the top of the plate coil and the top of the antenna coil was measured. The curves show that there is a considerable increase in efficiency when using very loose coupling. With very close coupling and with a coupling of $4\frac{1}{2}$ inches the antenna current is practically the same but the difference in plate current between the two settings is of a ratio of 112 to 65, or practically 2 to 1. While 112 milliamperes at 385 volts is equivalent to an input power of 43 watts, with decreased coupling we are able to obtain practically the same antenna current with a reduction of input power to 25 watts. As the coupling between the two coils is decreased it will be found that the tuning of the antenna circuit becomes much sharper, but that, even with a coupling distance of $4\frac{1}{2}$ inches between the coils, the coupling is still sufficiently close to produce two resonance peaks (a characteristic of coupled circuits). For example, in one of the tests, the grid condenser was set at the correct point for 80 meters, and with the antenna disconnected, the plate condenser was varied to a point where the tube oscillated most vigorously. With a coupling of $4\frac{1}{2}$ inches between the antenna coil and the plate coil the antenna circuit was closed and the antenna condenser, starting at minimum capacity, was gradually increased. The antenna current gradually increased until it reached a peak and at this point the wavelength was measured and found to be 84 meters. Turning the antenna condenser only a fraction of a degree more, however, produced a very large increase in antenna current and on measuring the wavelength again it was found that it had decreased to 80 meters. This double effect will not be found if the tuning of the antenna circuit is done in the opposite direction, that is, starting with the antenna capacity at a maximum and bringing the circuit into resonance by decreasing the capacity of the antenna tuning condenser. When tuning is done in this way the antenna current will gradually increase until the maximum is reached and after the antenna tuning condenser has been adjusted for maximum current, a slight readjustment of

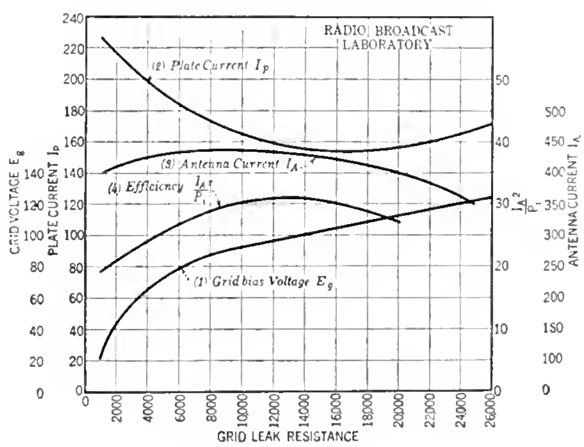


FIG. 6

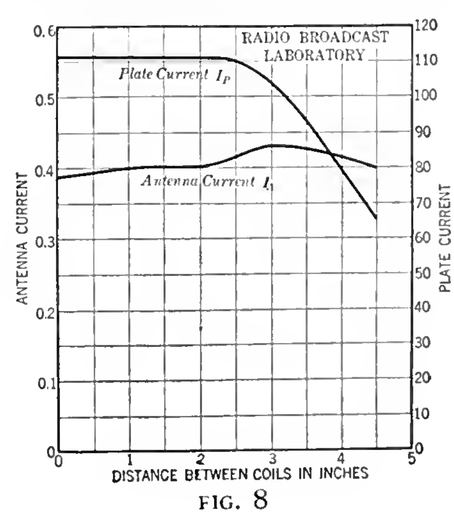


FIG. 8

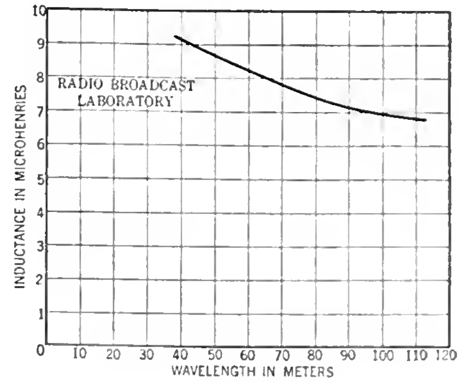


FIG. 5

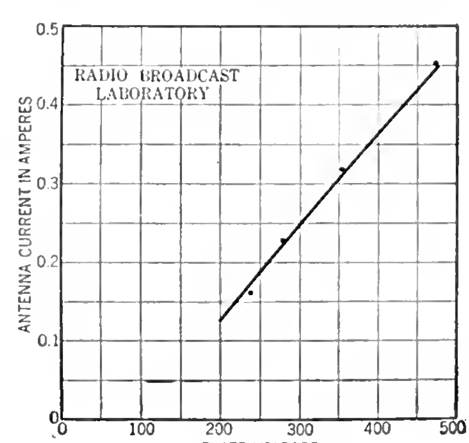


FIG. 9

the plate condenser is generally necessary to obtain maximum efficiency.

VARIATIONS IN PLATE VOLTAGE

THE power output from the transmitter of course increases with an increase in plate voltage, and Fig. 9 shows how the output power varies with plate voltages between about 200 and 500 volts. If the efficiency remained constant we would expect the power output to vary as the plate voltage squared. Doubling the plate voltage would then give four times as much *power* in the antenna circuit. The power in the antenna is proportional to the antenna current squared. Actually, however, doubling the plate voltage gives nine times as much power in the antenna, indicating that the efficiency also increases with increasing plate voltage and it is therefore advisable to use fairly high plate voltages in the operation of the transmitter. Every time the plate voltage is changed it is necessary to slightly readjust the condensers to obtain maximum power output.

In the operation of a tuned-plate tuned-grid transmitter it will be found that variations in the coupling between the antenna coil and the plate coil, and variations in the plate voltage, are the only practical means to control the amount of power going into the tube. Without any antenna load the input power to the tube is about 9½ watts. With the antenna connected, the input power can be made to go as high as 163 watts although most efficient operation was obtained with an input power of about 25 watts. The set operates very inefficiently with the high power and the plate of the oscillator tube gets very hot.

SOME GENERAL CHARACTERISTICS

IN FIG. 10 are given a group of curves which show in detail how the various quantities—plate current, antenna current, etc.,—vary as the plate condenser is tuned, the grid and antenna condensers having first been set at the correct point. With the plate condenser set at 100 (maximum capacity) the tube will not oscillate and the plate current is 85 milliamperes. The antenna current is, of course, zero, because the tube is not oscillating. If the tube is permitted to operate under these conditions for any length of time it will be ruined because the plate current is quite large and all of the power is dissipated on the plate, which becomes very hot. When the plate condenser dial is reduced to 50 the tube begins to oscillate and the plate current rapidly falls to 57 milliamperes. Further adjustments of the condenser cause the plate current to again increase. The plate current reaches a minimum when the dial reads 46 and the antenna current reaches a maximum with the dial set at 48.5 .The efficiency (antenna current divided by the plate current) as shown by the small curve, is at a maximum with the dial set at 47.5 and this point does not correspond with the maximum of either the plate current or the antenna current. All this means that an accurate adjustment is necessary to obtain maximum efficiency. If the transmitter is operated from B batteries, the increase in efficiency resulting from accurate adjustment is well worth while. In this particular case it would mean a reduction in B battery current drain from 80 milliamperes to 62 milliamperes (18 mA.), and this means longer battery life.

Radio Broadcast Photograph

A PHOTOGRAPH OF FIG. 3

The power unit is constructed on a baseboard with the power transformer on the left and the filter chokes and filter condensers at the right. The C-bias potentiometer can be seen at the rear center

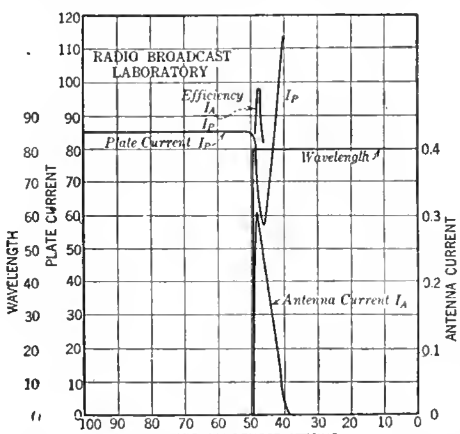


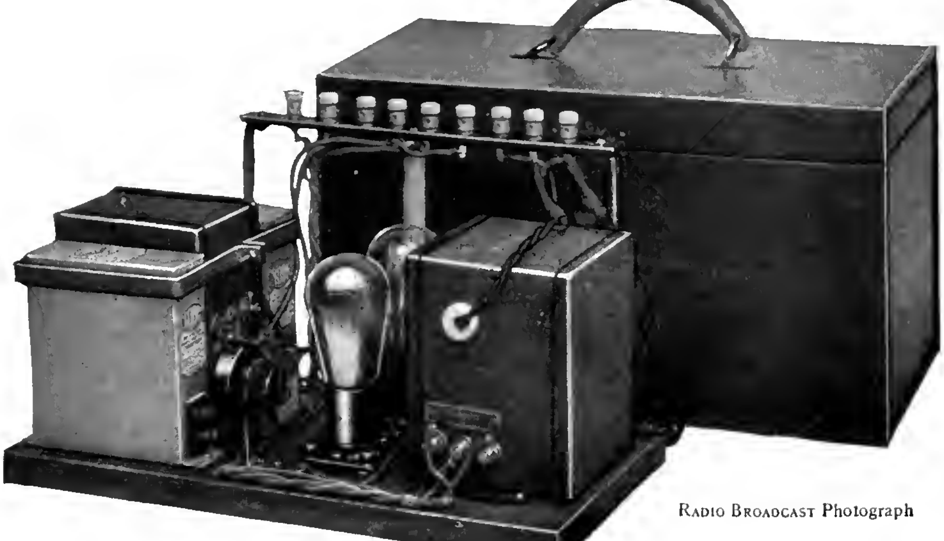
FIG. 10

In the course of the experiments, data were also taken on the effect of varying the size of the grid- and plate-coupling condensers. It was found that any.size between 0.0001 mfd. and 0.001 mfd. would give equally efficient operation, values less than 0.0001 mfd. giving somewhat less efficient operation. These values of course vary with the frequency at which the transmitter is being worked. They hold for 80 meters.

It is likely that most efficient operation will be obtained at any given wavelength with some particular value of inductance and capacity in the tuned circuits. In a transmitter of the type illustrated in this article, which is designed to cover a wide band of wavelengths without changing the coils, the inductance-capacity ratio cannot be considered because the actual value of the inductance is that value which will tune with the various capacities in the circuit to the shortest wavelength on which it is desired to transmit. The variable condenser must be of such a size that it will tune with the coil to the longest wavelength to be used.

A decided advantage of the tuned-plate tuned-grid transmitter is that it is possible to calibrate it so that it is a simple matter to set the transmitter on any desired wavelength. The procedure in adjusting the transmitter is about as follows:

First, the grid tuning condenser is set at the correct point according to the tuning chart, Fig. 4, and then, with the antenna circuit detuned, adjust the plate condenser to that point at which the plate current is at a minimum. With a coupling of about four inches between the plate coil and the antenna coil, the antenna tuning condenser is now adjusted for maximum antenna current. After the antenna circuit has been adjusted, a slight readjustment of the plate condenser is generally necessary to secure maximum efficiency. In making the preliminary adjustments on the set it is best to use somewhat low plate voltages so that the tube will not be damaged.



Radio Broadcast Photograph

A SIDE VIEW OF THE POWER UNIT

This photograph plainly shows the layout of apparatus. The center support of the binding post strip also acts as a holder for the 50,000-ohm fixed resistor. In the rear is the Kennedy tool case in which the power unit can be placed

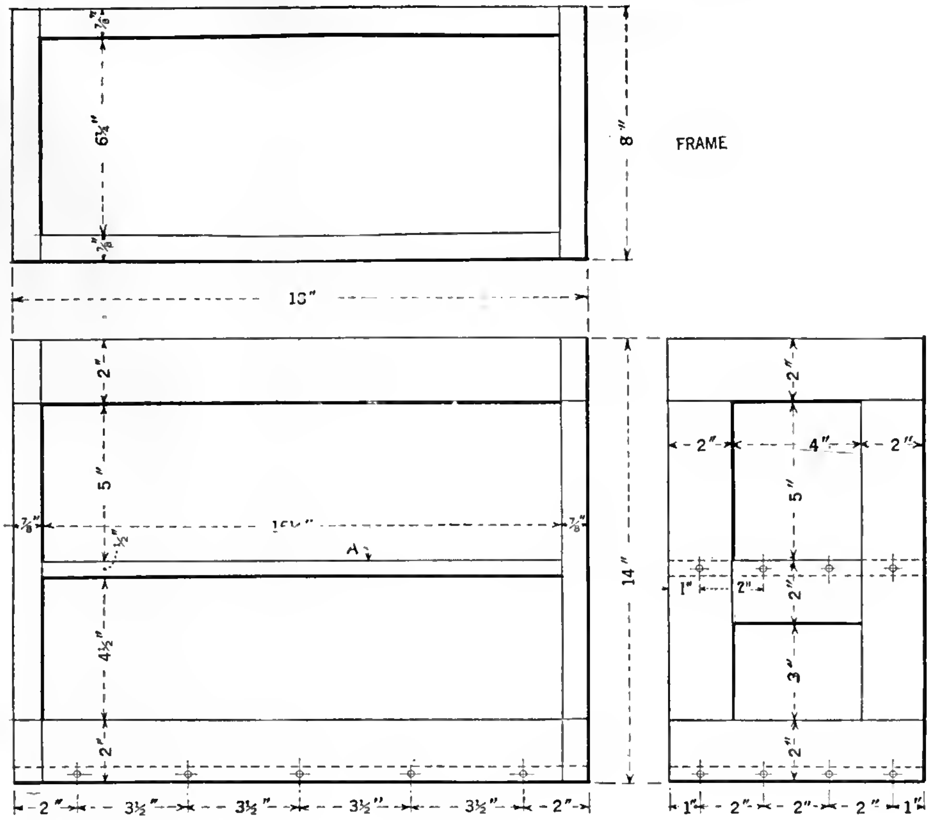


FIG. 11

PARTS USED IN THE TRANSMITTER

L_1, L_2, L_3, L_4, L_5—Aero Coil Kit, Type 4080	$12.00
L_6—Amertran Choke Coil, Type 709	10.00
C, C_1, C_2—Three Cardwell 0.0005-Mfd. Variable Condensers, type 173-C	15.00
C_3, C_4—Two Sangamo 0.00025-Mfd. Fixed Condensers	1.00
C_5, C_6—Two Tobe 1.0-Mfd. Bypass Condensers	1.80
T—General Radio Modulation Transformer	6.00
R—Mountford 12,000-Ohm Grid-Leak Resistor	1.50
S—Federal Four-Pole Double-Throw Switch	3.20
J—Yaxley Open-Circuit Jack	.50
P_1, P_2—Two Carter Telephone Pin Jacks	.60
A—General Radio 1-Amp. Antenna Ammeter Model 127-A	7.75
I—Weston 200 MA. Milliammeter, Model 301	8.00
Westinghouse Micarta Panel, 14 Inches x 18 Inches	5.00
Three General Radio Sockets, Type 156	3.00
Three General Radio Dials, $2\frac{3}{4}$ Inches in Diameter with Indicators	1.80
Nine X-L Binding Posts	1.35
Two Burgess Radio A Batteries	1.00
Federal Microphone	7.00
TOTAL	$86.50

The transmitter requires three 210 type tubes (DeForest type DL9) and the power supply employs two single-wave rectifiers of the 216-B type.

POWER UNIT PARTS

T—Thordarson Power Transformer, Type T-2098 (containing two filament windings and a center-tapped high-voltage winding)	$20.00
L—Thordarson Double Choke, Type T2099	14.00
C_1—Tobe 2-Mfd. High-Voltage Condenser	3.50
C_2—Tobe 4-Mfd. High-Voltage Condenser	6.00
C_3—Tobe 1-Mfd. Bypass Condenser	.90
R—Yaxley 1000-Ohm Potentiometer	2.00
R_1—Lynch 50,000-Ohm Fixed Resistance	3.00
Two Eby Sockets	1.00
Nine X-L Binding Posts	1.35
TOTAL	$51.75

The parts given in the two lists were used in the two units designed by John B. Brennan and illustrated in this article, but the parts of any other reputable manufacturers may be used if they are electrically similar.

CONSTRUCTION

IN THE actual physical layout of the transmitter considerable care was taken to keep the size of the unit as small as possible so as to make it easily portable. The method of construction will be evident from the various photographs in this article. The transmitter was built around a wooden framework having the dimensions given in Fig. 11. The tube sockets, coils, fixed condensers, grid leak, radio-frequency choke coils, and filament bypass condensers, were mounted on the shelf "A," Fig. 11. On the floor of the framework are mounted the two dry cells for the microphone, the Heising choke coil, and the modulation transformer. Extending from the rear of the shelf is a terminal strip holding nine binding posts. At the end of the transmitter is another small strip on which are mounted two additional binding posts for the antenna and counterpoise connections.

The following procedure should be followed in constructing the transmitter:

(1) Assemble the wooden frame in accordance with the data given in Fig. 11. Do not fasten the shelf very tightly.

(2) Lay out and drill the main panel in accordance with Fig. 12.

(3) Mount the various instruments on the panel and then fasten it to the wooden frame.

(4) Remove the shelf from the frame and mount the various instruments as shown in the illustrations.

(5) On the floor of the frame mount the batteries, choke, and modulation transformer.

(6) Drill $\frac{3}{16}$" holes through the shelf at the points where connections are to be made to the tuning condensers.

(7) Run long bus bar connections from the terminals of the three tuning condensers to points tallying with the position of the holes previously made in the shelf.

(8) Mount the shelf in place, passing the wires from the condensers through the holes in the shelf.

(9) Complete the connection of these wires to the coils.

(10) Wire the rest of the transmitter using No. 18 lamp cord for the power and filament leads and bus bar for the "hot" connections—i.e., grid and plate leads.

THE POWER SUPPLY UNIT

IN THE first part of this article mention was made of the fact that a power unit had been designed to supply this transmitter. This power unit is illustrated in photographs on page 216. The construction is very simple. The power transformer, filter chokes, filter condensers, and tube sockets are all mounted on a baseboard measuring $7\frac{1}{4}$" x $15\frac{1}{4}$". The binding post strip is mounted on two brass supports so as to come even with the top of the Kennedy Tool Kit case in which the power unit is finally placed. The center support of the binding post strip is a piece of round brass, and this support is used as a mount for the 50,000-ohm discharge resistance. C bias for the grids of the two modulator tubes is obtained from a 1000-ohm potentiometer placed in the negative plate circuit, and with it, voltages up to about 100 volts are available for grid bias. The binding posts on the power unit are arranged in the same sequence as those on the transmitter so that in connecting the two together it is merely necessary to connect wires between the corresponding binding posts. The main switch on the panel of the transmitter has one set of contacts connected in series with the 110-volt lead so that, with the switch in the center position, the power unit is off, and with the switch thrown to either the right or left, the power is on.

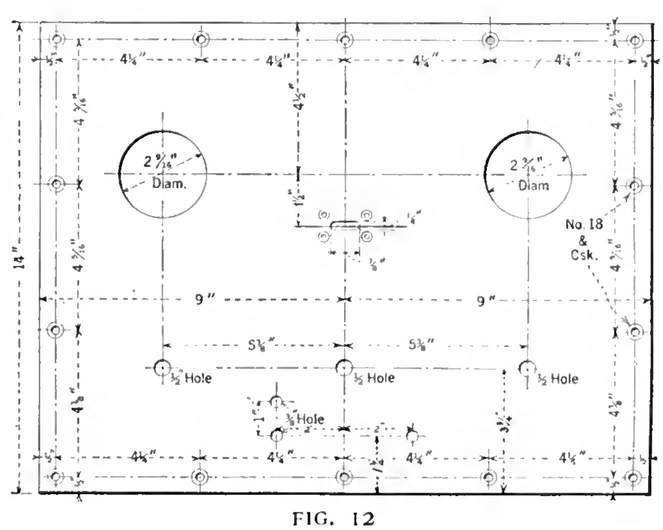


FIG. 12

THE LISTENERS' POINT OF VIEW

Conducted by John Wallace

Radio Is Doing a Good Job in Music

WITH all our skeptical remarks about radio education we have never yet expressed any mistrust of the important rôle radio can play, and is playing, in educating the populace in music appreciation. And when you get right down to it, even if the educational force of radio extends no further than this, there is small cause for complaint. Far more is gained by the initiating of ten people into the pleasures of music than by filling ten hundred with a miscellany of facts about economics or hog raising.

In the particular day and age in which we live there is a howling need for educating people in things esthetic and a very slight need for educating them in things practical. That is, there is very slight need for radio's exerting itself to educate them in practical things for a plethora of existing agencies is already busily engaged in bearing this burden.

Colleges and universities have increased their number and enlarged their enrollments to such a degree that it has come to be no longer a mark of distinction to attend one, but on the contrary rather classifies one as a member of the herd and the Babbittry. Technical schools, business colleges, night schools, and correspondence courses are likewise flourishing in a way never dreamed of a generation ago. The cities, through their health departments and citizenship bureaus, are daily educating thousands, and the bigger businesses and industries maintain after-hours schools for their employees. Even the newspapers devote columns to educational features and of course the current question book vogue is doing its bit toward equipping the man in the street with a knowledge of the date of the Battle of Waterloo and the specific gravity of lead.

ENTHUSIASM AT KPO

If this is the sort of thing you like, Hugh Barrett Dobbs, physical culture mentor, will be glad to put you through some pre-coffee exercises from KPO at some unearthly hour of the morning

In short, the man in the street is nowadays quite surrounded by persons who are both willing and anxious to educate him in any branch of practical knowledge, and who will do it for a song and at hours to suit his convenience. So even if radio does add its voice to those of the other practical educators it will augment the present clamor by only a small chirp.

Education in the useful arts is not to be railed at. In the nature of the present Western civilization it is as inevitable as tall buildings and prohibition. But it is not amiss to point out that for all the good it accomplishes, it in no wise assists in making more pleasurable man's journey through this terrestial sphere. In the good old days before we became so highly civilized the average man found in his day's labor not only the means to support himself in the world, but also the means to escape said world. Almost everyone was a craftsman of some sort. If an individual's job happened to be the making of door hinges, it earned him his daily bread; but more, it enabled him to escape into the realms of fancy in inscribing on the hinge elegant bits of embellishment. A man in the hinge business to-day, if he be among the higher ups, is embroiled in an unvarying routine of paper transactions, or if he be lower down, passes his days before a whirling bit of machinery, pressing a specified lever at a specified time and thus drilling a specified hole in a specified hinge on an endless belt. So occupied, there is little chance for his spiritual half to go wandering about in the great unmowed spaces of the fancy.

Of course means of escape still exist, but such specialists has our civilization made of us that they seldom exist in our day's routine. The impractical, and hence wholly pleasurable things, have themselves succumbed to civilization and become departmentalized. The arts, as we find them to-day, have been isolated like mumps and typhoid germs, tucked away into tightly sealed compartments and, like a bottle of strychnine, have been plainly labeled "Music," "Drama," "Painting," "Poetry," and so forth.

In the middle ages, before man was thoroughly educated, he got his drama by putting on a costume and cutting up on the great public festival days. Now the drama has been segregated and is to be found only in certain buildings labeled "Theaters." In those same days if a great and artistic cathedral were being built every man in the village would have a hand in it. Now all living art is cloistered away in "Latin Quarters" or placed under glass in gloomy and forbidding museums.

This is an unfortunate state of affairs, for if there was ever a time when mankind stood in need of the arts it is mankind of the Western civilization to-day. Being more highly civilized than his ancestor, man of the Twentieth Century is entitled to more highly civilized forms of recreation. The incongruous fact of the case is that his progress in pleasurable pursuits has not kept apace of his progress in practical pursuits. In his day's work he may be able to do things with a column of figures or with a lathe that would have completely mystified his prototype of the Thirteenth Century, yet when the five o'clock whistle blows he finds himself with no wit more knowledge of how properly to divert himself than did his ignorant forbear.

Logically, and by all rights, the arts should be enjoying their greatest usefulness to-day. They should rank high among man's various means of gaining pleasure and escaping dull routine. Evidently they are not so doing. Never in the history of the present culture have they been more exclusive, snobbish, and aloof.

But while these preceding remarks may hold true for the majority of the arts, they can no longer hold true for music. While the art of painting has steadily increased in complexity until it has reached a state where it is utterly beyond the grasp of the ordinary man, the art of music has intruded itself into his daily routine and once again become a part of his living.

There is no need to trot forth statistics, to quote questionnaires, or to tabulate radio station correspondence; the fact is beyond dispute that music is enjoyed and appreciated in the West to-day in a degree immeasurably greater than it was five years ago. Music is being heard to-day from all sorts of stations and on all sorts of programs that a few years ago would have been essayed only by the most highbrow station on its most highbrow hour.

We do not delude ourself that radio has been able to contribute a highly sophisticated taste in music to very many people. But (what is vastly more important as an opening wedge), it has given a taste for music to millions of people who previously hardly knew it existed.

However, great as the development has been, so far only the surface of music's possibilities has been scratched. The most radio has done so far is to acquaint the great mass of people with the fact that there is such a thing as music and that it is pleasant to listen to. Its next step is to cultivate the taste of its listeners to the point where they may get the most—or at least more—out of it. For any given piece of music will yield a hundred times more enjoyment to the person who "knows what it's all about" than to the person who simply listens to it as a vaguely pleasing succession of sounds. Yet an understanding of music is never gained by accident but can be realized only as the result of definite instruction in music appreciation.

What with all the zeal there is to-day for the imparting and securing of "education" there seems to be no good reason why some of this zeal may not be turned to the interest of music appreciation education. Radio is the best fitted agent to do this work and can function to its own best advantage by forgetting all its silly aspirations to supplant the technical college and by devoting itself to this equally large and far more important task.

Not all the millions of people in the United States who own receiving sets have the intelligence to really get the low-down on what music is, but that does not controvert the fact that there are thousands upon thousands of people in the land who have got the mental equipment to enjoy music if they put themselves to it. It is amazing how many people who are apparently cultivated, well educated, and surrounded by opportunities, and who profess to enjoy music, can be discovered, by a couple of well-directed questions, not to have the remotest idea of what music really means.

There are many excellent books on the market and in the public libraries which offer primer courses in the understanding of music. A very acceptable one, devoting itself primarily to radio listeners, was recently reviewed in this magazine. The only objection to learning music from a book lies in the fact that the book can't play the music it is talking about. It can quote measures but if you are unable to read music this is of little use.

Herein lies the unique advantage of radio; it can offer explanations and at the same time illustrate them. There have been a number of music appreciation programs on the radio already but the saturation point has been far from reached. An impetus in this direction is furnished by the report, new at the time we write, that Walter Damrosch has accepted the post of Musical Counsel for the National Broadcasting Company and has already under way a comprehensive plan for promoting fine music through the medium of radio broadcasting. This plan provides for a series of concerts supplemented by talks which can reach the majority of the 25,000,000 students in American schools and colleges. At the time of the announcement Mr. Damrosch made a statement, which, in case you have not read it, we will here quote:

My experiences of the past winter in broadcasting orchestral concerts with the New York Symphony Orchestra and in giving Wagner lecture recitals at the piano have so amply borne out my belief in the extraordinary possibilities of radio broadcasting that I have accepted with the greatest interest the position offered me as Musical Counsel of the National Broadcasting Company.

The plan which I propose to follow is the outcome of over 25,000 letters which I received not only from the larger cities, but from the smallest country towns and Western farms and ranches. In many of these letters the wish is expressed that orchestral music by radio should be extended to our schools and colleges—that my concerts and explanatory comments could thus supplement the work done by local teachers in the schools. This suggestion appealed to me greatly. The possibility of playing and talking to an audience of 25,000,000 young people fascinates me to such

MICKEY MCKEE
An accomplished lady performer on the whistle—her own—and heard in the "Roxy and His Gang" broadcast on the Blue Network Monday evenings

an extent that I shall gladly carry out the plan if it proves acceptable to the school authorities.

I propose to give twenty-four orchestral concerts with explanatory comments on the works presented and on the instruments of a symphonic orchestra. These concerts shall be broadcast to every school and college in the country that chooses to accept them. There will be three series of eight concerts each, with carefully graded programs, one for the elementary schools, another for the high schools, and the third for colleges.

Previous to each concert I would send to every school that desires it a questionnaire on the music to be performed and on my explanatory comments, together with the proper answers. These answers would, of course, be intended only for the eyes of the music teachers. After each concert the pupils could be examined by them and rated accordingly. If the parents are interested as well, the questionnaires could be distributed to them also, either through the school authorities or the local newspapers. The papers could print the answers a few days later.

The "Continuity" Program

WEAF Network. The "Coca Cola Girl!" The opening program of a new series. Advance notices prepared us to expect great things of this new weekly serial. It would, we were told, "combine drama and music in a manner never before used in radio." At last, we told ourself, we are to hear the ideal continuity program. So much for our expectations—we are still looking for the perfect "continuity" hour. The soft drink damsel's program is not it.

The saddest part of it is that it could have been. The general idea of the new feature is not bad at all—in fact, it's very good. But its execution is—terrible.

Each broadcast in the series is to present an episode in the life of one "Vivian," a beautiful young Southern girl. The first one saw her at her "coming-out" party, an occasion which brought back to her home town her friend of childhood days, Dick Amberson, accompanied by his friend James. Jim promptly fell in love with her, and, it is to be presumed, will pursue her through the remaining episodes. During their conversations snatches of music are introduced illustrative of what they are saying. So you see, the idea had marvellous possibilities.

But neither the actors nor their lines are good; though acting and lines would seem to be two important elements in drama. The lines are amateurishly written and horribly stiff. Jim being presumably an average American youth would probably have said, upon viewing Vivian, "Pretty swell-looking bimbo!" or something equally inelegant. Instead he is made to say: "I suppose everyone that lays eyes upon her is captivated by her." And on one occasion he is made to ejaculate "Capital!" To the actor's credit, whenever he has a line that isn't too infernally impossible he puts quite a bit of conviction into it. But the Vivian, aside from the handicap of poor lines, is ill suited for the part. She may *look* young, and beautiful and Southern, but all we have to go by is her voice, which, though not displeasing, is certainly not young or Southern. It is decidedly matronly and decidedly eclectic in its accent.

THE MUNICIPAL BAND OF BALTIMORE
Heard over WBAL every Friday night at nine o'clock E. S. T.

We dwell thus long on a feature which certainly doesn't deserve the space simply because of the great possibilities which it has left unrealized and because it paves the way for some other advertiser to take up the same idea and handle it properly.

How is it to be done properly? Well, it would take a considerable outlay of funds. In the first place, it would take an expert to compose the lines. It seems to us that the best writer available would be none too good. To suggest a couple of names, either Mary Roberts Rhinehart or Booth Tarkington could do the job handily. Either one could, without much effort, compose a series of thirteen episodes that would be not only true to life and entertaining but which would provide an interesting commentary on the contemporary younger generation.

Next a couple of talented, well-seasoned actors would be necessary to acquit the lines convincingly. The program here reviewed lacked what is known to the stage as "click." That is, the speakers didn't follow, overlap, or interrupt each other in a way characteristic of natural conversation. It can be done, and the proof of it is "Sam 'n' Henry." Whether you like these two WGN entertainers or not you must admit they deliver their stuff in a most expert and realistic manner. These actors would not have to be the same ones who furnished the singing bits as it is an easy matter for radio to double a singer without anyone knowing the difference.

As to the interwoven theme of music, we think in this phase of the program, at least, the "Coca Cola Girl" did itself proud and any subsequent imitiation of this program could study its method of handling the "score" to advantage.

We offer these suggestions for an ideal continuity program to whomsoever will take them. To engage the services of a "best-seller" author would, we grant, cost a lot of money. But we think it would be repaid in the prestige it lent the program. Moreover, it would intrigue many thousands of the more sophisticated radio set owners into listening without in any way diminishing the pleasure of the low-brow listeners who gobble up anything like this, good or bad.

Tolerating Jazz

VARIOUS readers of this department have belabored us for what they call our "leniency" toward jazz. But if "leniency" is not the attitude to adopt toward jazz we do not know what is. There is no use getting mad at it. It is no unnatural, monstrous thing to be shunned like a two-headed dog, but a perfectly normal manifestation of the present age. Jazz, as jazz, is no more reprehensible than a hot dog. Hence our failure to rant against it periodically. To be sure, we should not like to have a steady diet of jazz any more than we would like to have a steady diet of hot dogs. But there are times when the lowly weenie hits a spot that even a sirloin smothered in onions cannot reach.

There is still too much jazz on the radio, we grant; especially in the hinterlands. But fortunately most of it occurs at hours when good folk have gone to bed so it bothers us not. Those who like jazz are, we believe, entitled to it, and are not to be too much reviled for liking it. Those who understand real music realize, as no jazz addict ever can, that jazz is indeed a namby-pamby substitute for music; *but*, by way of vindicating them, list to what Paul Whiteman says in an article contributed to the New York *Times* Magazine:

I sincerely believe that jazz is the folk music of the machine age. There was every reason why this music sprang into being about 1915. The acceleration of the pace of living in this country, the accumulation of social forces under pressure (and long before the war, too), mechanical inventions, methods of rapid communication, all had increased tremendously in the past 100 years—notably in the past quarter century. In this country especially the rhythm of machinery, the over-rapid expansion of a great country endowed with tremendous natural energies and wealth, have brought about a pace and scale of living unparalleled in history. Is it any wonder that the popular music of this land should reflect these modes of living? Every other art reflects them.

Like the folk songs of another age, jazz reflects and satisfies the undeveloped esthetic and emotional cravings of great masses of people. Such music in any age has not been entirely negligible. Jazz is a spirit, not a manner. Crude, unmusical perhaps, but as healthily vulgar and sincere as were the vulgarities of the Elizabethan age—the music of an uneducated, vigorous man struggling ungrammatically to express his response to the age in which he is living. Since when in music have these forms of music been pronounced dead and worth ignoring?

THUMB NAIL REVIEWS

XXX—Due to a perhaps commendable reticence on the part of the broadcaster we were unable to discover what station was offering the program, but it was one of the best variations of the informational program we have yet heard. The two speakers were presumably touring in Alaska. The one asked the other various questions about the scenes and properties peculiar to that region with well-feigned curiosity. For instance: "What are those carved telegraph post things up in front of the houses?" Whereupon the other, who knew his Alaska, launched forth into a lucid and conversational explanation of the totem pole, and, led on by further questions, discussed their history, related how they were the personal insignia of the great families, just as are our family crests, explained why some are higher than others and included a bit of native gossip as to why one of them featured the bear among its carven decorations. By some hook or crook, music was worked into the feature to lighten it up a bit. We found ourself thoroughly interested, though ordinarily we loathe being "eddicated" by radio, and picked up quite a number of miscellaneous facts about Alaska that we had never heard of before. Only pressing duties at other parts of the dial induced us to desert it before the concluding announcement.

WJZ and the Blue Network—George Olsen and his Stromberg-Carlson orchestra. Of all its departments radio is probably best represented in its "light" orchestral section. There are no end of first-rate dance orchestras, hotel orchestras, and advertiser sponsored orchestras that can be regularly relied upon to play what they play well. Of these the Olsen organization is among the very best. Its program of popular numbers on this occasion was made up of some juicy and not-too-often-played tunes, among them: A Shady Nook; An Olsen Tango; Puszta Marden Waltz; An American Fantasy; and Melancholy Melody.

WJZ and the Blue Network—One of a series of operatic concerts under the direction of Cesare Sodero, featuring as soloists, Astrid Fjelde, soprano; Elizabeth Lennox, contralto; Julian Oliver, tenor; and Frederick Baer, baritone. Another chain feature that can always be counted on to be exceedingly good. The ordinary operatic program is inevitably made up of only the most popular arias of the various operas and fails to consider the second most popular and third most popular arias, which are often quite as good. The WJZ operatic hour gives the second string tunes a chance. For instance, on this program "Samson and Delilah" was represented by "Printemps qui Commence" instead of by the customary "Mon Cœur à Ta Voix." The "Mon Cœur" aria is certainly a "wow" but it shouldn't be allowed eternally to displace the "Springtime" song, which is every bit as musicianly and even more interesting on repeated hearings.

Broadcast Miscellany

ONE of the high spots in the history of KFI's broadcasting was the program contributed last spring by John Barrymore—a Shakespearian Hour. Mr. Barrymore is probably the foremost American Shakespearian actor. He included the soliloquies from Hamlet and King Richard the Third.

THERE ARE FEW BASS VIOL SOLOISTS

RADIO certainly permits you to hear musical curiosities which ordinarily wouldn't be stumbled across in a lifetime. Witness: the Edison Hour program from WRNY which featured Leon Ziporlin as soloist on the bass viol! There are only a handful of players in the country to-day who have mastered this ponderous instrument to the point of virtuosity.

WHAT A WINDOW-DRESSER THINKS ABOUT

OCCASIONALLY our name gets on the wrong mailing list and we are privileged to get in on some of the trade talk of the radio beezness, with frequently laughable results. This contribution to genuine and heartfelt sentiment by a "Dealer Bulletin:"

Another opportunity for ———— dealers. Possibilities of unusual window displays and newspaper ads selling the idea of remembering Mother by giving her a ———— Radio. Mother's Day comes but once a year—make the best of this opportunity. Dress up those windows—suppose you use a few photos of typical mothers, flowers, etc.

MISCHA ELMAN TALKS A BIT OF NONSENSE

A LOT of red-hot hooey contributed by Mischa Elman to the *Amplion Magazine* (London):

Can an artist give his best over the wireless? Judging from some sets I have heard, the best modern receivers are capable of reproducing the tone of a violin—even that of my £10,000 Strad—almost perfectly, but I am afraid an artist's personality suffers loss when he broadcasts.

The question of personality and broadcasting has been discussed a great deal since the introduction of wireless. I believe that a speaker can develop to a very high degree what is generally called "wireless personality," but in the case of a musician, it is inevitable that a great deal must be lost in transmission through the ether. If you consider the question carefully you will find that in listening to a violinist in a concert hall you use all your senses—chiefly your eyes and your ears, but your other senses also to some extent. The combination of these feelings enables you to appreciate the music to the full—to "sense" the artist's personality to the full, and, after all, that is the object of going to hear him.

Sight is very important—not because it enables you to admire his virtuosity in a set of Paganini variations, but because it enables you to "take him in"—to sense his personality.

THE book review and literary period presented over WOW every Saturday evening from 8 to 8:30 has proved one of the popular features of the station. The period is conducted by Eugene Konecky, of WOW's staff. The latest books are reviewed by Mr. Konecky.

WALTER MALLORY AT WCCO, MINNEAPOLIS-ST. PAUL

Mr. Mallory, a popular tenor, sings with the Buick Gold Seal Vagabonds from WCCO each Monday from 9 to 10 P. M. Central Time

GILBERT SELDES in the *New Republic:*

I have tried again and again to make myself a picture of the air at one of those moments when every tiny turn of the dial brings something new to the loud-speaker. It hardly seems possible that so many things could be of interest, that so many people would be trying to sell or persuade or exploit. Maxwell House Coffee presents old Southern melodies; Mrs. Augusta Stetson talks about God-de; *Collier's Weekly* transposes its forthcoming issue into music and drama; the political situation is summarized by Frederick William Wile; dinner music is broadcast direct from Janssen's Midtown Hofbrau House; Aimee MacPherson wishes that she could tell you how lovely Jesus has been to her; specialists speak on recondite subjects which suggest that they have collaborated with Robert Benchley; a lesson in Spanish from the municipality's own station; a plea for Jews to speak Hebrew; how to take care of an Airedale; Al Smith addresses newsboys and can't remember what year this is—waves, voices, personalities crowd each other, interfere with each other; a faint hum of jazz accompanies a Catholic priest; a prize-fight cuts into Bach; as you rapidly turn the dial from one end of the gauge to the other, you hear grunts and shrieks and the wild whistle of static. It is everything that America is interested in; it is America.

WARNINGS TO PURCHASERS

AN INCREASING number of local organizations of the National Better Business Bureau are taking up broadcasting as a means of disseminating their findings. The Bureau, as you probably know, busies itself at the ferreting out of dishonest practices in advertising or in selling, and its exposes are generally interesting and always valuable. The following stations are now used by Bureaus:

WNAC—Boston	KFJR—Portland, Oregon
WMAF—Chicago	WJAR—Providence
WSAL—Cincinnati	KFSD—San Diego
WTAM—Cleveland	WIAN—Scranton
WAIU—Columbus	WSBF—St. Louis
WWJ—Detroit	KWG—Stockton
WOWO—Fort Wayne	WFBL—Syracuse
KPRC—Houston	WIBX—Utica
WOQ—Kansas City	WRC & WMAL—Washington, D. C.
KFON—Long Beach	

A POPULAR WGN FEATURE

THE Salernos—Frank and Lawrence—are one of the best of WGN's several twenty-minute regular features. Their program opens with Lawrence, the vocal member of the pair, singing an old Neapolitan street song, to his own guitar accompaniment, while Frank supplies an accordion accompaniment in the background. Then they go into old Italian folk-songs, Frank interjects several accordian solos, and Lawrence devotes his excellent baritone voice to classical and popular numbers.

Correspondence

NARRAGANSETT, RHODE ISLAND.

SIR:

It is primarily for the more technical articles that I read *R. B.*, but nevertheless your department is always interesting. Was pleased with your grilling at the "Radio-Pest," but your rules for operating a radio set, like too many of the suggestions and informative articles appearing in the radio magazines, are all very well for the city listener, but how about us, provincials? In my own case, the nearest broadcasting station with any power is 35 miles away with 500 watts. There is no high-powered station within 125 miles. Our first move in the evening is to find out whether the static is bad. If it is we go to the show, or maybe read. At any rate we have no local station to fall back on when a bad night comes along.

Suppose there is no static. Do we pick out a good program and wait for that time before tuning in on the set? We do not. We have learned better. Although I knew better than to try it, one Wednesday evening, recently, I decided to read until time for the Maxwell House program. There was little or no static, so that one should have no doubt about being able to enjoy the program. The concert started at 9:00 P. M., and all was fine until about 9:10 when a ship with a spark set started calling Tuckerton, WSC. The operator called almost steadily until 9:30. At that time another ship called and got WSC and QSQ'd; received instructions to QSR from the other ship, and did so. At 10:00 P. M., when the Maxwell House concert was presumably at an end, the tail end of the QSR'd message was just getting into Tuckerton.

The above is just one instance. Every evening we are bothered by spark sets. Since the S.S. *Boston* and *New York* started the season, conditions are worse than ever. WJK will call WEL for some time, then will start sending long dashes and the "three dot dash dot" combination. This is often kept up for the duration of a feature program, one which has been anticipated, maybe, for a week.

We don't mind the harmonics of the c.w. sets, but the sparks spoil the program on any wave down to 300 meters or below. This looks so much like a complaint that perhaps it should go to the Commission; but I will send it to you to show how we, in the outlying districts, need a little help.

H. C. DOW.

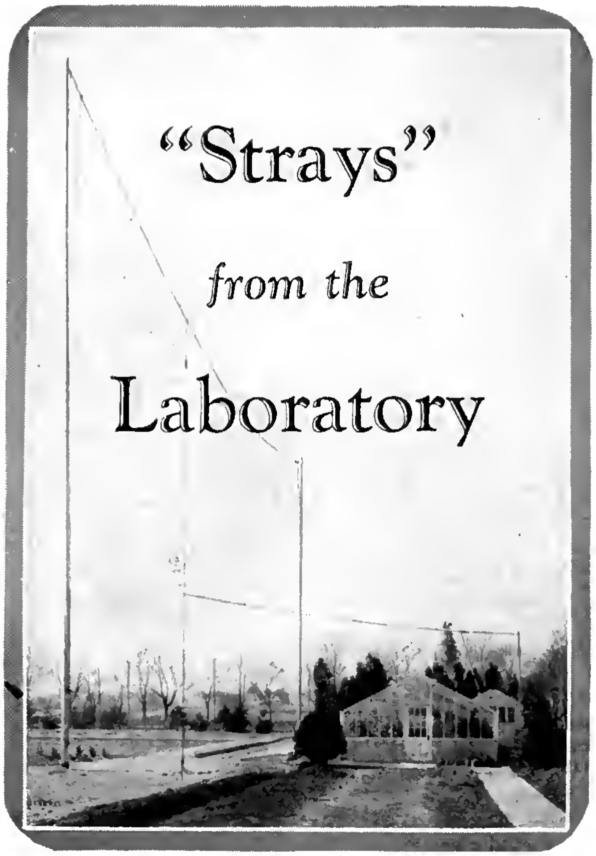
PARK V. HOGAN

Organist heard from WJZ during the Estey Organ Recital on Sundays at 7.00 o'clock

THE CROSLEY MOSCOW ART ORCHESTRA

A recent bi-weekly feature broadcast on Sunday afternoons over twenty-two stations of the Red Chain. This feature was on the air between 5:30 and 6:30, a time which had been practically open until the institution of the Crosley feature last winter. The violinist standing before the microphone is Arno Arriga, Director of the Orchestra. This group specialized in semi-classical selections, which were found to suit the popular taste best. They are scheduled to return in September

"Strays" from the Laboratory



The "Myracycle"

AMONG the many suggestions made to the newly created Federal Radio Commission is that of a gentleman from the Middle West whose wishes, if they came true, would do away with the term "kilocycle" in favor of a new and perhaps more useful expression, the "myracycle." The myracycle would represent a unit of ten kilocycles, and since stations on the familiar broadcasting band are to be separated by ten-kilocycle—or one-"myracycle"—intervals, the suggestion should not be dismissed without a hearing.

Using the term myracycle would mean that a station operating on 660 kilocycles would be rated at 66 myracycles, and at the top of the broadcasting band a station now on 1500 kilocycles would be known as a 150-myracycle station. This term would do away with the final cipher in our present listing of stations.

It should be remembered, however, that it has taken a number of years to bring the term kilocycle into even the outer consciousness of the average radio listener who still prefers to think in terms of wavelengths, and to introduce another term might put the whole business of frequency designations back into the middle age method of designation by meters. There is already another frequency term, the "megacycle," which represents a thousand kilocycles (one million cycles). We first heard it used in Doctor Pickard's study after his summer spent in measuring the polarization of high-frequency signals, and although it sounded strange at first, it proved to be very useful in speaking of amateur frequencies. The relation between these several units is shown in the table below:

1 cycle = 10^0 cycles = 1 cycle
1 kilocycle = 10^3 cycles = 1000 cycles
1 myracycle = 10^4 cycles = 10,000 cycles = 10 kilocycles
1 megacycle = 10^6 cycles = 1,000,000 cycles = 1000 kilocycles

The Use of Exponents

WHICH brings up another interesting point—the use of exponents in the arithmetical calculations in which all radio engineers must indulge from time to time. Exponents are among the mathematician's most useful shorthand symbols, as the table below will indicate:

1	$= 10^0$	= Units
10	$= 10^1$	= Tens
100	$= 10^2$	= Hundreds
1000	$= 10^3$	= Thousands (Kilo.)
1,000,000	$= 10^6$	= Millions (Mega.)

1	$= 10^0$	= Units
.1	$= 10^{-1}$	= Tenths
.01	$= 10^{-2}$	= Hundredths
.001	$= 10^{-3}$	= Thousands (Milli.)
.000001	$= 10^{-6}$	= Millionths (Micro.)

Now the rules dealing with these complicated looking figures are simple, and when mastered, provide an exceptionally easy method of handling large numbers, or numbers in which the decimal point of the answer is in doubt. The rules are as follows:

When multiplying numbers, add exponents.
When dividing numbers, subtract exponents.
When squaring numbers, double exponents.
When getting square roots, halve exponents.
When transfering an exponent across the dividing line, change its sign.

For example the following problem may be simplified and solved:

$$\frac{1234 \times 0.02 \times 1000 \times 64}{2468 \times 800 \times 0.001 \times 100}$$

$$= \frac{1.234 \times 10^3 \times 2 \times 10^{-2} \times 10^3 \times 64}{2.468 \times 10^3 \times 8 \times 10^2 \times 10^{-3} \times 10^2}$$

$$= \frac{1.234 \times 2 \times 64 \times 10^3 \times 10^{-2} \times 10^3}{2.468 \times 8 \times 10^3 \times 10^2 \times 10^{-3} \times 10^2}$$

$$= \frac{1.234 \times 2 \times 64}{2.468 \times 8} = 8.0$$

As a somewhat more practical problem, let us consider the formula which states that the resonant frequency of a tuned circuit in cycles is as given below, when the inductance is in henries and the capacity in microfarads. If the coils and condensers in question are rated in millihenries and micro-microfarads, what will the constant above the line become?

$$f \text{ cycles} = \frac{159.2}{\sqrt{L \text{ h } C \text{ mfd.}}}$$

and since mh. = 10^{-3} hand mmfd. = 10^{-6} mfd., this formula becomes:

$$f \text{ cycles} = \frac{159.2}{\sqrt{L \times 10^{-3} \times C \times 10^{-6}}}$$

$$= \frac{159.2}{\sqrt{(L C \times 10^{-3}) \times 10^{-3}}}$$

$$= \frac{159.2 \times 10^3}{\sqrt{L C} \times \sqrt{10^{-3}}}$$

$$= \frac{159.2 \times 10^3 \times 31.6}{\sqrt{LC}}$$

$$= \frac{5.033 \times 10^3}{\sqrt{LC}}$$

$$f \text{ kc.} = \frac{5.033}{\sqrt{L C}}$$

The Telephone Transmission Unit

THE use of exponents is the basis of our logarithms, as well as the foundation of the transmission unit, TU, which has been explained by Carl Dreher on several occasions in his department "As the Broadcaster Sees It." For example the exponent of 10^2 is 2, that of 10^3 is 3, and all numbers between 100 and 1000 have logarithms to the base 10 somewhere between 2 and 3. This amounts to saying that all numbers between 10^2 and 10^3 have exponents between 2 and 3.

The need for the transmission unit may be explained as follows. Let us suppose we have an electrical circuit—a telephone wire—connecting two points, and at the end of the first mile, the power has dropped to 0.9 of its original value. At the end of the second mile it has lost another 0.1 or is 0.9 of what it was at the end of the first mile, or 0.9 x 0.9, or 0.81, of its original value, and so on, to the end of the line. What is it at the end of eight miles? It is not only unwieldy to manage numbers of this sort but we must multiply them, which is less easy than addition.

Let us assign a unit to the ratio between the power at the end of the first mile to the original power, say A. This then represents the loss in that mile. Likewise, the ratio between the power at the end of the second mile to what appears at the end of the first is also A. In other words, at the end of the second mile we have lost twice A, or two units. If the line is eight miles long we shall have lost 8 units, and as Table No. 1 shows, the power will be 0.43 of its original value.

Reversing the direction of procedure along the line, as we approach the starting point we gain one unit for each mile of progress.

Again let us suppose that at the end of each mile as we go toward the end of the line we interpose an amplifier—a repeater as the telephone people call them—and that it boosts the power back to its original value. It is certainly much simpler to state that the amplifier has a power gain of A units than that it amplifies the power 1.111 times, for it must do such to raise 0.9 of the power back to its original value. The total gain of eight such repeaters will be 8 units.

The telephone engineer's foot rule, the transmission unit, is defined as ten times the logarithm to the base ten of the ratio between any two powers, or twenty times the logarithm of the ratios of voltages or currents into equal impedances. In mathematical language:

$$TU = 10 \log_{10} P_1/P_2 = 20 \log_{10} E_1/E_2 = 20 \log_{10} I_1/I_2$$

Thus an amplifier with a power gain of 100 has a gain of 20 TU since the exponent, or logarithm, of 100 is 2.0. Two of these amplifiers in series will have a gain of 40 TU or a power gain of 100 x 100, or 10,000. When a full orchestra plays fortissimo it is roughly 60 TU's more powerful than when playing pianissimo, a power ratio of 1,000,000. It is fortunate that the ear hears according to a logarithmic scale!

To become more familiar with the TU business the following facts may be useful. The average two-stage amplifier as used in broadcast receivers has a voltage gain of about 300, or 50 TU. The difference in power between a 500-watt station and one of 5000 watts is ten TU, and the latter enables a listener equidistant from the two to use 10 TU less amplification to get the same volume, which means that the receiver will be less susceptible to extraneous noises such as static. A variation of 10 TU at the two extremes of the audio-frequency spectrum, say at 100 or 5000 cycles, can be noted by the ear but will not make such an extraordinary difference in quality as some amplifier parts manufacturers would have us believe. That is, the volume at 100 cycles can be reduced by 10 TU, *i.e.*, the power can be reduced to $\frac{1}{10}$ or voltage to 0.316 of its former value before the ear notes it. A further reduction of 10 TU is appreciable.

Another example of the use of the TU, and one which merits very careful study, is shown in Fig. 1; it was taken from the *Bell System Technical Journal* for January, 1927, from an article by Lloyd Espenschied. The data for these curves which show the relative selectivity of several popular types of receivers were taken in the following manner. A laboratory oscillator was modulated at a fixed voice frequency, the receiver was tuned to the carrier, and the detected audio current measured as the oscillator was tuned in 10 kilocycles steps away from the original frequency.

The first significant point to note is that all receivers have a distinct cut-off within 10 kilocycles of resonance. Even at 5000 cycles the better grade receivers are 10 TU "down," which means that audio frequencies of this value will be down, and that a rising characteristic amplifier is probably a good idea. The curves show that the super-heterodyne or double-detector is considerably more selective than the others, and, as was to be expected, the simple single-circuit affairs have very little discrimination between wanted and unwanted signals.

Mr. Espenschied points out that undesired signals may not be bothersome when only 40 TU below the desired signals when the latter are strong, but when the program happens to call for a pianissimo passage the unwanted signals are disturbing. Reducing the level of the unwanted station to 60 TU eliminates this trouble.

The chart shows what may be expected in an area where stations are separated by 50 kilocycles and put an equal field strength about a given listening station. The sets with radio- or intermediate-frequency amplification give a 60-TU discrimination against unwanted signals with some to spare to take care of signals from more powerful stations. If the listener wants to "get out" he imposes a much greater task on his receiver. Suppose he receives 50,000 microvolts from a local station and 500 from a distant station (the example is Mr. Espenschied's). This represents a difference of 100 to 1, or 80 TU in favor of the local station. To reduce the local signals to the same level as the distant station, then, requires a selectivity of 80 TU and to take care of the added 60 TU necessary to reduce the local to the point where its signals will not bother during weak musical passes makes a total discrimination of 140 TU which the receiver must possess. This means a current reduction of the order of 10,000,000 to 1 —a high order of selectivity.

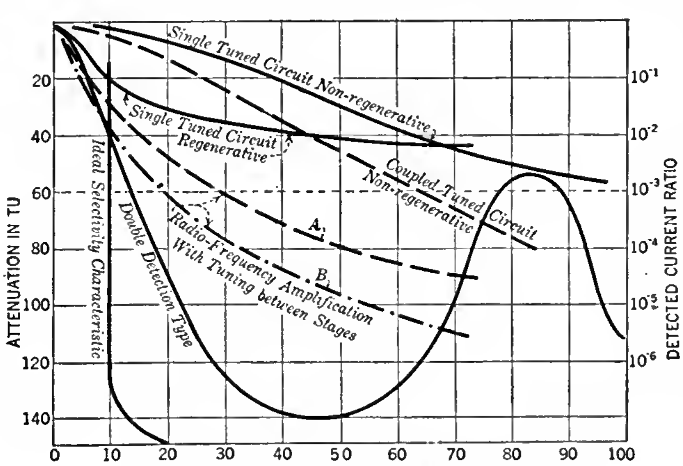


FIG. I

Colored Sockets and Bases

ONE of the most interesting items of news from the "Nema" convention at Hot Springs, Virginia, is that regarding the new color arrangement for sockets and tube bases. According to this code, which was proposed by the Benjamin Electric Company, the bases of radio-frequency and first-stage audio tubes, and the receiver sockets into which these tubes are used, will be colored maroon; the detector will be green, while the final tube, the power amplifier, and its socket, will be colored orange. The arrangement is, therefore, as follows:

MILES	0	1	2	3	4	5	6	7	8
POWER	1	0.9	0.81	0.729	0.657	0.59	0.531	0.478	0.43
"UNITS LOSS"	0	1	2	3	4	5	6	7	8
POWER TO BASE 0.9	0.9^0	0.9^1	0.9^2	0.9^3	0.9^4	0.9^5	0.9^6	0.9^7	0.9^8

TABLE NO. I

Maroon: R. F. and 1st amplifier	201-A, 199, 226
Green: Detector only	200-A, 199, 227
Orange: Power tube only	112, 171, 210, 120

If we wanted to be facetious, we would suggest a crimson tube for Harvard and one for Lindbergh in whatever his favorite color may be.

We wonder what will be done with the other special-purpose tubes, such as the r. f. amplifier tubes with higher amplification factors and consequently higher impedances, rectifier tubes, high-mu tubes for resistance or impedance amplifiers, etc.?

The suggestion, admittedly, provides precaution against the danger of wrecking tubes or receiver through unfamiliarity with the inner workings of a complicated electrical machine. The average user of tubes has very little idea of the functions of the individual parts of his set. In receivers with an unusual arrangement of sockets, he can not know that the third tube from the end is not the detector unless he is warned before, either by reading a more or less dull and technical booklet, or by noting the color of the socket. While this color scheme has much to commend it, it seems somewhat inadequate in its present form.

New A. C. Tubes

THE new R. C. A. tubes marked 226 and 227 operate from raw a. c.; their existence was vigorously denied by representatives of both the R. C. A. and Cunningham staffs only a short time ago. One day, seemingly, the very thought of new tubes is abhorrent to these companies, while the next day complete operating data, photographs, etc., drop into the Laboratory, by special delivery, like a bolt from the blue. In the meantime—that is, between our statement last month and the time of going to press this month—a. c. tubes have been received and tested from the Armstrong Electric and Manufacturing Company, the Van Horne Company, the Sovereign Company, and the makers of the familiar Marathon tubes. Others proposed or available are the Arcturus, the Schickerling, the Quadrotron, the Zons, and probably others.

These tubes in general use are of two types, those using a low-voltage high-current filament, and those employing an extra heater which is not electrically connected to the receiving circuit. These latter tubes require several seconds to heat up and "get under way." The others are ready for reception as soon as the current is turned on. The R. C. A. has tubes—ready perhaps early in July—of both types; the R. C. A. high-current tube is for all positions except detector, and the heater type is for the detector socket. All of these tubes require different values of filament voltage and current, making the problem for the transformer manufacturer, or the home constructor, difficult, to say the least.

The new a. c. tubes can be used in place of d. c. tubes now in use, but we must admit that with a high-quality amplifier and a high-quality loud speaker, we have not heard a receiver using the a. c. tubes which was as "absolutely without hum" as the advertising would indicate. This, however, may be the fault of the receiver or plate-supply unit design. Time will tell.

Complete data on the various a. c. tubes will be prepared in time to appear in the September RADIO BROADCAST, we hope.

New Apparatus Received

DURING the month of May, the following apparatus has been received in the Laboratory: Frost's new line of rheostats, jacks and sockets; resistances from American Resistor Company, Arthur H. Lynch Incorporated, De Jur, Electro-Motive Engineering Corporation, Aerovox, International Resistance Company, and Amsco; condensers from Aerovox, John E. Fast Company, Dubilier, and Globe Art Manufacturing Company; sockets and cables from Howard B. Jones; A. C. tubes from Marathon, Van Horne, Armstrong, Sovereign Electric and Manufacturing Company; d. c. tubes from the Allan Manufacturing Company, Supertron, Magnavox, and Cable Supply Company; a pair of push-pull, high-quality transformers from Samson; a midget cone speaker from the Alden Manufacturing Company; a fine supply of Benjamin apparatus, including sockets, switches, condensers, etc.; a "Baritone" loud speaker unit; output filters from Federal, Erla, Muter, and Centralab; a new dry rectifier unit from Kodel; X-L binding posts; the Varion, a Raytheon A, B, C unit made by the Morrison Electric Supply Company, and recently described in *Popular Radio*; Marathon's new rectifier tubes; and as this is written, two very beautiful Westinghouse high-resistance volt meters.

The General Radio transformer type 285-N is for use as a coupling device between the element of the string oscillograph and a high-impedance bridge or tube circuit, and not as mentioned recently in these columns.

Judging Tone Quality

Training the Ear to Discriminate Between Good and Poor Quality—How Harmonics Cause Different Instruments to Be Distinguishable—Practical Hints for the Potential Set Purchaser

By EDGAR H. FELIX

APPRECIATION of good tonal reproduction is an art rather than a science. Scientific analysis of amplification curves are valuable to the engineer in determining possible causes of distortion, but the best and final test of reproduction quality is the ear of a trained and practiced observer. In working for good tone quality from a radio receiver, whether manufactured or home built, half the battle is understanding what good tone means.

In spite of the average radio enthusiast's opinion, not one in a thousand listeners is a discriminating judge of tone quality. Only most unusual exaggeration or the complete absence of low, high, or middle frequencies in the sound output of a receiver registers emphatically on the consciousness of the average observer. The most precise judgment which the self-appointed expert is able to pass upon a receiver's tonal capabilities is usually confined to such generalities as "good," "fair," and "poor." Yet the brain center of hearing is capable of making the most delicate discriminations. Only by learning to judge tonal defects with precision is one able to analyze the numerous possible causes of distortion in a radio receiver.

Much has been said and written regarding the causes of distortion. Oftentimes a particular make of transformer or a certain brand of sound reproducer is recommended as the panacea for deficient tone quality. But no one part of a radio set can, of itself, produce good tone. On the other hand, there is hardly a link in the radio chain which cannot exert a damaging influence on an otherwise perfect reproducing system.

In general, there are three kinds of distortion: (1.) Exaggeration of a particular frequency, causing a blasting effect; (2.) overloading, distorting all loud music of any pitch; and (3.) under or over amplification of a broad range of frequencies, such as the low, middle, or upper registers. Each of these is caused by specific faults in the design or operation of the receiver.

Simply that the causes of distortion may be viewed comprehensively at the outset, here is offered a partial list of the possible causes of distortion which may adversely affect the tonal output of a receiver, no matter what kind of audio and radio system is employed:

(1.) ANTENNA
- (a.) Too long, causing overloading of detector tube with sets lacking effective radio-frequency amplification control.
- (b.) Inadequate, requiring overworking of radio-frequency amplifier.

(2.) RADIO-FREQUENCY AMPLIFIER
- (a.) Regenerative or near-regenerative.
- (b.) Incorrect grid or plate voltages.
- (c.) Imperfectly synchronized circuits.
- (d.) Wrong type of tubes.
- (e.) Magnetic coupling with alternating current elements of power supply or with audio-transformers.
- (f.) Insufficient filtering or inadequate bypassing of power supply leads.

(3.) DETECTOR
- (a.) Overloaded:
  - (1.) By radio-frequency amplifier.
  - (2.) Because of incorrect grid voltage.
- (b.) Over-regeneration.

(4.) AUDIO AMPLIFIER
- (a.) Incorrect grid or plate voltages.
- (b.) Tube output impedance incorrect for load impedance.
- (c.) Audio-frequency regeneration due to:
  - (1.) Magnetic coupling between transformers or coupling devices.
  - (2.) Conductive coupling through imperfectly bypassed power leads.
  - (3.) Acoustic or mechanical coupling of tube elements with resonant cabinet.
  - (4.) Magnetic coupling with power circuits.
  - (5.) Acoustic or mechanical coupling with reproducer.

(5.) REPRODUCER
- (a.) Saturation of magnetic element.
- (b.) Incorrect adjustment of vibrating element in relation to electro-magnet.
- (c.) Mechanical resonance in moving element.
- (d.) Discrimination against or favoring of certain frequencies in the electro-magnetic unit.
- (e.) Acoustic resonance or filtering of certain frequencies in sound radiator.
- (f.) Limited frequency range of magnetic or acoustic elements.

This seemingly endless variety of possibilities may appear discouraging, so numerous are the hidden causes which may contribute to distortion. Nevertheless, modern amplification systems permit of relatively perfect reproduction, implying the conquest of each one of these possible causes of distortion. An optimist may be inclined to dismiss most of the list as unimportant and confine his attention to reproducer and transformers—favorite subjects for condemnation. But even the most superficial analysis will reveal that a few precautions in connection with the power supply, in the placing of the reproducer, and in the use of recommended tubes, will overcome most defects. Oftentimes, a slight readjustment will bring marked improvement in a receiver's tonal output. Other adjustments may make no perceptible contribution to improved tone quality, yet they may be, in fact, causing a really valuable improvement. Herein lies the most important obstacle to the attainment of true reproduction—the fact that the average listener is affected only *subconsciously* by most of the distortion to which he is subjected.

THE DELICATE SENSE OF HEARING

HOW delicate the discriminations which the ear can make, consciously or subconsciously, is indicated by the fact that there are 24,000 separate nerve endings in the ear membrane which may report impressions to the brain simultaneously. Each of these, habituated to the detection of conventional sounds of voice and musical instruments, is ready to report to the brain any deviation from the accustomed tone. Indeed, so complex and numerous are the impressions to which the sense of hearing may respond that we think definitely and specifically of only a very minute part of the actual impressions which the brain senses. If a loud speaker rattles harshly on a high note, you may notice it consciously and speak of it, but your trained ear has probably detected the existence of that rattle or harshness a thousand times a minute before it was sufficiently acute to be perceived consciously! The millions of subconscious recognitions of distortion which your highly-developed hearing sense impresses upon your brain each minute of listening to a "fair" receiver are of great importance because they make radio music sound tiresome and unpleasant. They cause it to be mysteriously unreal and are the reason why you sometimes shut off your receiver without being able to offer a valid reason.

The sense of hearing is a creature of habit and, after a few hours or even a few minutes of listening, it can accustom itself to a persisting form of distortion. This is the cause of most of the misjudgments made with regard to tone quality. After listening habitually to a receiver having certain distorting characteristics, listening to a better set without that same distortion may be, at first, quite disagreeable. At the same time, a receiver having the opposite characteristics (one exaggerating the "lows," for example, after the listener has become habituated to one with marked absence of "lows") sounds peculiarly pleasing, although it is also a distorting receiver.

As evidence that habit accustoms one to distortion, the first telephone conversation in any individual's experience is generally quite difficult because the lower voice frequencies, which contribute mellowness, resonance, and sympathy in tone, are strangely absent. After a little practice, however, the ear accustoms itself to this form of distortion, so that almost any voice can be understood over the telephone without difficulty.

Obvious distortion in radio reproduction, such as rattles, whistles, and howls, etc., or the wholesale absence of low or high frequencies, can be appreciated by the most untrained ear, but the radio receiver that attracts admiration is the one designed not only to eliminate obvious causes of distortion but to bring out the many hidden fine points of tone quality which impress only the subconscious mind of the average listener. Once the earmarks of certain kinds of distortion are clearly understood, the trained observer becomes competent to distinguish forms of distortion otherwise felt only subsconsciously. Appreciation of subtler kinds of distortion often enables you to find their cause in the radio-frequency amplifier, detector, audio-frequency amplifier, or loud speaker.

Mr. George Crom, Jr., of the Amertran engineering staff, has stated that the final test of a reproducing system is its effect upon the listener as measured over a period of several hours. If the loud speaker can be kept on continuously for many hours without wearying those within hearing or interfering with their regular occupations, it is likely to be reproducing with good quality.

Distortion due to resonance peaks and overloading is obviously distressing and most easily analyzed. But elimination of these obvious forms of distortion by correct adjustment of neutralization, elimination of undesirable interstage couplings, correction of overloading, and substitution of non-distorting coupling devices and reproducer, may yet fail in producing faithful reproduction.

Although there may be neither resonance peaks nor overloading, a receiver may still not give true music. In that case there is either insufficient or exaggerated reproduction of low, middle, or higher registers. Consequently, before proceeding with detailed analysis of causes, one must be able to recognize true reproduction—full, equal, and natural amplification of all of the essential range of frequencies.

Excellent reproduction is attainable in both transmitter and receiver, provided every element accomplishes its function properly. Perfect reproduction is not confined to any one system of amplification, such as resistance, impedance, or transformer, or to any one loud speaker. If this article appears to lay much stress, at first, on *what* good tone is, rather than *how* it is attained, it is because the understanding of this point is of great importance in analyzing the causes and capabilities of radio receivers and their audio-amplifiers and loud speakers.

INDEFINITE QUALITY TERMS

THERE is ample evidence in the advertising columns of any radio magazine that we speak of tone quality in most general and casual terms. Claims of instruments producing rich tones, mellow tones, and brilliant tones, and claims of good reproduction of low tones or upper harmonics, reduce frequently to admissions that such instruments distort. Yet tone is so little understood that a distorting quality may be claimed as a virtue. There is only one kind of reproduction which is to be sought as ideal and that is faithful reproduction, without any embellishments, exaggerations, or special qualities added to the original. Rich tone, for example, may be a pleasing contrast to thin tone, but it is a species of distortion which, in the end, is as tiring as thin tone.

True reproduction requires that the sound waves released from the loud speaker possess precisely the same characteristics as to frequency and amplitude as exist electrically in the audio-frequency modulation of the incoming carrier waves. This entails equal amplification of all the frequencies essential to good tonal reproduction, their transmission through all the various units of the reproducing system with equal facility, and their ultimate release as sound impulses, without any alteration. It means equal amplification of low, middle, and high registers, without marked resonance peaks. All these invisible qualifications of the perfect reproducer are manifest in its ultimate output—the music and speech impressed on the listener's consciousness.

Such faithful reproduction as described above is an attainable ideal but one quite beyond the reach of the average set owner. Satisfactory reproduction, however, requires fairly uniform amplification of the low, middle, and high registers rather than precisely equal amplification throughout the range, complete absence of sharp resonance peaks in the low and middle registers, and entire avoidance of overloading. But even granting these concessions to economy and simplicity from the ideal standard—true reproduction—it is surprising how far below the standard of satisfactory reproduction the average radio receiver falls.

Fundamentally, we are concerned with tone reproduction, with variations in air pressure, and with tiny air impulses mechanically set up by an electric machine. These impulses cause the diaphragm of the ear to vibrate, which, in turn, acts upon 24,000 sensitive nerve endings within the ear. Musical sounds are rhythmic variations in air pressure; noises or unmusical sounds are interrupted and irregular.

The most recognizable quality of tone is pitch. Pitch is the only characteristic of music which we record in printed form as notes upon the musical staff. Melody is a pleasing succession of pitches. The clear, colorless, sound of the tuning fork is perfectly "pure" tone.

Pitch is our conscious recognition of the fundamental vibration of musical sound. The fundamental of the middle C on the piano, for example, is one of 256 impulses per second. So, also, is the fundamental set up by every instrument or musical sound sounding that particular pitch. The greatest amount of sound energy released by a musical instrument is concentrated on the fundamental.

The chart on page 226 shows the range of fundamental pitches set up by various instruments and voices. The lowest tone of a giant organ actually goes down to sixteen impulses per second. No commercial reproducing instrument goes so far down in frequency; in fact, only a few radio receivers respond to less than 100 cycles frequency, while most of them confine their attention only to frequencies higher than 150. Yet even these latter receivers reproduce a sound when the organ is broadcasting its lowest tone. That sound is due to the harmonics—energy released as double, triple, and higher multiples of the fundamental frequency.

The individual characteristics of different instruments, which enable a hearer to distinguish one from the other, even when sounding the same pitch, are embodied in these harmonics. When three instruments, for example, sound the same tone, not only is the fundamental alike in frequency, but so also are the harmonics. It is the *proportion* in which energy is distributed among these harmonics of identical frequency that gives instruments their individuality. The highest note of the French horn has a fundamental frequency of about 850. If the reproducer cut off at 900, you could recognize the highest pitch, but you could not distinguish what kind of an instrument was being broadcast. In the case mentioned, the French horn's individuality lies in the proportion of energy distributed among the fundamental frequency and higher harmonics. In a good reproducer, the French horn is distinguishable from the clarinet, for example, because the latter ranges the energy among the harmonics in a different way.

It is on account of the harmonics that it is important for a reproducing system to cover a wide frequency range, at least up to 6000 cycles. In judging the capabilities of an amplifier, the easiest method is to observe how clearly and easily distinction can be made among various instruments.

The following table, showing the relative energy distribution among fundamental and harmonics of the harp, piano, and violin, was calculated by Helmholtz:

HARMONICS AND THEIR RELATIVE INTENSITIES

Harmonic No.	1	2	3	4	5	6
Harp . . .	100.0	81.2	56.1	31.6	13.0	2.8
Piano . . .	100.0	99.7	8.9	2.3	1.2	0.01
Violin . . .	100.0	25.0	11.0	6.0	4.0	3.0

An amplifying system which is very weak in the region of the first harmonic of a certain note of the piano but which gravely exaggerates its third and fourth, might well make the piano sound like a harp. The existence of resonance peaks may so greatly alter the tonal quality of similar instruments, without however affecting the melody, that the instruments cannot be distinguished, and subtleties of composition and orchestration are thereby lost.

Perhaps the importance of unimpaired and unaltered reproduction of harmonics is best appreciated by considering the mechanism of our organs of speech. Through the so-called vocal cords and diaphragm, we set up a fundamental tone or pitch and a wealth of harmonics. The different vowel sounds are produced by increasing or decreasing certain of these harmonics at will. In the mouth and throat are several resonance chambers, the size and shape of which we can alter with the aid of the tongue and jaws. "E," for example, is sounded by placing the tongue in such a position that one of the higher harmonics of the fundamental tone is stressed and the energy in intermediate harmonics reduced. It would be quite possible to make "ah" sound like "e" on a radio receiver for voices of a certain pitch by introducing a resonance peak at the proper point. Oftentimes the inability to understand speech from a radio set easily and without tiring is due to some such effect. Although we are never specifically conscious of a harmonic, the fundamental thing that makes a Stradivarius worth thirty thousand dollars and a cheap violin worth six dollars lies in minute percentage differences in the distribution of energy in their respective harmonics.

Certain instruments reproduce well on the poorest radio sets because their fundamental tones lie in the frequency range most easily reproduced and their harmonics are not important. A Hawaiian orchestra is particularly popular with the owner of an inferior radio set because distortion affects that particular musical combination the least. If an organ, concentrating as it does on the lower frequencies, sounds magnificent with a radio set, but sopranos are strangely colorless and without feeling, it is due usually to absence of high frequencies in the reproduction.

The characteristic of radio sets prior to 1925 was the almost entire absence of low tones. The reaction which followed resulted in an era of exaggerated low tones, a much pleasanter form of distortion. We are about to enter upon an era of true reproduction. This involves curbing of the present trend to excessive booming mellowness and richness, when these are not present in the original music reproduced; and also the curbing of their predecessors, brilliance and sharpness of tone, the product of excessive amplification of high tones.

JUDGING QUALITY

THE expert sound critic, in testing a receiving system, listens to different kinds of music because each kind brings out the ability of the receiver with certain frequencies. The easiest way to learn to judge the deficiency of any reproducing system is to listen to distortion-free music and then to apply filters of known characteristics which take out various frequency bands. A little training will enable anyone of musical discrimination to analyze what is missing in music upon hearing it. An attempt will be made here to do this for you in words, describing familiar forms of distortion in the hope that you will be able to recognize them.

When a radio set is being demonstrated in a store, the most likely thing which you will hear is the male voice of an announcer. Fortunately, a male voice can reveal the principal characteristics of a sound reproducing system because it has a great wealth of harmonics. An absence of adequate amplification of the low tones, a characteristic of cheaper receivers incapable of great volume, is manifested by undue prominence of the consonants of speech. As we have seen, the lower frequencies give the pitch characteristic, the volume, and power, but it is the harmonics which give intelligibility and distinction. Hence, loss of the low tones does not detract materially from intelligibility. You could clearly understand what the announcer says if everything below a frequency of 500 cycles was cut off. If the announcer sounds as if he were talking over the telephone rather than speaking to you in person, it is likely that the "lows" are not adequately reproduced. The absence of "lows" detracts from the sympathy and resonance of the voice and makes it difficult to distinguish between individuals.

The other extreme is exaggeration of "lows" and loss of the "highs." If the male voice sounds throaty, booming, husky, muffled, and hashy, so that you think the speaker has asthma or needs a cough drop, you are likely to be listening to a receiver which exaggerates the low tones. Even with a moderate priced receiver, the male voice should be so clear that, when you turn from the loud speaker, you have difficulty in determining whether someone is speaking in person or whether you hear radio reproduction. The characteristic "radio speech" that makes you comment "it sounds like a radio," instead of "that sounds like a man speaking," is a recognition of distortion in one form or another.

A second form of radio reproduction likely to be heard at a demonstration is the piano. The piano has long been the most elusive instrument so far as reproduction is concerned. A majority of broadcasting stations are incapable of reproducing that instrument. Consequently, when listening to it critically through a radio receiver, you must be certain that you are tuned-in to a first class station. If that is the case, you will be able to detect inadequate amplification of low tones. If the piano sounds tingly, bell-like, sharp, and thin, and if the melody in the treble is prominent while the bass is weak, you can be sure that the low notes are not adequately reproduced. If you are fortunate enough to hear a fortissimo passage in the bass and find those low, crashing notes are only moderately reproduced and none of the grandeur of the piano is felt, you may rightly attribute these characteristics to imperfect reproduction of the lower frequencies.

If you are familiar with the tone of the clavichord, and piano reproduction reminds you of it, you may be certain that the low notes are not adequately reproduced. The essential improvement of the piano over its predecessor, the clavichord, lies in its possession of a large, resonant sounding board, which gives strength and body to the fundamental tones. If the lower frequencies are not reproduced by the radio receiver, obviously the piano will sound like the clavichord.

On the other hand, absence of the upper frequencies and exaggeration of the "lows" makes the fortissimo in the bass sound rich—almost organ-like. Reproduction in this case lacks the brilliance and brightness of the piano and possesses excessive richness and booming qualities. Fine trills in the treble or upper notes sound garbled and mixed, lacking entirely the penetrating brilliance characteristic of the piano.

A jazz orchestra also gives you opportunity for critical observation. The most prominent instruments, saxophone and cornets, use principally the middle registers. Reproduction in which the saxaphone is permitted to dominate over piano, violin, and banjo, so that the latter form only a hazy background, exaggerates the middle registers. Usually, there is a set of instruments strumming time in the jazz orchestra, sometimes a piano, sometimes the banjos. It requires good reproduction of the higher harmonics to enable you to distinguish between piano and banjo instantly and decisively. If you have to stop and think about it before deciding whether piano or banjos are keeping time, the upper harmonics are not adequately reproduced.

When the piano contributes significantly to the melody by taking a lead in the treble, it should stand out prominently and clearly with its bright tingle. If it is submerged by the instruments in the low frequencies, the "highs" are being neglected. When the drums and the tympani come in, they should be emphatic and crashing, but a receiver which neglects the low frequencies makes the drums sound wooden and lacking in depth, instead of booming and rich. It is a good test of the power of the reproducing system with low tones.

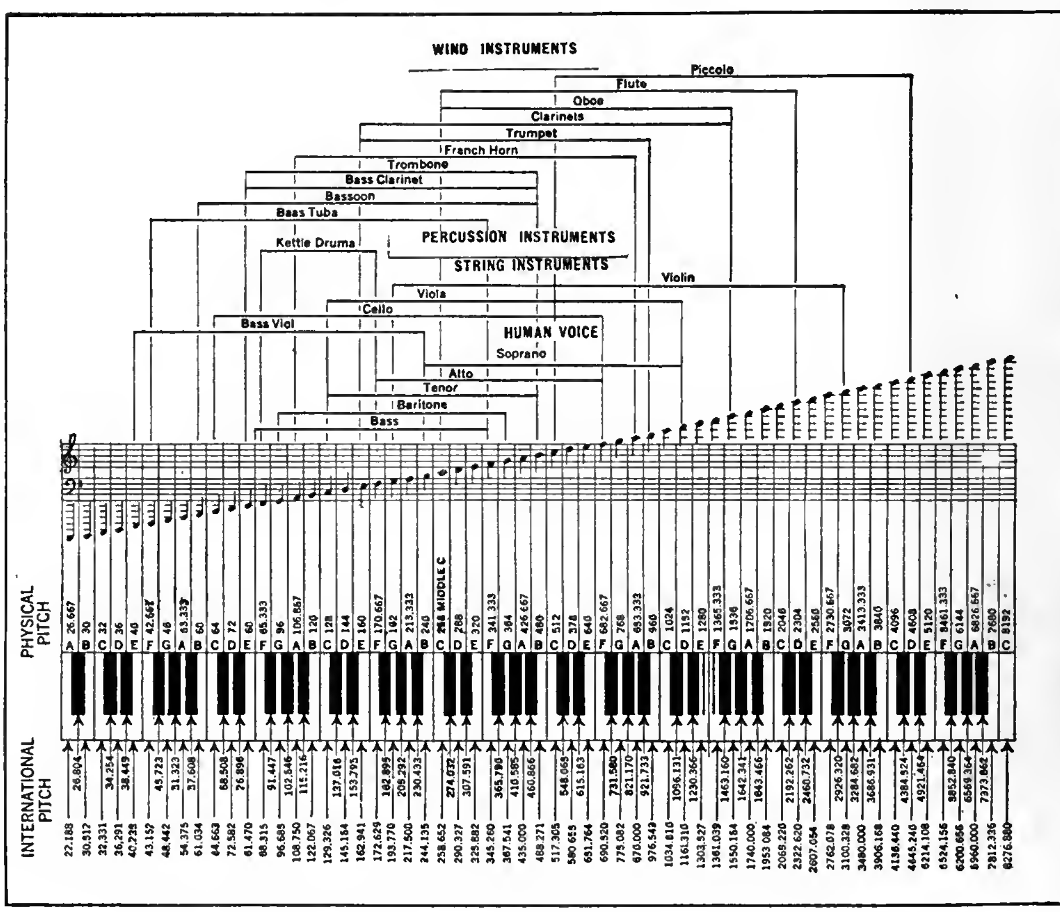
Reproduction of the symphony orchestra should be sufficiently clear as to the upper harmonics so that there is not the slightest hesitation or difficulty in forming conscious distinction between the cellos and the violin. Given a good broadcasting station with a careful pick-up, the crashing of the tympani in the finale should be thoroughly imposing to the radio listener. When the violins take the lead and come forward busily, they should be sweet and strong and not scratchy and penetrating like an army of mosquitoes.

The last word in a test of reproduction of low tones is given by the organ. Few broadcasters are capable of sending out this instrument with anywhere near its true worth. Nevertheless, the organ should have majestic power reflected in its radio reproduction. Failure to reproduce the low notes makes it sound much like the flute or saxophone. An organ recital places the most severe test, not only upon the loud speaker and audio amplifier system, but also on the capacity of the plate potential supply to furnish the necessary current to accommodate the peaks of modulation present when the music of this instrument is broadcast.

It is not necessary to discuss in great detail that distortion due to sharp resonance points, because they are quite obvious. The listener notices an indefinable but disagreeable flatness in a certain pitch, usually a high note on the piano. That instrument, because of its sustained quality, brings out resonance points with particular emphasis. If that pitch is identified in the listener's consciousness, he will observe that a soprano singing that note sounds flat and slightly off key. Resonant points are most likely to be due to defective coupling devices in the audio-amplifier and mechanical resonance in the loud speaker or cabinet.

Overloading, also, is more easily considered as we go over the radio receiver part by part, to identify the causes of distortion. A receiver offering excellent tone with soft music but scratchy and blaring when it is turned on full, is likely to be suffering from overloading. Certain requirements with regard to tube output capacity, loud speaker volume capacity, and power supply, must be met to avoid distortion due to overloading. These points are fully discussed in an article on tone quality in the next RADIO BROADCAST.

For the present, if the reader has learned how to listen to a radio receiver, to appreciate its tonal quality, and to identify its weaknesses—whether they lie in the lower, middle, or upper registers—he will have taken an important step forward in judging the faithful reproduction qualities of a receiver.



THE RELATION BETWEEN THE MUSICAL SCALE AND PIANO KEYBOARD

The organ range, not shown, is from 16 to 16, 384 cycles. The chart is published through the courtesy of the Waverly Musical Products Company, Long Island City

RADIO BROADCAST Photograph

MEASURING THE CAPACITY OF A MICA CONDENSER BY MEANS OF THE MODULATED OSCILLATOR SHOWN IN FIG. 1

Condenser, Coil, Antenna Measurements

Some Simple and Practical Uses of the Modulated Oscillator—Comparing Its Accuracy with Other Systems of Measurement

By KEITH HENNEY

Director of the Laboratory

AMONG other uses to which the modulated oscillator described in the June RADIO BROADCAST and shown schematically here in Fig. 1 may be put, is that of comparing or measuring the capacities of small condensers. For example, it may be necessary to measure the maximum and minimum capacity of a variable condenser in terms of a standard, or it may be desirable to calibrate such a condenser. The modulated oscillator is very useful for this purpose, making it possible to substitute visible measurements for the audible indications of a bridge balance.

It is necessary only to have an inductance and a condenser whose capacity is definitely known. This latter should be a variable air condenser whose calibration is not likely to change with time, with as low a resistance as is practicable, and whose maximum capacity is from 500 to 1000 mmfd. Such a condenser is the General Radio Type 239 E or even the "can" condenser, type 247, made by the same company. The 247 E is inexpensive, has a dial calibrated in micromicrofarads, and can be read to within about 2 per cent. It has a maximum capacity of 500 mmfd., and as an all round instrument it is to be highly recommended, although a better instrument is the 239 type. The latter is naturally more expensive.

Suppose, then, that we have a condenser whose calibration is known, and that around the laboratory we have an inductance, say about 60 turns on a three-inch diameter form, and another with about 15 turns on the same diameter form. These will enable us to tune to both low and high frequencies. Both windings may be on the same form.

The method of calibrating the unknown variable is essentially one of substitution. We connect the unknown across the inductance, couple the inductance to L_2 of the oscillator, and adjust C_3 until we get a reaction on the grid-current meter, when we know that resonance has occurred. Then the standard condenser is substituted and its capacity varied until resonance is again obtained, care being exercised to see that the capacity of C_3 is not altered. Under these conditions we know that the settings of the two condensers—the standard and the unknown—when resonance is obtained, represent equal capacities.

When the unknown capacity is small it is simpler and more accurate, probably, to place both condensers in parallel, to resonate the circuit to some frequency so that about half of the standard is used, then to remove the unknown and readjust for resonance, the difference in capacities of the standard under the two conditions representing the unknown capacity. If the unknown is large, the two condensers may be placed in series and resonance obtained. In this case the mathematics is not quite so simple, but the accuracy is the same and provides a good check on the parallel arrangement. In the series case the two should be connected and tuned first to some frequency so that the standard is near its top dial reading. Then the unknown is removed, and the standard lowered in value to a new resonance. The unknown value may then be found by using the formula and examples given below, where Cx represents the unknown capacity:

PARALLEL CASE

Standard alone, 88° = 910 mmfd.
Standard and Cx, 52° = 415 mmfd.
Cx = 910 — 415 = 495 mmfd.

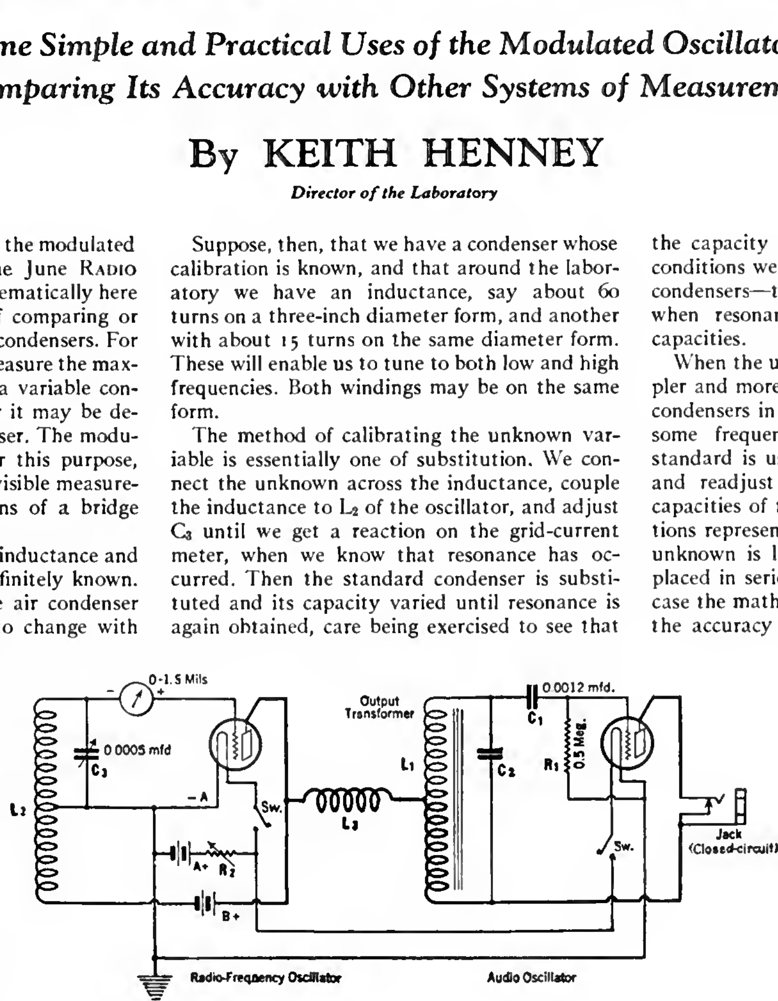


FIG. 1

Series Case

Standard alone, 37° = 215 mmfd.
Standard and Cx, 48° = 380 mmfd.

$$Cx = \frac{\text{Product}}{\text{Difference}} = \frac{380 \times 215}{380 - 215} = 495 \text{ mmfd.}$$

Provided the dial on the condenser, and the calibration chart, could be read accurately, the percentage of accuracy of the unknown condenser, which was marked 0.0006 mfd., is as follows:

$$\text{Percentage Accuracy} = \frac{\text{Measured Value}}{\text{Rated Value}} \times 100 = \frac{495 \text{ mmfd.}}{600 \text{ mmfd.}} = 82.5\%$$

and the percentage "off" is:

$$\frac{\text{Difference}}{\text{Rated Value}} \times 100 = \frac{105 \text{ mmfd.}}{600 \text{ mmfd.}} = 17.5\%$$

If it is impossible, however, to read the condenser dial closer than 5 mmfd. or to read the calibration closer than this figure, our error of reading may be 10 mmfd. and if the maximum capacity is 500 mmfd. the total error will be 2 per cent. With a large dial, and correspondingly large calibration chart, much greater accuracy may be obtained. If, in addition, the condenser is accurate to within 2 per cent., our total error of measurement may be 4 per cent.

MICA CONDENSERS

When one comes to measure small fixed mica condensers by the method outlined above, curious results are obtained. At high frequencies, the distribution of charge on the condenser differs from that at 1000 cycles, and certain changes seem to occur in the dielectric. Manufacturers rate their condensers according to readings taken at 1000 cycles. It is also true that the equivalent series resistance of the condenser becomes appreciable at high frequencies. The result of all of these factors is that the apparent capacity of the condenser is smaller at high frequencies than at 1000 cycles. For example, the figures below give the values of several condensers measured at 1000 cycles and by the above method at 1000 kilocycles:

Rated	1000 Cycles	1000 Kc.
250 mmfd.	230 mmfd.	220 mmfd.
250 "	200 "	190 "
500 "	405 "	350 "
500 "	500 "	480 "
600 "	530 "	500 "

TO MEASURE DISTRIBUTED CAPACITY OF COILS

Another interesting use for the oscillator is that of determining the natural wavelength, effective inductance, and distributed capacity of coils. The procedure is simple. The coil under test is resonated to various wavelengths by tuning it with known capacities, say with the variable standard. Then the added capacity is plotted against wavelength squared, as is illustrated in Fig. 2.

The data for this curve are given below:

TABLE NO. 1

Added Capacity	Frequency	Wave-length	(Wave-length)²
500 mmfd.	562 kc.	534 meters	284,000
400 "	625 "	480 "	230,000
300 "	725 "	414 "	170,000
200 "	892 "	336 "	113,000
100 "	1290 "	243 "	59,000

The actual method of finding the inductance and distributed capacity is explained by the formula in Fig. 2. Where the line crosses the wavelength squared axis is the natural wavelength, squared, of the coil. The values for a certain coil, the dimensions of which are given below, as read from the graph, are given herewith, together with the figures obtained when different methods of measuring were employed:

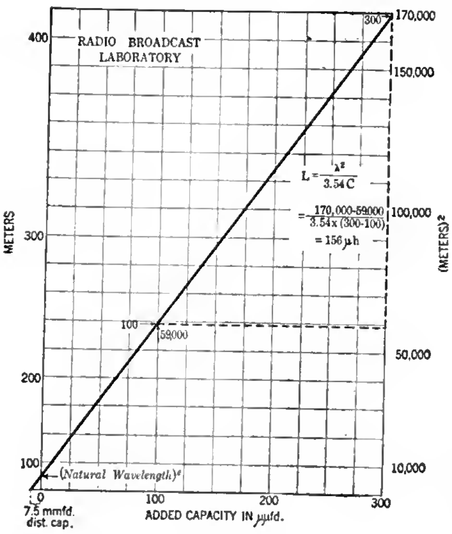


FIG. 2

Natural wavelength (by graph)	67.0	meters
Natural wavelength (by mod. osc.)	59.5	"
Distributed capacity	7.5	mmfd.
Inductance at 1000 cycles (bridge)	170	microhenries
Inductance at 1000 kc. (graph)	156	"
Coil diameter	2⅝	inches
Length of winding	1⅞	"
Number of turns	60	

TO MEASURE ANTENNA CAPACITY AND INDUCTANCE

The oscillator can also be used to measure the capacity and inductance of antennas by the following methods. In the first method, two known inductances are inserted in the antenna system, and resonance obtained with the oscillator. If the inductance is in microhenries, and the capacity of the antenna is in microfarads, we shall have two equations:

$$\lambda = 1884 \sqrt{(L + La) \times Ca}$$

$$\lambda^1 = 1884 \sqrt{(L^1 + La) \times Ca}$$

where L and L^1 are the two known inductances, C_a is the antenna capacity, and L_a, the antenna inductance. C_a may be eliminated from the two equations, and after solving for L_a we have:

$$La = \frac{L^1 \lambda^2 - L \lambda^1_2}{\lambda^1_2 - \lambda^2}$$

After getting L_a, its value may be substituted in either of the two original wavelength equations and C_a obtained.

The second method, whose similarity with that mentioned above to determine the capacity and inductance of coils is apparent, consists in plotting wavelength squared against added inductance, as shown in Fig. 3. The intercept on the inductance axis represents the apparent inductance of the antenna; the intercept on the wavelength squared axis represents the square of the natural wavelength. The capacity of course is the slope of the line as shown in the illustration.

The third method of determining the apparent capacity is to measure the wavelength, or frequency, of the antenna system with a certain, but not necessarily known, inductance, in series with it. Then the antenna and ground, or counterpoise, are removed and a calibrated condenser connected to the inductance. When resonance is obtained by tuning the condenser, its capacity is equal to the apparent capacity of the antenna.

All of these measurements at high frequencies will differ from those at audio frequencies, and will in general be true only at the frequency measured. They indicate an important class of experiments and measurements, however, that can be performed with the high-frequency part of the modulated oscillator. Care must always be taken that too close coupling to the oscillator does not vitiate the operation. Resonance should be indicated on the grid meter with as small a deflection as possible. The accuracy of measurements using these methods lies in the accuracy with which the oscillator is calibrated and read, and the accuracy of the standards.

Inductance standards are simple to construct. Their inductances at low frequencies may be calculated with sufficient accuracy for all home laboratory measurements. The interested experimenter is referred to the Bureau of Standards Bulletin 74 which gives formulas and descriptions of small standards of inductance. A subsequent article will describe a series of coils for use in the home laboratory as inductance standards.

The data for a short-wave antenna are given below and show how the values secured by the several methods compare:

Added Inductance	Frequency	Wave-length	(Wave-length)²
162 microhenries	1612 kc.	186.6 meters	34,500
100 "	2030 "	147.5 "	21,800
18 "	3938 "	76.2 "	5,850

C_a = 55 mmfd. by method No. 1
" = 55 " " " No. 2
" = 54 " " " No. 3
L_a = 7.1 microhenries by method No. 1
= 12 microhenries by method No. 2
Natural λ = 47 meters by method No. 2

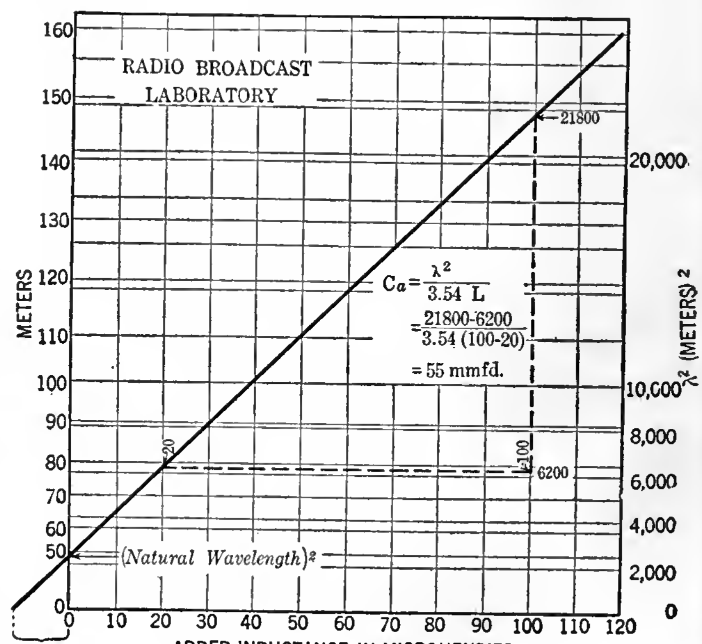


FIG. 3

A Super-Sensitive Five-Tube Receiver

Constructional Data for the Home Builder Who Desires a Selective Shielded Tuned Radio-Frequency Receiver with Controlled Regeneration in the Detector Circuit

By HERBERT J. REICH, M. S.

Physics Department, Cornell University

THE simplicity and selectivity of the various types of tuned radio-frequency receivers have for some time placed them in the foremost rank of popularity among the many receivers available to the radio enthusiast. A great deal of constructional data on receivers of this type has been published and a large percentage of the tuned radio-frequency receivers now in use are probably home-built.

The chief difficulty that has to be overcome in the design and construction of a good tuned radio-frequency receiver is the tendency for the radio-frequency stages to oscillate. Oscillation in this type of set is obviously undesirable—for several reasons. In the first place oscillation ordinarily takes place at fairly low values of signal amplification, so that the overall efficiency of the receiver is low. Quality also suffers, and the tendency toward oscillation makes tuning critical, and when the set is in the hands of an inexperienced or thoughtless operator, it can cause serious annoyance to other receivers for miles around. If losses are introduced to prevent oscillation, the efficiency drops still further.

The use of some form of neutralization, and the careful placing of coils and other apparatus, partially overcomes this tendency toward oscillation. In spite of these precautions, however, there still remain capacitative and inductive feed-backs which careful placing of parts cannot prevent, and the obvious way to overcome these leakage feed-backs is to shield completely the individual stages. Many tests by the author and the recent appearance upon the market of several completely shielded neutrodynes indicates the value of properly designed shielding.

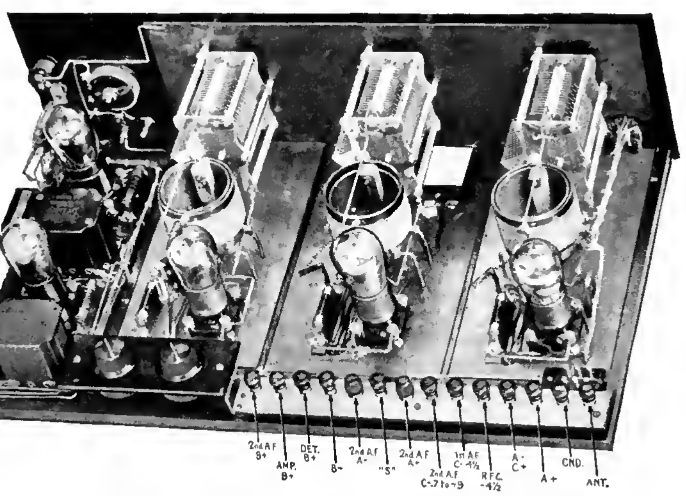
A receiver developed by the writer consisted of two stages of completely shielded and neutralized tuned radio-frequency amplification, a shielded regenerative detector, and two stages of high-quality audio-frequency amplification. From the standpoint of sensitivity and volume, this receiver is the equal of any tuned radio-frequency set and on a loop, or a ten-foot indoor antenna, it will give all the volume desired on local stations. Station WEAF is a rather difficult station to get with good volume at Ithaca, yet the writer has frequently had it with sufficient undistorted volume at 6:30 in the evening to be understood 400 feet from the cone loud speaker. Mexico City can often be heard with almost equal volume. Any time of day, from setting-up exercises to midnight dance orchestras, two or three stations at least may be had with as much loud-speaker volume as desired and with excellent quality on both local and DX. The limit of sensitivity is the general noise level, and the best evidence of a poor night is the number of whistles and yowls emitted by less fortunate neighbors. The receiver is simple to construct, extremely easy to operate, and comparatively inexpensive.

Fig. 1 shows the wiring diagram for the receiver. It will be seen that the circuit differs from the ordinary neutralized tuned radio-frequency circuit mainly by the addition of controlled regeneration in the detector stage. The means of controlling regeneration, i. e., by means of a midget condenser, C_7, results in extreme simplicity and makes possible a wide variation in the amount of regeneration with only a very slight change of the tuning of the detector stage variable condenser. Regeneration also makes possible high amplification at the long wavelengths, where the gain would ordinarily tend to fall off.

The double-pole double-throw switch in the first radio-frequency stage is for the purpose of cutting out this stage when desired and connecting the antenna to the primary of the second stage. This can frequently be done on good nights and somewhat simplifies tuning. The obvious objection is that selectivity is not so good.

Ordinarily, volume is controlled by means of the rheostat of the first r. f. stage, which is mounted on the panel. The regeneration control can usually be set at zero, but when additional volume is desired for weak stations or for daytime reception, additional amplification, equal to that of a third stage of radio-frequency, is instantly available with a turn of the midget condenser. The rheostat control makes possible the variation of volume from a mere whisper to the maximum the loud speaker can carry. When the first stage is cut out, volume is controlled by the midget condenser.

Separate terminals have been specified for the filaments of the second audio tube and the loud-speaker return, S, in order to make possible the operation of the power tube filament with a. c. from a transformer winding in a socket power device if this is desired. If the power tube is to be operated from the common A battery, these extra filament leads are connected directly to the main A terminals, and S, the loud speaker return, to A minus. The choke coil, L_{10}, may be put in any place in the B+180 volt lead if there is insufficient room in the set.



THE RECEIVER CONSTRUCTED BY THE AUTHOR

COIL CONSTRUCTION

THE coils are probably the most vital parts of the whole receiver, and particular care must be taken in their construction. Fig. 2 shows the design of the coil assemblies and the arrangements of the terminals, which are so placed as to give the most simple and direct wiring. The letters distinguishing the terminals correspond to those in the wiring diagram. At "A" and "B" is shown the detector stage transformer assembly, which contains three concentric tubes. The second stage radio-frequency transformer is identical with this except that the inner 2″ tickler coil, and the M and T terminals, are omitted. The proper position for the terminals on the second and third stage transformers is determined by dividing the circumference of the outer tube into eight equal parts, as is indicated at "B." At "C" in Fig. 2 is given the arrangement for the first-stage transformer.

The secondaries are wound upon $2\frac{3}{4}''$ tubing and the primaries upon $2\frac{1}{2}''$ tubing placed within the secondaries and spaced by means of washers

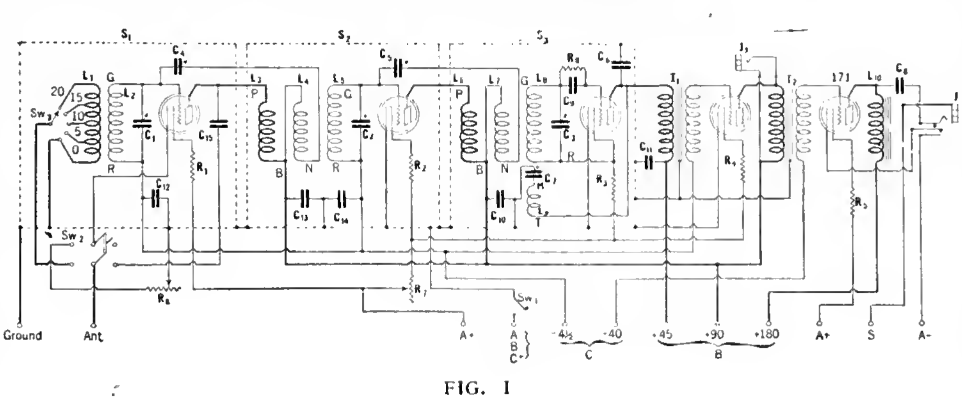
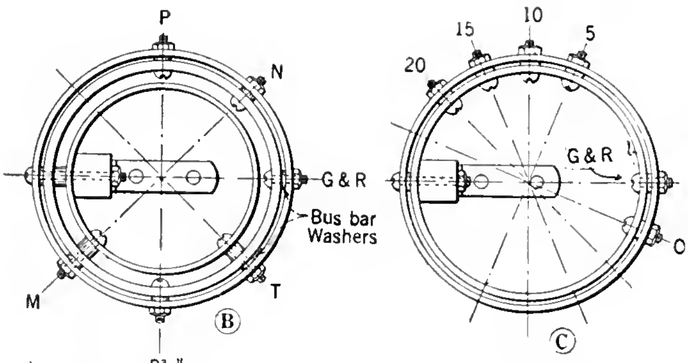


FIG. 1



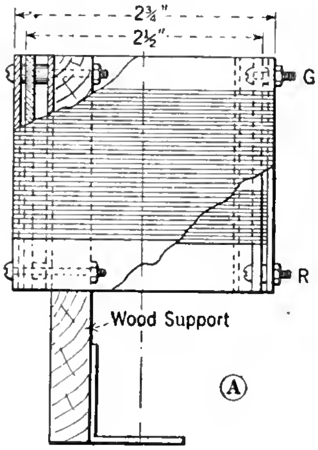


FIG. 2

made of bus bar placed over the terminal posts as they are inserted. The best length for the tubing is $2\frac{3}{4}''$, although $2\frac{1}{2}''$ can be used. The tubes should be assembled temporarily and the terminals located before the coils are wound. In order to insure the proper lining up of the holes in the different tubes, it is well to drill those in the outer tube first and locate the holes in the inner tubes by means of these, inserting the terminal posts and washers as each hole is completed. The tickler coil may be held by means of the screws which fasten the coils to the wooden upright and spaced with nuts or small pieces of panel. It will not matter if the tickler coil is not accurately centered. Round-head brass machine screws, 6-32 and $\frac{1}{2}''$ long, make excellent terminal posts.

The secondaries, L_2, L_5, and L_8, consist of 50 turns of No. 24 double cotton-covered wire. The upper ends of these windings should be started just far enough from the ends of the tubing to allow about a sixteenth of an inch clearance between the wire and the nut which holds the terminal post.

The primaries of the second and third stage transformers, L_3 and L_4, L_6 and L_7, consist of double windings of No. 28 or No. 30 double cotton-covered wire wound simultaneously, *i. e.*, with the two wires side by side, turn for turn. Fig. 3 may help to make clear the proper way to make the primary connections to the terminals. One wire is fastened to the inside tubing at a point just above the "N" terminal, to which it should be connected after the coil has been wound; the other wire is fastened at a point just above the "B" terminal to which it will ultimately be connected, at the same distance from the lower end of the tubing as the lower end of the secondary is from the bottom of the outer tubing. The two wires are then wound simultaneously in the direction which carries them from "N" toward "B," the one connected to the "N" terminal above the other, until thirteen complete turns have been made with the upper wire (the one started at "N"). This will bring the free ends of the wires above the "N" terminal. A small hole should then be drilled in the tubing just above the "P" terminal at such a height that the lower wire can pass into it and be fastened to the "P" terminal below. It is well to mark the proper point for the hole and unwind the upper turn of both wires while drilling the hole, or to determine the proper location and drill the hole before starting to wind. The upper wire should then be unwound a half turn, which will bring the free end above the "B" terminal. Another small hole should be drilled and this wire passed down to the "B" terminal, where it is finally fastened. If the terminals have been properly placed and the winding done as directed, there will be approximately $12\frac{1}{2}$ turns on each coil, and the lower ends of the coils will be at the same height as the lower ends of the secondaries.

The primary of the first-stage transformer, L_1, consists of a single winding of 20 turns of No. 24 d. c. c. tapped at 5, 10, and 15 turns. A neat way to connect the taps is to drill holes in the tubing at the proper points before starting the winding, and to bare the wire at these points when it is being wound, passing the tap wires through the holes and twisting them around the main wire. The joints can be soldered when the winding is completed.

The tickler winding, L_9, consists of 50 turns of No. 28 or No. 30 d. c. c. wire wound on the 2" tubing in the same direction as the primaries and secondaries. The lower end is connected to the "T" terminal and the upper end to the "M" terminal. The lower end of the winding is at the same level as the lower end of the secondary.

A good way to hold the ends of the wires to keep them from loosening up is to drill three holes close together and thread the wire in and out through them. A coat of collodion should be applied to the windings to hold them firmly in place. It is preferable to solder the ends of the windings directly to the heads of the machine screws rather than to terminal lugs, as this will save quite a few joints.

Wooden posts about $\frac{1}{2}''$ square with angle brackets at the bottom will serve to support the coils. The method of fastening the coils to the uprights is shown in Fig. 2, "A." The proper height is that which gives equal clearance from the shielding above and below the coils.

PARTS REQUIRED

THE choice of apparatus to be used in this receiver depends somewhat upon personal preference. In order to obtain the quality described in the discussion of performance, however, it is absolutely essential to use the very highest grade of audio transformers. Uniform amplification of all the frequencies necessary for the faithful reproduction of voice and all forms of music can be expected only if each individual element of the receiver, including the audio transformers and loud speaker, is in itself capable of passing these frequencies. The use of old transformers salvaged from another receiver is to be discouraged.

The list below indicates what parts are necessary to construct the receiver; any standard makes may be used that have the proper characteristics:

C_1, C_2, C_3—Hammarlund Variable Condensers, 0.0005 Mfd.
L_1, L_2—, L_3, L_4, L_5—, L_6, L_7, L_8, L_9— Home Constructed Coils. Specifications in Text
C_4, C_5—Hammarlund Neutralizing Condensers, 0.000015 Mfd. Approximately.
C_6—Sangamo 0.0001-Mfd. Fixed Condenser
C_7—Hammarlund Midget Variable Condenser, 0.00005 Mfd.
C8—Sangamo 4-Mfd. Output Condenser
C_9—Sangamo 0.00025-Mfd. Grid Condenser
C_1, C_{11}, C_{12}, C_{13}, C_{14}—Sangamo 1-Mfd. Bypass Condensers
C_{15}—Sangamo 0.001-Mfd. Fixed Condenser
R_1, R_2, R_3, R_4—Amperite Filament Resistors for 201-A Tubes, Type 1A
R5—Amperite Filament Resistor for Power Tube, Type 112 (not necessary with A. C.)
R_6—Yaxley 20-Ohm Rheostat
R_7—Yaxley 6-Ohm Rheostat
R_8—Tobe 2-Megohm Grid Leak
L_{10}—General Radio Output Choke Coil
J—Yaxley Single-Circuit Filament-Control Jack
J 1—Yaxley Single-Circuit Jack
S_1, S_2, S_3—Copper Shields
SW_1—Yaxley Filament Switch
SW_2—Kresge Double-pole Double-Throw Switch
SW_3—Carter Antenna Tap Switch
T_1, T_2—Amertran Audio Transformers
Five Benjamin "CLE-RA-TONE" Sockets
Nine Binding Posts. Twelve if A. C. is used.
Three Dials
7" x 24" Panel
Copper Panel Shield, 6" x 18"
Three Base Shields, 6" x 11"
13" x 23" Baseboard

The antenna coupling switch is best mounted within the shielding and should therefore be small enough to clear the tuning condenser and the side of the can.

SHIELDING

FIG. 4 shows the design of the shielding cans. Sixteen-ounce, or heavier, sheet copper should be used for all shielding. The cans are $10\frac{1}{2}''$ long, 5" wide, and $5\frac{1}{2}''$ high, and are open at the panel end. A $\frac{3}{8}''$ or $\frac{1}{2}''$ flange around the bottom affords the most satisfactory method of fastening the cans to the baseboard. A 3" hole in the top with its center $3\frac{1}{2}''$ from the back and right edges, makes it possible to insert and remove tubes without taking off the cans. The holes should be supplied with lids. Most builders will find it better to have a good tinsmith make the cans than to attempt to make them at home.

The panel shield (see photograph) is a single sheet 6" high and 18" long. It is a little better to use three separate 6" x 11" base shields for the three stages than one large one.

The general layout of apparatus may be discerned by references to the photograph. The condensers should be so placed as to allow as much clearance as possible on all sides of the stator plates and sufficient clearance for the rotor plates to insure freedom from short-circuits to the shielding cans. It is best to allow equal clearance on both sides of the coils and to allow at least $\frac{3}{4}''$ clearance between the coils and condensers.

The three shielded stages should be spaced just far enough apart so that the can flanges do not make contact with one another. As the frames of the first and second condensers are connected to C minus and that of the third to A plus, whereas the shielding is connected to A minus, it is necessary to cut holes in the panel shield around the condenser shafts and mountings. If metal dials are used, care should be taken to make certain that no short-circuit occurs between the dials and the screws which hold the shielding in place.

The screws which hold the sockets and coils will serve to fasten the base shields. The panel shield is held by four brass machine screws behind each condenser, placed so that they will be hidden by the dials. The base shields are soldered to the panel shield at two points in each stage.

If possible, the midget condenser should be placed within the shielding of the third stage, but it will probably be impossible to obtain sufficient clearance from the tuning condenser. The panel shield must be cut away where the antenna switch is mounted. The output condenser may be mounted on edge beside the second audio transformer, and the detector B plus bypass condenser, C_{11}, beside the first audio transformer. This will leave room for the r. f. amplifier B plus bypass condensers, C_{10} and C_{13}, within the second and third stage cans, and for the C minus bypass condensers, C_{12} and C_{14}, within the first and second-stage cans.

In fastening the filament resistors it is best to separate the mountings from the shielding by means of strips of gasket rubber or similar insulation. Short-circuits are likely to occur if this precaution is not observed.

Little difficulty will be experienced in wiring the receiver, as most of the connections within the shielding are short and direct. Flexible wires tied into a cable will be found both neat and convenient for filament and battery leads leaving the cans, and for filament and battery leads going from the audio-frequency end of the board to the terminal strip at the rear of the set. Different colored insulations for the different leads will make it easier to check the wiring. Busbar should be used for all connections within the shielding, particularly for grid and condenser leads and for interstage plate and neutralizing leads. The rigidity of this type of wire will insure permanence of neutralization and of tuning condenser calibration.

There are two simple and equally good methods of leading wires out of the shielding. Probably the easier and neater way is to drill holes through the base shielding and board and cut short grooves in the underside of the baseboard under the edges of the cans to take the wires. The wires should be covered with spaghetti in the holes and grooves. After wiring, the grooves may be filled with tar or sealing wax taken from the tops of old dry cells. The two sets of interstage plate and neutralizing leads should be run in separate slots spaced about an inch or so apart.

The second method is to run the wires above the base shielding and cut notches in the bottom edges of the cans. The wires may be protected under the edges of the cans by means of bridges of copper soldered to the base shields. The notches in the bottoms of the cans should be as small as possible. If they are made too large, they form closed paths for eddy-currents and a slight amount of interstage coupling is likely to result. To minimize capacity to shielding, the neutralizing and plate leads should be kept a quarter to a half an inch above the base shielding except where they pass out of the cans. For the same reason, the copper bridges should be just long enough to afford protection to the wires.

The antenna, midget condenser, and detector plate leads may also be taken out of the shielding in either of the ways described, but as directly as possible. Each should be taken out individually through separate holes and grooves in order to prevent undesirable feed-back and capacity.

All leads within the shielding should be as direct as possible and close parallel wires should be avoided. The wires connecting the grid terminals with the secondaries and the condensers should be short and placed so as to keep them well away from the tops of the cans. This precaution will prevent the narrowing of the tuning range as the result of high minimum tuning capacity.

Obviously, since the shielding is connected to A minus, negative filament terminals, bypass condensers, midget condenser, etc., may be connected directly to the shielding, thus simplifying the wiring.

ADJUSTMENT AND OPERATION

BEFORE inserting the tubes into the sockets, it is well to check all connections by means of a battery and phones, buzzer, or voltmeter. The tubes should be inserted and lighted before the plate voltage is applied to the set. Another good test is to connect the A battery to the B-battery terminals and make sure that the tubes do not light. After this, all connections to the set may be made. If all connections are correct, the familiar microphonic ring will be heard when the detector tube is tapped. As the set has not yet been neutralized it will probably oscillate as soon as the three dials are brought into resonance, particularly at the shorter wavelengths, and tuning will be very critical.

Neutralization is a very simple process. The carrier wave of any fairly strong station at the short wavelength end of the dials will serve for this purpose. The regeneration control should be turned up far enough so that a strong heterodyne whistle is obtained when the first and second stages are detuned sufficiently to stop them from oscillating. The receiver should then be tuned so that the whistle is at maximum volume. The radio-frequency stages may be prevented from oscillating by turning down the rheostats. The first-stage shielding should be removed and the filament of the first tube disconnected by moving the filament resistor or turning off the volume control rheostat on the panel. It will be found that the whistle is still fairly loud and varies in intensity with the adjustment of the neutralizing condenser in the first stage. The neutralizing condenser should be adjusted until the whistle cannot be heard, or, at least, is at a minimum. It may be necessary to re-tune the first-stage tuning condenser slightly during this adjustment. The replacing of the can will probably upset the balance slightly. This difficulty may be avoided by adjusting the neutralizing condenser through a small hole in the can, but if this is done, the screw-driver must be thoroughly insulated by means of tape where it passes through the can. Failure to take this precaution will result in the short-circuiting of either the B or the C battery.

If neutralizing has been carefully done, it will be found that the receiver will not oscillate with any setting of the tuning condensers or antenna switch, providing detector regeneration is turned off. It should be possible to turn up the regeneration quite a bit without causing oscillation, and tuning should be very smooth. If the set oscillates when brought into resonance, there is some

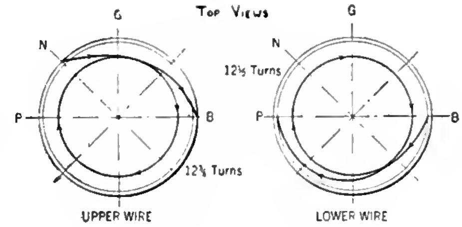


FIG. 3

error in the construction of the coils or in the wiring, or neutralization has not been perfectly accomplished.

The antenna coupling switch serves several purposes. Primarily it affords a means of adjusting the set to antennas of different lengths. It will, however, be found necessary to change the switch setting for stations of different wavelengths in order to obtain best results. The longer wavelength stations require a much greater amount of coupling for maximum volume than do those of short wavelengths. The antenna coupling tends to raise the wavelength of the first stage and broadens the tuning. This becomes very noticeable below about 300 meters (1000 kc.), and hence it is necessary to reduce the antenna coupling to ten or even five turns for the lower stations. With five turns, the tuning will be very sharp, down to the lower limit of the receiver. Decreasing the antenna coupling increases the selectivity; it also increases the volume of short wavelength stations but decreases that of long wavelength stations. This decrease of volume may be largely compensated by the use of regeneration, which also sharpens the tuning of the detector stage.

If the coils have been carefully constructed and the wiring carefully done, so that the three stages are as nearly alike as possible, the three dials should tune the same to within half or three-quarters of a degree over at least three-quarters of the broadcast band. At the lower end of the band, where the effect of the antenna circuit necessitates the change of antenna coupling, the first dial may read slightly different from the other two. For an average antenna the fifteen-turn tap will give the best coördination of dial settings. The use of regeneration will vary the detector dial setting by not more than half or three-quarters of a degree.

Fair results will be obtained if 199 tubes are used in the first three stages, but the volume will not be anywhere nearly as great as when 201-A tubes are used, and the quality will also suffer somewhat. In fact, much of the improvement that results from the use of shielding will be lost if small tubes are used, and it is therefore strongly recommended that 201-A tubes be employed. A 201-A tube must be used in the first audio stage, and either a 112 or 171, with proper plate and grid voltages, in the second audio stage. A 200-A detector tube will give slightly greater volume but is inclined to be quite noisy and microphonic, and broadens the detector tuning noticeably. A 2-megohm fixed grid leak of the best manufacture should be used with the 201-A tube. Excellent volume will be obtained if a loop is used in place of the secondary coil, L_2, of the first r. f. stage.

The set is not an experiment. It has been developed by a series of careful tests of various types of apparatus and circuits. Following the publication of data on an earlier model of the same receiver, the writer received a large number of letters from successful builders, some of whom have built a second and third set. It is partly in response to requests for data on modifications and improvements that the present article has been written.

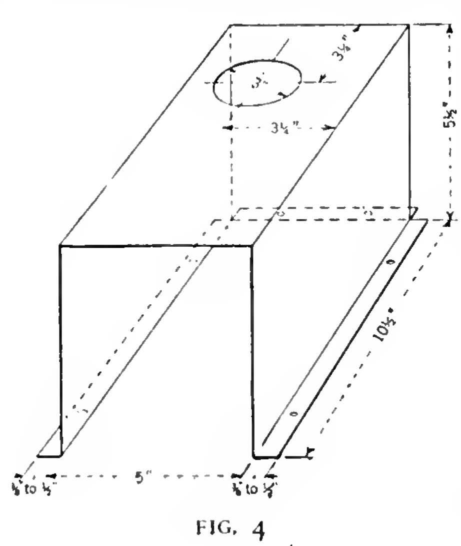


FIG. 4

Radio Broadcast Photograph

Constructing a Five-Tube Neutrodyne

Selectivity, Sensitivity, Ease of Operation Embodied in this Shielded Receiver—A Circuit for the New A C. Tubes

By HOWARD E. RHODES

IN THE preceding article Mr. Herbert J. Reich described the construction of an efficient five-tube neutrodyne type tuned radio-frequency receiver. Mr. Reich's receiver, using home-made coils and shields, will appeal to experienced home-constructors, but there are also many who would prefer to construct the set using standard manufactured parts. Such a receiver has been constructed in the Radio Broadcast Laboratory and is illustrated herewith. In building this receiver some slight circuit changes were made which simplify the construction. For example, the circuit has been altered so that the variable condensers need not be insulated from the shields; insulating them was necessary in order to get a $4\frac{1}{2}$-volt grid bias on the r. f. tubes. In the revised circuit shown in Fig. 1, the r. f. tubes have only one-volt bias on the grid and consequently the total plate current drain is about 4 milliamperes greater than it would be with a $4\frac{1}{2}$-volt bias. The change from $4\frac{1}{2}$ volts to 1 volt for r. f. grid bias does not result in any loss of efficiency.

Some loss in efficiency possibly results through the use of coils not having the specifications recommended by Mr. Reich (which is the case with the receiver herein described), but even so, the completed model gave excellent results, it being possible during several tests at the Laboratory in Garden City to hear WGY, Schenectady, and WJAR, in Providence, R. I., during the daytime. Excellent local reception can also be had using a loop or a 12-foot piece of wire thrown across the floor.

The circuit diagram of the receiver given in Fig. 1, and the various photographs illustrate very clearly how the receiver was assembled. The following parts were used in the construction:

L_1, L_2, L_3—; L_4, L_5—; L_6, L_7, L_8— Three Silver-Marshall Coils, Type 116-A
L_9—Samson R. F. Choke Coil, Type 85
C_1, C_2, C_3—Amsco 0.00035-Mfd. Variable Condensers
C_4, C_5—Hammarlund Neutralizing Condensers
C_6—Sangamo 0.00025-Mfd. Grid Condenser
C_7—Hammarlund 0.00005-Mfd. Midget Variable Condenser
C_8, C_9—Aerovox 1.0-Mfd. Bypass Condenser
C_{10}—Aerovox 4-Mfd. Condenser, Type 200
T_1, T_2—Thordarson R 200 Audio Transformers
T_3—Thordarson R 196 Choke Coil
S_1, S_2, S_3—Alcoa Aluminum Box Shields
R_1, R_2, R_3, R_4—Amperite Filament Resistors Type 1-A

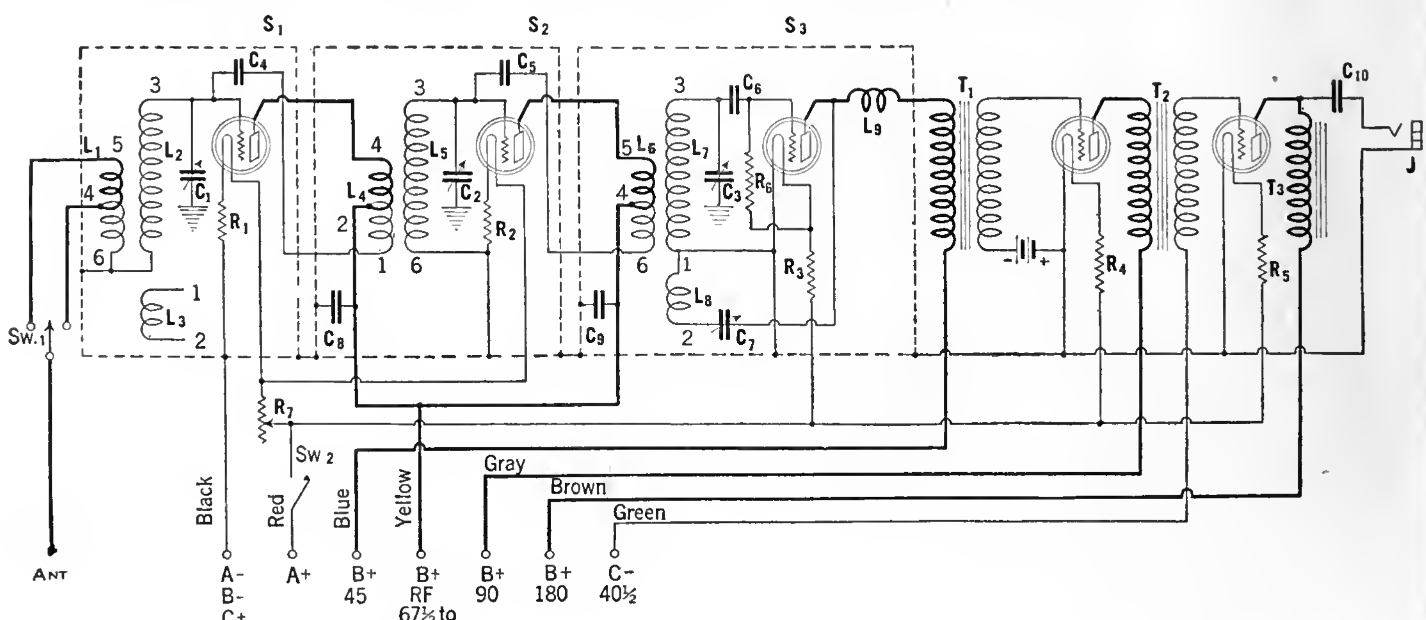


FIG. 1

R_5—Amperite Filament Resistor, Type 112
R_6—Lynch 4-Meg. Grid Leak with Mount
R_7—Carter Imp, 15-ohm Rheostat, Type IR-15
J—Yaxley No. 1 Single-Circuit Jack
SW1—Yaxley No. 730 S. P. D. T.
SW2—Yaxley No. 10 Filament Switch
Five Frost Sockets, Type 530
Three Karas Dials
Lignole Panel 7" x 24"
Three Silver-Marshall Coil Sockets, Type 515
Yaxley No. 660 Seven-Wire Battery Cable and Plug
Kellogg Switchboard and Supply Co. Hook-up Wire
Kester Rosen Core Radio Solder
Hardwood Baseboard, 23" × 12".

In order to adapt the Silver-Marshall 116-A coils to this receiver, some slight changes in two of them are necessary. In drawing No. 1, Fig. 2, is shown the way in which the coils are connected when they are purchased, the numbers on the coil terminals corresponding to the numbers on the Silver-Marshall type 515 coil sockets. It should be noted that the lower end of the secondary coil "A" is connected to terminal No. 6 and that the lower end of coil "B" is also connected to the same terminal. The Silver-Marshall coil can be used without any changes whatsoever for the antenna stage and by referring to the circuit diagram, Fig. 1, it will be found that the various coil terminals are marked with figures indicating the terminals on the coil socket.

In sketch No. 2, Fig. 2, we show the coil revised for use ahead of the second r. f. tube of the receiver. The small winding connecting to terminals Nos. 1 and 2 should be removed entirely and then the three leads connecting the coil "B" terminals Nos. 4, 5, and 6 of the coil socket should be removed and the leads of this coil connected instead to terminals 1, 2, and 4, as indicated in drawing No. 2.

The detector coil is shown in sketch No. 3 and the 116-A coil should be so altered as to conform with this sketch. Coil L_8, connecting to terminals Nos. 1 and 2, is not the same coil as "C" in sketch No. 1 because this coil has not sufficient turns to produce regeneration. Coil "C" should be removed and a new coil wound in the same slot. It should consist of 40 turns of No. 30 wire and the winding should be started at terminal No. 1, which is also the terminal to which the lower end of the secondary is connected, and should be wound in the same direction as the secondary winding, until the required number of turns has been placed in the slot and then the winding should be completed at terminal No. 2. Those home-constructors desiring to make their own coils will find the necessary data in the preceding article by Mr. Reich.

The various photographs given herewith will be very helpful in constructing the receiver since they show very clearly the layout of the apparatus. It will be found best to first lay out the apparatus in the three shielded stages and then drill holes in the aluminum bases of the shield cans at the correct points. The apparatus can best be fastened to the bases by means of 6-32 machine screws. The coil sockets should be mounted on $1\frac{1}{4}$" 6-32 brass machine screws and in this way the coil socket can be supported so that it is about 1" from the bottom of the can. The coil, when it is placed in the socket, will be more or less centered within the shield. In fastening the 6-32 screws that hold the coil sockets to the base it is a good idea to place a lug under each nut, which can later be used for making connections between the apparatus and the shield. The mountings for the Amperites should be prevented from touching the aluminum base by placing a couple of small washers between the mounting and the base when the former is fastened.

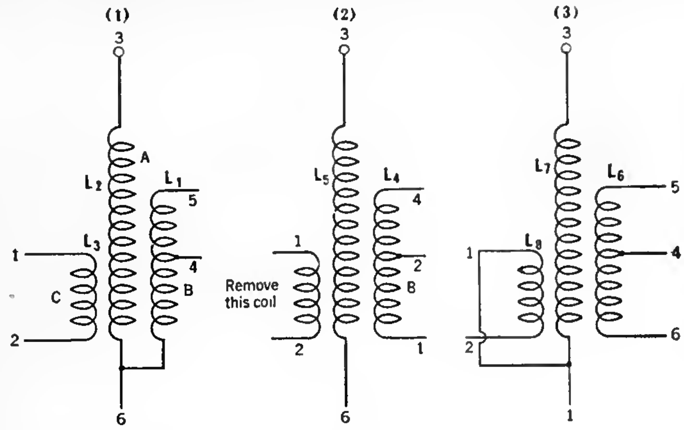


FIG. 2

It is not at all essential that the apparatus be laid out in any exact fashion and for this reason no drilling template is given for the base of the aluminum cans. It will be found easier and in most cases more accurate to actually lay the apparatus on the base and mark with a center punch the various holes that must be drilled. The drilling dimensions for the front panel are given in Fig. 3. The panel is held to the receiver proper by means of six flat-head machine screws which are passed through the six No. 28 holes indicated in Fig. 3 and then passed through six corresponding holes in the fronts of the three shields and finally held with a nut. In this way the fastening screws for the main panel will be concealed under the dials and the appearance of the front panel thereby improved.

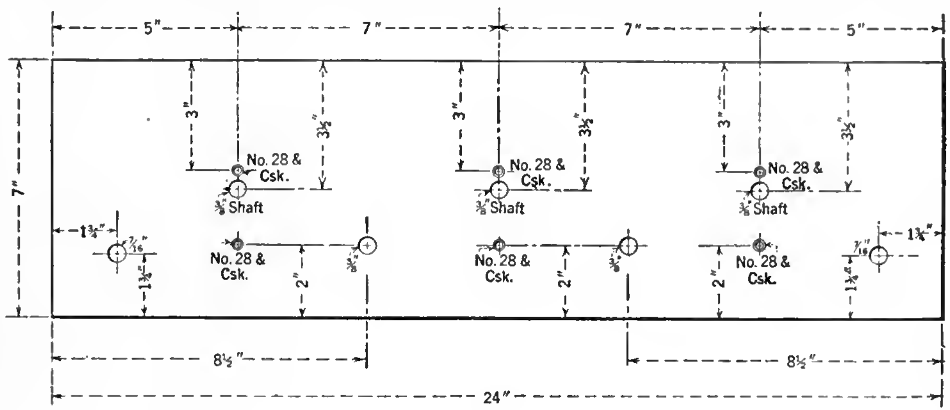
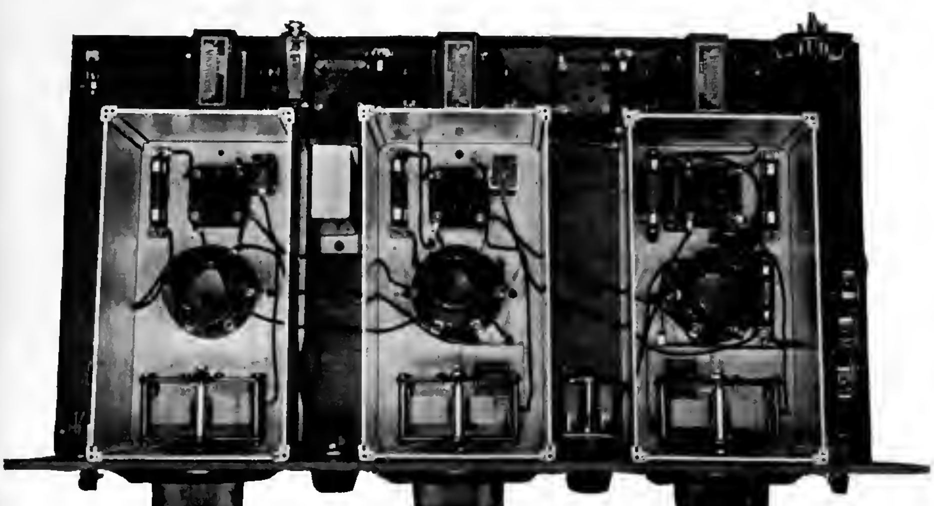


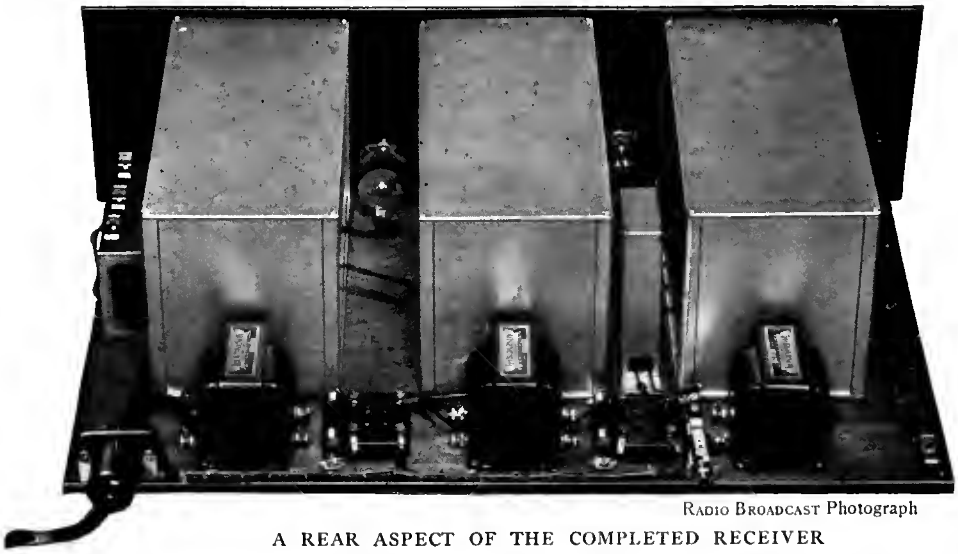
FIG. 3

In wiring the receiver, full advantage should be taken of the fact that the shields connect to the negative A. This makes it unnecessary, for example, to connect any wires between the rotor plates of the variable condensers and the lower end of the secondary windings. It is merely necessary to fasten the lower end of the secondary winding to the shield and then, since the variable condenser is also connected to the shield, the circuit will be complete. The leads connecting between the various stages can be run out of the shields by making small notches in the lower edge of the side of the shield and then passing the wire under these notches.

The C battery on the first audio stage is placed in the set itself, as can be seen in the accompanying photographs.

In connection with the building of this receiver, it is suggested that the reader carefully read Mr. Reich's manuscript because it contains many constructional hints that will be helpful. After the construction is completed it will be necessary to neutralize the receiver in order to obtain most efficient operation. The process of neutralizing the receiver should be the same as that explained by Mr. Reich except that with


COMPLETE EXCEPT FOR THE LIDS OF THE SHIELD CANS



Radio Broadcast Photograph

A REAR ASPECT OF THE COMPLETED RECEIVER

this receiver the filament of the tube which is to be neutralized should not be turned off by removing the Amperite but, instead, should be disconnected from the circuit by removing from the socket the positive filament lead. This change in procedure is necessary because in Mr. Reich's receiver the Amperites are in the positive filaments and in this receiver they are in the negative filaments.

A. C. OPERATION

THERE have been announced several new tubes designed for operation on alternating current. Four types of these tubes have been received by the Laboratory and are illustrated in a photograph on this page. Many readers will doubtlessly be interested in the possibility of using these new tubes in conjunction with the shielded receiver described so as to make a complete a. c. receiver out of it. The Laboratory experimented with these tubes and all of them proved quite satisfactory when used in the receiver.

The Marathon and Sovereign tubes at the left are of the heater type, while the Van Horne and Armor tubes at the right are of the a. c. filament type. In the case of the first two tubes, of the heater type, the alternating current flows through a filament which becomes hot and heats up a special cathode which, when hot, emits electrons and acts similarly to an ordinary filament in a 201-A tube. In the case of the latter two tubes, the alternating current passes through a heavy filament which is itself the source of electrons necessary for the operation of the tube.

When using any of these a. c. tubes it was found best to change the detector circuit so as to make it a C-battery type detector because, with a grid leak and condenser for detection, there was a small amount of hum which practically disappeared when C-battery detection was used.

To use the Marathon tubes, no changes in the filament circuit of the receiver are necessary. These a. c. tubes are merely placed in their sockets and then extra filament wires are run from a filament transformer to the several tubes, which are connected in a parallel arrangement. These tubes have characteristics similar to the 201-A type tubes and are therefore suitable for use in the two r. f. stages, the detector, and first audio stage. An ordinary 171 should be used in the last stage with its filament operated on a. c.

The Sovereign tube can also be used without any filament circuit changes in the receiver except that the filament terminals on all the sockets, except that one holding the 171 power tube, should be strapped together. The tubes are then energized by connecting the heater terminals in parallel and supplying them from a small transformer.

To use the Van Horne or Armor tubes it is necessary to slightly change the filament circuit of the receiver. The revised circuit diagram for these tubes is given in Fig. 4. It should be noted that both sides of each filament are connected across two terminals of a small transformer. A low-resistance potentiometer should be made from a 10-ohm. rheostat and is shunted across the transformer, negative B, plus C, and ground connecting to the movable arm of the potentiometer. This circuit also indicates a C-battery type detector. The second winding on the filament transformer supplies 5 volts to the 171 power tube in the output stage. Transformers satisfactory for use in conjunction with these various tubes are made by Mayolian, Amertran, Dongan, Thordarson, Samson, and Enterprise.

Radio Broadcast Photograph

SOME NEW A. C. TUBES

They are described in the text on this page

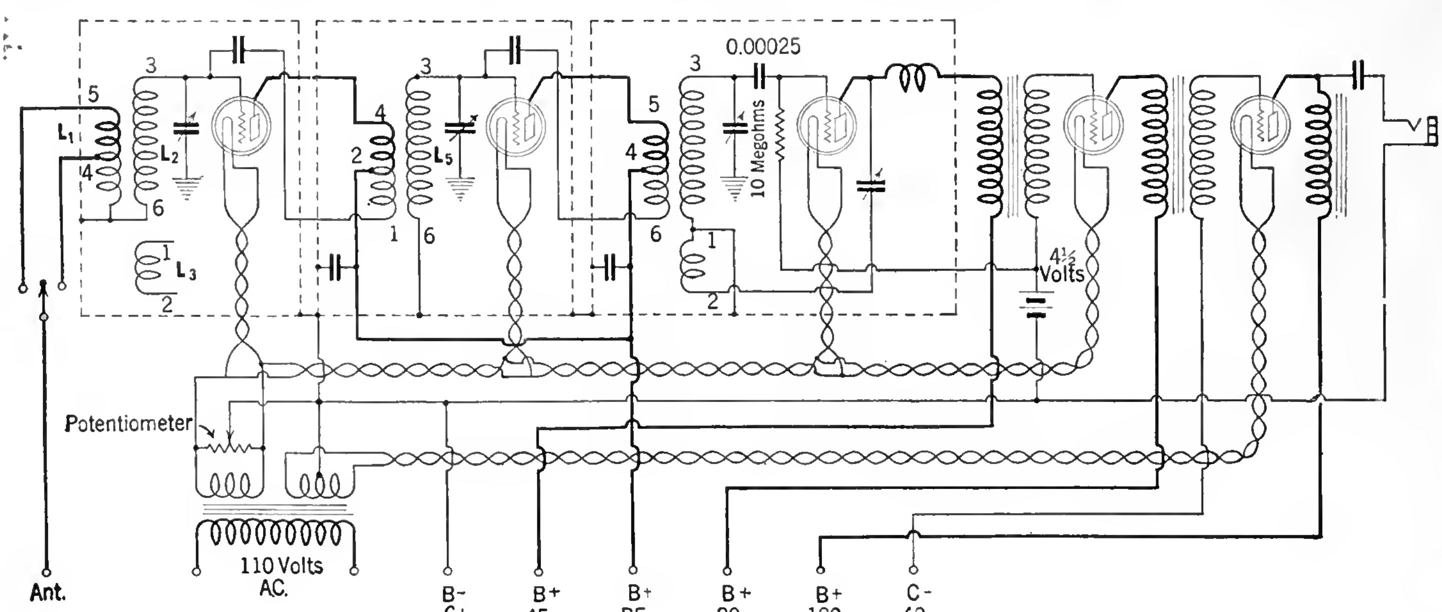
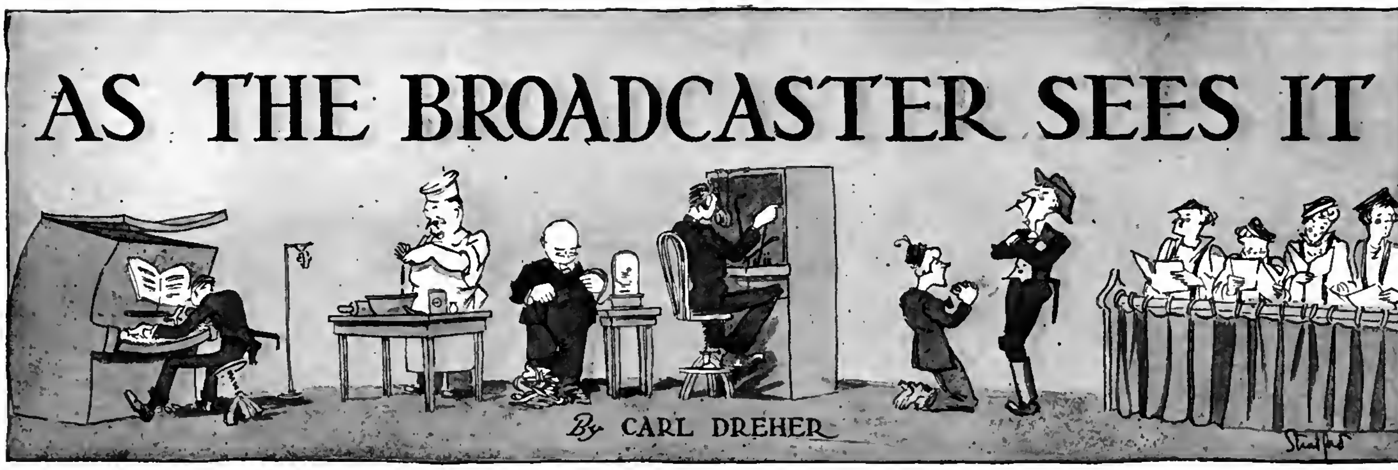


FIG. 4



Drawings by Franklyn F. Stratford

The Future of Television

IN THE July issue we discussed at considerable length the place of television among the communication arts, from what might be termed a metaphysical viewpoint. We tried to outline the fundamental relationships of the different branches of electrical, acoustic, and optical communication and reproduction in time and space. A moving picture showing Charlie Chaplin being hit in the nose by a custard pie, or a television apparatus reproducing for observers in New York the smile of a pretty telephone operator in Washington, may not seem very promising subjects for an analysis of this nature, but the content of the reproduction has nothing to do with the abstract functions of the machinery involved. Having disposed of these fundamentals to the best of our ability, we may proceed with an examination of the practical aspects of television. What part may it be expected to play in the industrial and social life of countries like the United States?

One thing should be noted before we embark on our self-appointed mission of prophecy. Practical television is not around the corner. Many moons will wax and wane before televisor screens in our homes show us distant events and people. Many sleepless nights are ahead of the engineers and scientists charged with the task of putting the new art on a production and commercial basis. If I had at this moment, in a lump sum, the money I expect to earn in very modest annual increments before television becomes a practical reality, I should depart forthwith for a pleasant winter in Algiers and live on the interest for the rest of my life. Anyone who hesitates to buy a radio receiver, for example, because he fears that one equipped with television features may be put on the market before he can realize on his investment, is taking a position almost as ludicrous as that of a man who decided not to buy a gasolene-driven automobile because some inventor might devise a vehicle which would run ten centuries on the intra-atomic energy of a pound of sodium bicarbonate. The everyday application of television is a remote possibility in five years, a fair possibility in ten, a probability in fifteen. Many good radio receivers, appealing to the ear only, will issue from the factories, play their melodies in millions of homes, and succumb to old age and new tastes, in that time. Or, if a slight mutilation of Horace is permissible: "To-morrow do thy worst, for I have listened to-day!"

But when the day arrives, and the engineers produce, for a reasonable expenditure, a television apparatus capable of reproducing distant events in a life-like manner on a sufficiently large screen, what then? Will the accomplishment be a blessing? Not always—take that from one who has seen many broadcast artists. For others, I wish we could have it to-morrow. Sometimes I have seen and heard some beautiful girl with an equally beautiful voice rehearsing her program in the afternoon, and, at the receiver in the evening, have had to be satisfied with hearing her only, and it has certainly been a deprivation. To be limited to one sense is more or less of a hardship in such cases. On the other hand, as I write this article I am listening to a capable group of musicians playing dinner music at one of the hotels. I hear the music and the announcements, although primarily my attention is focused on the typewriter. If my receiver had a television attachment now I should turn it off. In the first place I have no optic interest in the hotel musicians. They are probably just as homely as I am. In the second place, I don't want to look at anything; it would distract me. The ear is happily capable of carrying on its function soothingly and pleasantly, given the right material, without interfering with other activities. Many people rarely listen to a radio program with great concentration. Everyone does, at times, but, as frequently, radio music forms a background for conversation or reading. Often people talk during the music and pause to listen to the announcements. I generally read during the whole evening's program of a given station, but I hear the announcements and know pretty well what has happened afterwards. Obviously in such cases television is not a remarkable boon. It is even possible that when television has come to stay that some programs will be transmitted with the visual component and others without it.

"MANY SLEEPLESS NIGHTS ARE AHEAD OF THE ENGINEERS"

The movie theatres, it would seem, can do without television. As we saw in the preceding article on television, the motion picture is primarily an art for transferring the past, optically, into the present. The moving picture audience finds no difficulty in attaining a feeling of being in contact with reality, even though the actors went through their parts months ago. There would be nothing gained by substituting television in such a case, and something would be lost. In the recording arts there is always the advantage of being able to try over and over until one gets the right results, and offering to the public only a finished product. Both the phonograph and the motion picture have this advantage. However, television in conjunction with telephony might be employed to reproduce distant spectacles, not only in the home, but in theatres. For example, a movie house might interrupt its program for a short speech, reproduced visually and audibly, by the President—an appeal for aid, for example, in time of national disaster. The theatres have not used broadcasting to any extent to serve their actual audiences; it has been merely a medium of advertising to them, a means of attracting audiences. If the visual component were added to broadcasting as we now know it, the motion picture theatres might find it a useful adjunct to their shows, probably in a form we do not foresee now. But it will not be a necessity; they can probably keep on doing a tidy business without it. Aural broadcasting has affected the motion picture industry only to a moderate extent. In the larger centers the hunger for amusement is so avid that every form of diversion is eagerly soaked up. Most families in a city like New York have radio receivers and use them, and yet colossal theatres continue to spring up and the patrons besiege the box offices as soon as they are finished. Adding television to telephone broadcasting will probably not alter this condition.

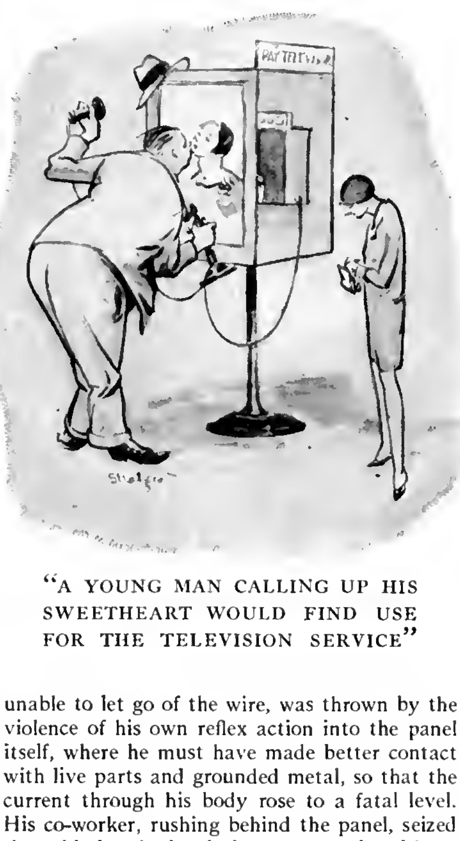
In point-to-point communication, television may be used to supplement telephony, for sentimental or other purposes. A good deal of the expensive conversation which passes over the Atlantic radio telephone link is not acutely essential. People call each other up between New York and London for a thrill as much as in the way of business, it is probable. A young man calling up his sweetheart would, on the same basis, find use for the television service in conjunction with the telephone, even though it cost money. But, as Mrs. Herbert Hoover remarked during the television tests between New York and Washington, sometimes one would rather not be seen as well as heard. Everyone is free to imagine his own situations in verification. In the largest number of cases, television, as it would not add much to the communication value of the connection, would not be called into use. One business man calling up another to ask for a quotation on forty kegs of wire nails would certainly not pay for television service; all he wants is the price of the nails, if he knows what they are like—and he usually does. If he does not, then a sample nail might be shown him, of course. It is a terrific job to compare curves or observations involving circuit diagrams, by telephone, as every technical man knows. In such cases television would come in handy. But in most cases the mouth and ear form an adequate communication circuit; for this reason, as the wire or point-to-point telephone is primarily a means of communication, television will probably be limited to the rôle of an adjunct in this field, an important adjunct, however.

It is interesting to note, in conclusion, that television, as now realized, involves no startling new discoveries. The principles on which it is based were understood decades ago. The same holds true for photoradiograms and the like. Ranger, at the beginning of his paper on "Transmission and Reception of Photoradiograms" (*Proceedings of the Institute of Radio Engineers*, April, 1926) says disarmingly: ". . . the art of picture transmission . . . is as old as the communication art itself." And Ranger goes on to state that the 1842 scheme of Alexander Bain "is so basically correct that it is only right at the start to show the simplicity of his plan and, how, generally, we are all following in his footsteps." Modern inventors marshall all the forces of modern industry to accomplish ends which were visualized imaginatively years ago, but which previous generations lacked the technique to carry out in actuality. This should not be construed as a reflection on the capacity of contemporary research workers. It is simply that their ingenuity is of another kind and utilizes other tools. They have as much courage, determination, and resourcefulness as the inventors of any previous generation. In the case of television they have needed all they have of those qualities to bring them to the present stage of achievement, and they will need no less to achieve the practical applications looming on the industrial horizon.

Another Broadcast Fatality

CONSIDERING the fact that there are only a few thousand broadcast operators in the United States, the fatal accidents among them are too frequent, as I have remarked before in this place. Another case occurred on May 12th at a New Jersey station. A young man (he was twenty-two years old) was instantly killed while working on a transmitter panel at 4 o'clock in the morning. The circumstances, as nearly as they can be ascertained, are worth recounting, in the hope that the analysis will lead some of the boys to take precautions which they might neglect otherwise.

The station in this case was not on the air. Repairs or alterations were being made during the night in order to avoid interference with program service. The man who was killed was working behind the panel, where there were two-thousand volt terminations fed from a generator in the basement of the building. This generator could not be heard running in the transmitter room. It is not known whether the victim of the fatal accident was working on live circuits with confidence that he could avoid getting across the high tension, or whether he imagined that the machine had been shut down. He took hold of the bare copper of one of the high-tension cables, while he was partially grounded through his shoes. This put him across the 2000-volts, but probably would not have killed him in itself. He exclaimed, "Wow, it's hot!" causing a fellow worker, who was in front of the panel, to run to his aid. In the meantime the man on the circuit,



"A YOUNG MAN CALLING UP HIS SWEETHEART WOULD FIND USE FOR THE TELEVISION SERVICE"

unable to let go of the wire, was thrown by the violence of his own reflex action into the panel itself, where he must have made better contact with live parts and grounded metal, so that the current through his body rose to a fatal level. His co-worker, rushing behind the panel, seized the cable by the insulation, apparently without shutting down the machine, and tore it out of the fallen man's hand. The wire was rubber-insulated against high tension, and the rescuer got away with his effort, which was both heroic and foolish. A third operator who was present attempted artificial respiration without success. The young man was dead.

What is the moral? There is only one: Be sure that the high tension is shut down before you do any work on potentially live parts of the transmitter. Two thousand volts is not terribly high; many of us have taken it and remained among the living. But if you make a good contact you are as good as dead on a much lower potential. Furthermore, once you are caught you may be thrown into any part of the machinery; you no longer have any control over your movements, and in a few seconds the tragedy is complete. It is perfectly possible for a man to receive a shock on 110 volts which in itself would only be moderately painful, but if the high-tension portion of the equipment is running he may be flung onto a 10,000-volt circuit before anyone realizes what has happened.

But sometimes one thinks the juice is off when it is not off. Or someone may throw it on while a man is working on the circuits, through a misunderstanding. The remedy for that is simple; the cost is about five cents, and a little thought. Take a stick of dry wood one inch by one inch by, say, twenty inches. Screw on one end of this stick a piece of copper an inch wide, an eighth of an inch thick, and about six inches long, bent in the form of a hook. Let this copper hook be permanently grounded through a heavy, well-insulated flexible wire. When the set is running on program let the contraption lie under the frame or beside the panel. When anyone is going to work on the transmitter, take the copper hook by its insulating stick and hang it gently on the plate bus. If the bus is alive, by chance, there will be an explosion, but you won't get hurt. A new hook can be made in five minutes. If someone turns on the current while the plate bus is shorted, the hook will take the bulk of the flow, and a man's body, with its relatively high resistance, will not receive enough to kill him, perhaps not even enough to hurt him.

One more point is worth taking up. A great deal of testing is done at radio stations during the early morning hours, for obvious reasons. In fact, the regulations restrict broadcast stations to the hours between midnight and 11:30 A. M. for testing. During the early hours of the morning, what with fighting sleep and fatigue, a man does not think as clearly as he might at other times. He is at a lower tension of consciousness, and not as distinctly aware of the outside world and its perils as he might be after eight hours of sleep. That is the more reason why a simple automatic device like the bus hook described above should be provided in every station and its use made mandatory, until it becomes so habitual that no one thinks of working without it. Even then, of course, there is no substitute for prudence and conscious direction of all one's movements when one is in the vicinity of a radio transmitter. The thing is dangerous, highly dangerous, and for innocently taking a chance with it one is apt to pay with one's life. And that chance need only be taken once.

Local Regulation of Broadcasting

DURING the partial interregnum between the Zenith decision and the passing of the Dill-White bill to provide for adequate Federal regulation of broadcasting, there was manifest a tendency on the part of some states and municipalities toward local handling of interference problems and the like. Now that Federal administrative machinery is once more functioning, this development will probably peter out by itself. It is worth discussing, however, because in at least one case—that of the City of Minneapolis—an ordinance possessing broad regulatory powers was adopted (on February 11, 1927), and may still be in force.

The Minneapolis ordinance provides for annual licensing by the City Council of all broadcasting stations within the city, the fee being $50.00. Transmitters located within the city limits, or less than two miles outside, are limited to an antenna power of 500 watts. Between 500 and 1000 antenna watts the transmitter must keep at least four miles from the nearest city boundary line, or at least eight miles if the antenna power is 1000–5000 watts, and so on up to output power of the order of 50,000–100,000 watts, when the prescribed distance is increased to 25 miles. There are also provisions limiting the total number of hours of evening broadcasting allowed to any station in the city or within two miles thereof, to twelve per week; and the Building Inspector of the City is assigned power to regulate the hours of such stations. Another section is directed against radiating receiving equipment, violet ray machines, X-ray apparatus, and vibrating battery chargers of types capable of interfering with radio reception. Fines between $15.00 and $100.00, or imprisonment up to 90 days, are prescribed for violations. "Each and every day's continuance of any violation of this ordinance," reads the punitory section, "shall be deemed a separate offense." Another section forehandedly provides: "In case any section or any part of this ordinance is declared invalid, it shall not affect the validity of the remainder of this ordinance."

The manner of enforcement contemplated against transmitters outside of the city limits is of interest. The relevant section reads, "It shall be unlawful for any owner, lessee, or licensee of any metal wires, after written notice from the Building Inspector, to permit the use of such wires in the operation of any broadcasting station which is being operated by the owner or operator thereof in violation of the provisions of this ordinance." In other words, if the transmitter, located outside of the City of Minneapolis, does not conform in location, or otherwise, to the regulations of the municipality, the City will cut it off from electrical connection with any studio within the City, if the courts permit.

Obviously Federal regulation must intervene in all the major questions of broadcasting. The radiation of a broadcasting station does not proceed to the bounds of any city, state, or country and then drop dead. It is an interstate affair if there ever was one. Since there must be centralized regulation of the most complicated sort, it is not a very sapient procedure to attempt decentralized regulation at the same time. The two are bound to overlap. State and municipal control is probably unconstitutional. Professor Frank S. Rowley, of the University of Cincinnati College of Law, in a valuable article on "Problems in the Law of Radio Communication" (*University of Cincinnati Law Review*, January, 1927), writes as follows on the general principle involved:

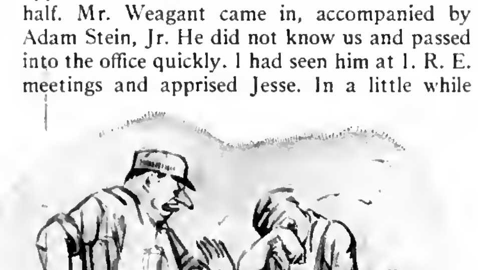
> . . . even though we concede that such stations (of low power and normal intrastate range) operate on a purely intrastate basis, there is excellent authority for sustaining Federal regulation of the same, by analogy to decisions governing regulation of other instrumentalities of intrastate traffic. The Commerce Clause of the Constitution necessarily excludes the states from direct control of subjects embraced within the clause which are of such a nature that, if regulated at all, their regulation should be prescribed by a single authority. That such a doctrine applies particularly in the case of regulation of radio communication is very apparent. A chaos of interference and confusion would result if powers of regulation were divided between federal and state authorities. To avoid such a possibility, a single authority must be given complete control.

Professor Rowley's discussion, although not written with the Minneapolis case in view, seems to me to say all that needs to be said about this or similar attempts. The Radio Commission, or the Secretary of Commerce, can take care of the radio needs of municipalities quite adequately. Such agencies possess much more effective means for compelling interference-causing transmitters to move out of congested districts than any municipality or state body can create or use. Whatever good might be accomplished locally would be overbalanced by possible evils which any layman can foresee. Local authorities had best keep their hands off, in my view. And I might add that I am a rabid states-rights exponent, a natural Jeffersonian, and a natural anti-Hamiltonian—in everything but radio. Radio is not a town-meeting affair, and can't be made one by the best of town legislators.

ROY A. WEAGANT
Said: "The salary will be $10.00 per week as a beginning"

Memoirs of a Radio Engineer. XIX

On a sunny afternoon in May my classmate, Jesse Marsten, and I, fresh from college, sat in an ante-room of the Marconi Company's factory at Aldene, waiting for Mr. Weagant, the Chief Engineer. The year was 1917. Did I say we sat? We stood, as a matter of fact. The office force, unimpressed by our appearance and demeanor, did not invite us within the enclosure wherein high-powered office managers, assisted by beautiful secretaries, guided the Marconi Company's destinies. Mr. Weagant was expected, so we waited. We had an appointment. We waited about an hour and a half. Mr. Weagant came in, accompanied by Adam Stein, Jr. He did not know us and passed into the office quickly. I had seen him at I. R. E. meetings and apprised Jesse. In a little while Mr. Weagant came out again. He looked preoccupied; there was reason enough for it, as a matter of fact. In a small stone building, with a few bungalows scattered about it, the Marconi Company was trying to meet war-time demands for apparatus which would have overtaxed a plant six times as large. As Mr. Weagant passed the second time, going out, Marsten stopped him and reminded him of the appointment Doctor Goldsmith had made for us. Mr. Weagant looked dazed for an instant, then, recollecting, he apologized with his usual grave courtesy, and, dropping far more important business, took us to his office in the small wooden engineering building near the main plant. He questioned us and told about the engineering course which the Marconi Company had planned for such aspirants as ourselves. The idea was to move the student engineers about in the various departments of the plant, so that they could become acquainted with all the intricacies of design and manufacture of radio apparatus. We murmured our approval. The salary, continued Mr. Weagant, would be $10.00 per week as a beginning, with an increase of $1.60 per week every six months. If we had commercial operator's licenses, he added, six months' credit would be extended. I thereupon produced my first-class ticket, for which I had undergone the ordeal of examination at the Brooklyn Navy Yard some years before. Mr. Weagant seemed surprised; he examined the document carefully, and granted me the increase in salary which it rated.



"I WAS SUBJECT TO SAVAGE LAYING-OUT BY THE NEAREST FOREMAN"

Next, with the assistance of two of the engineers at the Marconi plant who were graduates of the City College, Messrs. Barth and McAusland, we secured board and lodging in the near-by village of Roselle, with a very charming middle-aged couple, a retired ship's purser and his wife. The lady was childless but maternal, so she lavished attention on the canary bird, Jesse, and me, and really made things unusually comfortable for us during our stay at the Aldene factory. The room and board amounted to $8.00 a week apiece. Each of us had a very nice room in a good neighborhood, with typical suburban streets shaded by old trees, and we were not badly off, except, of course, that we were not quite self-supporting on our respective salaries of $10.00 and $11.60 per week. This worried us considerably, and we felt that the world is very cruel to newly fledged college students. It is. Why shouldn't it be? But, as a matter of fact, we were able to knock down an average of fourteen dollars a week by working overtime. Some weeks I climbed to the dizzy height of sixteen dollars and fifty cents. A young man could live quite well on that sum in 1917.

We started to work on a Monday. Marsten, I believe, was relegated to the drafting room. I became a tester. I worked from seven in the morning to three in the afternoon, with a half-hour for lunch, punched a clock, and wore overalls. There were no halfway measures, either. If I came five minutes late in the morning my card showed it and I was docked fifteen minutes' pay. The overalls were dirty at the end of the first day I wore them. I was a factory hand like any other, subject to the same discipline, the same savage laying-out by the nearest foreman when I did anything wrong, the same difficulties of organization and manufacture which beset the other cogs in the machine. My B. S. was hidden under the overalls; nobody knew about it except my immediate superior, and he did not hold it against me after a few weeks. I forgot it. My life differed from that of my fellows only after 3 P. M., when, washed and arrayed in white flannels, I played tennis on the turf courts of Weequahic Park in Newark, and spent the evenings reading H. G. Wells.

Use of Tubes Having High Amplification

A Discussion of the Theory Underlying the Functioning of High-Mu Tubes—A Paper Delivered Before the Radio Club of America

By A. V. LOUGHREN

Research Laboratory, General Electric Company

THE amplifier tube has, within the last two years, undergone a notable change. In 1923 all amplifier tubes were of the general-purpose type and all were alike. To-day, on the other hand, we have, in addition to this general-purpose tube, two distinct groups of special-purpose amplifier tubes.

One of these groups—that having a low amplification factor and low plate-to-filament resistance as its chief characteristics—was brought into being to satisfy the demand for more speech power which arose when reception on the loud speaker became common. The performance of this group of tubes has already been discussed in some detail ("Output Characteristics of Amplifier Tubes," J. C. Warner and A. V. Loughren, *Proceedings Institute of Radio Engineers*, Vol. 14, No. 6, Dec., 1926).

The second group, consisting of tubes having amplification factors of 15 or more, will be treated in the present paper. It should be understood, of course, that tubes with high amplification factors are not at all new, as such tubes have been built since 1912. Some of their uses have not been completely investigated, however, until recently.

Any treatment of the uses of tubes having high amplification factors is of necessity primarily a discussion of their use in resistance-coupled amplifiers. In order to understand their application to this type of amplifier it is necessary to have its underlying theory clearly in mind.

Fig. 1 is a diagram of a two-stage amplifier with resistive-interstage coupling. The operations may be sketched roughly as follows:

When a signal is impressed on the input circuit, consider the phenomena at the instant when the grid potential has reached the highest value occurring during the cycle. In Fig. 2 this condition is represented by the point t_1. At this same instant the plate current reaches a maximum. Now, looking back at Fig. 1, we see that the voltage at the plate of tube No. 1 is equal to the battery voltage minus the IR drop in the resistance R_{p1}. The value of this drop is simply $I_p \times R_{p1}$. Therefore, it is directly proportional to the plate current. Thus, when the plate current is greater, as at t_1, the drop in the coupling resistance, R_{p1}, is greater, and hence the plate voltage on the tube is less. The curve of plate potential in Fig. 2 shows this exactly. Incidentally, it may be noted that the signal has been shifted 180° in phase by going through the first stage.

The alternating component of this plate potential is applied to the grid leak resistance, R_{g2}, of the second tube, while the direct component is kept back by the blocking condenser C_{b2}. The grid of tube No. 2 is so connected that the drop in the grid leak resistance is the alternating component of grid voltage. In this stage the action is exactly like that in the preceding one.

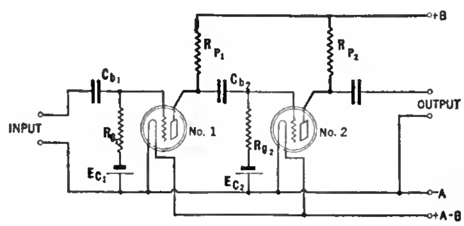


FIG. 1

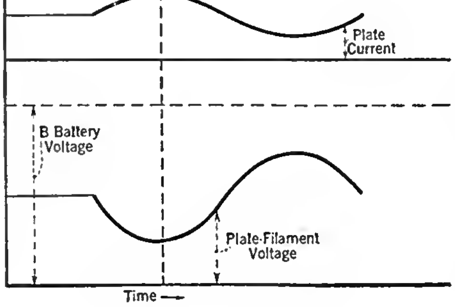


FIG. 2

Now, having a slight familiarity with the circuit and its mode of operation, let us proceed to a more rigorous analysis of the performance. To do this we make use of a fundamental principle of physics which may be stated as follows: With circuit elements whose coefficients are constants, the circuit response to a complex emf. may be determined by evaluating the respective responses to each of the (simple) component emf's. and taking the summation, if desired. In the present case this principle permits us to analyze the performance of the amplifier circuit for the alternating quantities alone, neglecting entirely the direct components.

Fig. 3 is drawn in this way. It may be noted that only the quantities entering into the alternating-current phenomena are shown. The interstage coupling resistor, R_p, is shown connected from the plate back to the filament. In practice it is connected to the positive terminal of the B battery and through the latter to the filament, but here we do not need to show the battery. The representation of a tube by a generator and the series resistance r_p is quite common in analyses of tube output characteristics.

By the use of Kirchoff's Laws for alternating current circuits an expression may be worked out for the relation between e_{g2}, the output voltage of the network, and μe_{g1}, the input voltage. The first voltage corresponds to the alternating voltage on the grid of the second tube while the second is proportional to that on the grid of the first tube. The steps of the mathematics are hardly worth showing in detail. The final expression is that given in Fig. 3. This expression contains a group of terms independent of frequency, and two terms containing the quantity P, where $P = 2\pi \times$ frequency, which are dependent on frequency. The first of these latter is directly proportional to frequency and thus may be expected to interfere with the amplifier performance more at higher frequencies; the second, on the contrary, is important at low frequencies since it is inversely proportional to frequency.

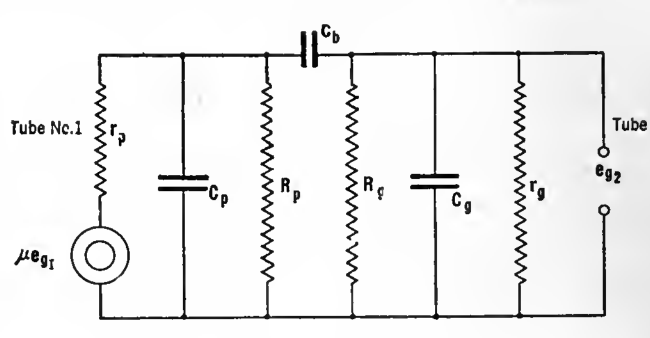
Before investigating the magnitudes of these two frequency effects we must see what the values of the various circuit coefficients are. Certain of them are quite familiar to radio workers, such as the internal plate circuit resistance r_p, the coupling resistance R_p, the grid leak R_g, and the blocking condenser C_b. The quantities C_p, C_g, and r_g have not been in common use, so a word about their magnitudes will hardly be amiss.

The plate-to-ground capacity, C_p, is very nearly the sum of the following:

(1.) Tube inter-electrode plate-filament capacity.
(2.) Tube inter-electrode plate-grid capacity.
(3.) Stray capacities in wiring.

For the Radiotron UX-240 the first two are 1.5 and 8.8 micro-microfarads, respectively.

The quantities r_g and C_g cannot be treated rigorously without going beyond the scope of the present paper. Their magnitudes are de-



SOLUTION:

$$\mu e_{g_1} = e_{g_2}\left[1+\frac{C_g}{C_b}+\frac{r_p}{R_p}+\frac{r_p}{R_g}+\frac{r_p}{r_g}+\frac{r_g C_g}{R_p C_b}+\frac{r_p C_p}{r_g C_b}+\frac{r_p C_p}{R_g C_b} + jPr_p\left(C_g + C_p + \frac{C_p C_g}{C_b}\right) + \frac{1}{jPC_b}\left(\frac{r_p}{R_p}+1\right)\left(\frac{1}{R_g}+\frac{1}{r_g}\right)\right]$$

FIG. 3

pendent on the constants of the plate circuit of the second tube. For our purpose it will be sufficiently accurate to consider r_g infinite as long as the second tube is biased sufficiently. C_g may be expressed as:

$$C_g = C_{gf} + C_{gp}(A_v + 1)$$

The reason for the appearance of the quantity $(A_v + 1)$ where A_v is the voltage amplification actually obtained between grid and plate of the second tube, is explained in the appendix on page 240. In practice C_{gf} is usually 3 to 4 mmfd. and C_{gp} 8 to 10 mmfd. while A_v may be between 2 and 25 or more. Accordingly C_g will vary over the range from 20 to perhaps 300 mmfd. The figures given, by the way, do not include the stray capacities in the wiring. It should further be noted that there is no marked difference in the values of these capacities for low and high amplification tubes; that is, the Radiotron UX-201-A for which $\mu = 8$ and the Radiotron UX-240 for which $\mu = 30$, have substantially the same inter-electrode capacities. The Radiotron UX-171 has nearly the same grid-to-plate capacity as the others, but as it has twice their filament surface its grid-filament capacity is somewhat greater.

The frequency characteristic of each individual stage may be calculated by the relation shown in Fig. 3. The frequency characteristic of the complete amplifier is equal, of course, to the product of the frequency characteristics of the individual circuits. Fig. 4 shows certain of these overall frequency characteristics. It should be noted that the use of higher value coupling resistances increases the amplification, but that these increases are always less in magnitude at the upper end of the frequency characteristic than in other portions of the range. Accordingly, the frequency characteristic becomes poorer as the coupling resistance is increased.

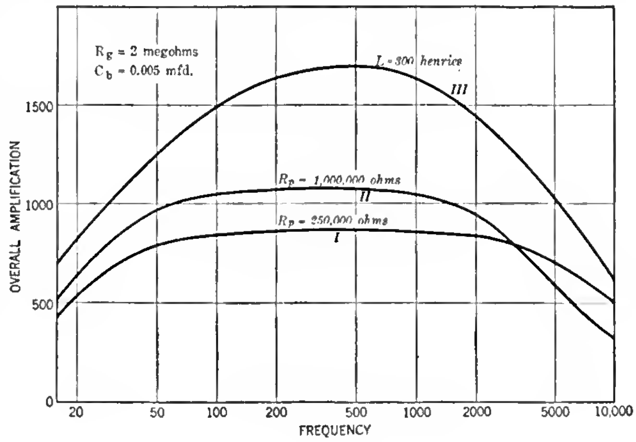


FIG. 4

FIG. 6

CHOICE OF AMPLIFICATION FACTOR

THIS is an excellent point in the discussion to take up the question of the choice of the amplification factor. It should be pointed out that this factor is completely under the control of the tube designer so that there is little difficulty in building tubes having values anywhere between 0.5 and 500. Any increase in the amplification factor, however, involves an increase in the plate resistance of the tube, if the filament and plate dimensions and the spacings are kept the same. Fig. 5 shows this variation in plate resistance with amplification for tubes similar to the UX-201-A in plate and filament structures. It may be shown from the mathematical expression in Fig. 3 that any increase in the plate resistance r_p leads to a loss of amplification which will be more pronounced at the high frequencies than elsewhere. Further, as the actual voltage amplification of tube No. 2 is increased, the capacity C_g of Fig. 3 is increased almost directly, as may be seen from the expression already given for it; this capacity increase also tends to make the amplifier "lose" higher frequencies.

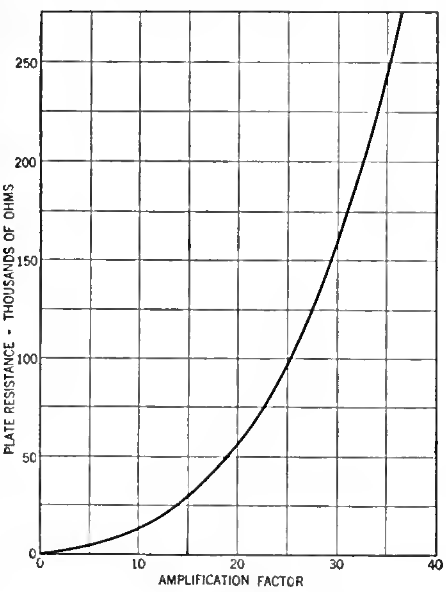


FIG. 5

Accordingly, the choice of the proper amplification factor for a tube for resistance-coupled amplification should be the highest value which is consistent with a satisfactorily flat frequency characteristic. Of course, opinions on frequency characteristics differ, but it is felt that in the design of Radiotron UX-240 the greatest value of amplification factor that should be used in a high-quality receiver has been chosen.

FIG. 7

One of the curves of Fig. 4 shows an experimentally determined overall frequency characteristic when iron-core inductances are used for interstage coupling. The units used have unusually high inductance, but the loss of amplification at low frequencies shows that, even so, impedance coupling was unsatisfactory.

So far we have assumed that the circuit coefficients are constants. Actually this may or may not be a valid assumption in a practical case. The two circuit coefficients which may

FIG. 8

FIG. 9

FIG. 10

FIG. 11

FIG. 12

vary appreciably in practice are the plate resistance and the grid resistance.

Variation of the plate resistance becomes a matter of importance if the plate current is permitted to decrease to too low a value at any time during the cycle. The effect of this may be seen by comparing the oscillograms of Figs. 6 and 7. Fig. 6 shows the output of the UX-240 when operating normally, while in Fig. 7 the negative bias on the grid is excessive. The resulting distortion on the lower half of the plate-current wave is quite objectionable.

Variation of the grid resistance is negligible in magnitude when the grid potential is negative. When the grid becomes positive, however, its resistance falls quite rapidly, and it may, under some conditions, introduce appreciable distortion. If the source of the signal voltage has good regulation there is little likelihood of distortion occurring; the oscillogram of Fig. 8 demonstrates this. It shows the output of the UX-240 for the same signal voltage as in Fig. 6 and 7; that is, 1.06 volts effective, this time with no bias at all. The plate current is obviously undistorted. Fig. 9 shows the rather poor results obtained when the regulation of the signal source is unsatisfactory.

If the tube is operating with a blocking condenser and grid leak and receives sufficient signal to make the grid positive, the electrons which flow from the filament to the grid must continue through the leak and back to the filament. In doing so they will develop a voltage drop across the leak which will bias the grid negative; the trouble will thus be largely self-correcting. Fig. 10, which illustrates this point, was made under the same conditions as Fig. 9 except that a blocking condenser of 0.015 mfd. was interposed in the lead from the grid to the signal source and a grid leak of 1 megohm was connected from grid to filament. The improvement in output wave form over that of the preceding oscillogram is quite striking.

Fig. 11 shows the distortion that occurs with no bias and the same signal amplitude as before, when the signal is supplied from another tube through an interstage transformer. Here the grid current cannot bias the tube appreciably as it has a low-resistance return to the filament and hence produces only a negligible IR drop. In the record of Fig. 12 this condition has been corrected by the introduction of a suitable bias.

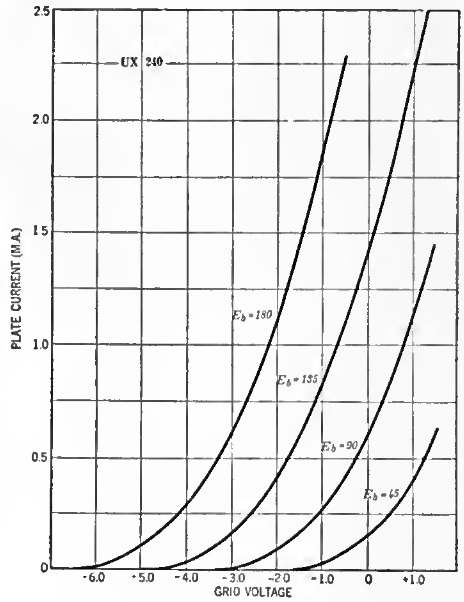


FIG. 13

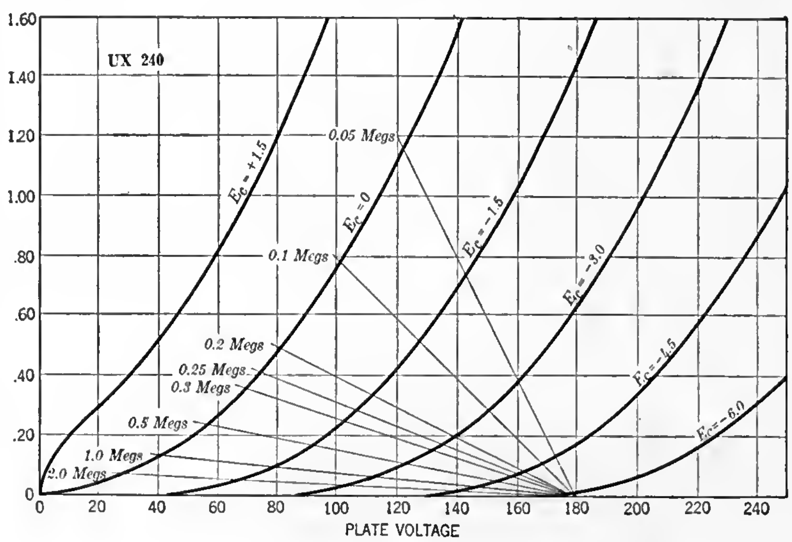


FIG. 14

Perhaps a word about the UX-240, the tube on which our work is based, would not be amiss. In external appearance this tube is identical with the UX-201-A. The filament characteristics and ratings are also identical. Normal operating conditions for the tube are 1.5 to 3 volts grid bias, 135 to 180 volts plate supply voltage, with a 250,000 ohm resistance in series with the plate. Under these conditions the actual voltage amplification will be between 15 and 20, representing better than 50 per cent. utilization of the tube's inherent amplification factor of 30.

Fig. 13 shows the mutual characteristics of the tube and Fig. 14 shows a family of plate characteristics. These are the two forms in which static characteristics are conventionally shown and are reproduced for that reason.

APPENDIX

The change in grid-to-ground capacity introduced by the plate and plate circuit of the tube may be treated as follows: In the case of a resistance-coupled circuit having substantially unity power factor, so that there is no appreciable phase shift, let us observe what happens when the grid is raised in potential 1 volt. The plate potential falls by an amount A_V volts, where A_V is the actual voltage amplification which the stage is furnishing. Now, across the direct grid-filament capacity we have introduced a net change in potential difference of 1 volt, and accordingly the quantity of electricity which will raise this potential difference 1 volt is added to that already providing the electro-static field between grid and filament. Across the direct grid-plate capacity we have introduced voltage changes of 1 volt at the grid side and of A_V volts at the plate side, the two changes being of the same sign insofar as their effect on the electrostatic phenomena is concerned. As a result, a quantity of electricity sufficient to change the grid-plate capacity to $1 + A_V$ volts must flow on the grid.

By combining these two terms we find that the effective capacity from grid to ground is:

$$C = C_{gf} + C_{gp}\,(1 + A_V)$$

It should be noted that a general treatment of this capacity effect is, ipso facto, a study of regeneration due to inter-electrode capacity.

Radio Broadcast is the official publication of the Radio Club of America, through whose courtesy the foregoing paper has been printed here. Radio Broadcast does not, of course, assume responsibility for controversial statements made by authors of these papers. Other Radio Club papers will appear in subsequent numbers of this magazine

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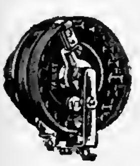

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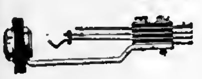

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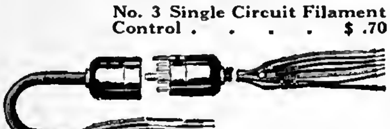

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THE RADIO BROADCAST Laboratory Information Sheets are a regular feature of this magazine and have appeared since our June, 1926, issue. They cover a wide range of information of value to the experimenter and to the technical radio man. It is not our purpose always to include new information but to present concise and accurate facts in the most convenient form. The sheets are arranged so that they may be cut from the magazine and preserved for constant reference, and we suggest that each sheet be cut out with a razor blade and pasted on 4" x 6" filing cards, or in a notebook. The cards should be arranged in numerical order. An index appears twice a year dealing with the sheets published during that year. The first index appeared on sheets Nos. 47 and 48, in November, 1926. Last month an index to all sheets appearing since that time was printed.

The June, October, November, and December, 1926, issues are out of print. A complete set of Sheets, Nos. 1 to 88, can be secured from the Circulation Department, Doubleday, Page & Company, Garden City, New York, for $1.00. Some readers have asked what provision is made to rectify possible errors in these Sheets. In the unfortunate event that any such errors do appear, a new Laboratory Sheet with the old number will appear.

The Information Service of RADIO BROADCAST is conducted entirely by mail, the coupon on page 255 being used when application is made for technical information. It is the purpose of these Sheets to supply information of original value which often makes it possible for our readers to solve their own problems. —THE EDITOR.

No. 113 RADIO BROADCAST Laboratory Information Sheet **August, 1927**

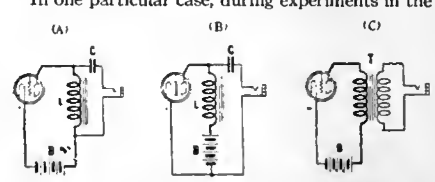
Output Circuits

THREE POSSIBLE CIRCUITS

IN THE sketch on this Sheet are shown three output arrangements that can be used to couple a loud speaker to a power tube in order to prevent the direct current in the plate circuit of the power tube from passing through the windings in the loud speaker and affecting its satisfactory operation. In sketches "A" and "B," the inductance of the choke coil, "L," should be at least 60 henrys and these coils should have a low resistance so as to prevent any great loss in voltage which would occur if the resistance was very high. A good unit should not cause a loss in voltage of more than 15 or 20 volts and this means that its d.c. resistance must not be greater than 750 ohms. The blocking condensers, "C," should have a capacity of from 2 to 4 mfd. The larger size theoretically gives somewhat better reproduction but practically little difference will be noticed with most loud speakers whichever size is used.

The arrangement shown at "A" has the advantage that, if the condenser breaks down, it will not result in any damage to the loud speaker because a breakdown in the condenser will merely cause the loud speaker to be shunted across the output choke "L" whereas, with arrangement "B," a breakdown of the condenser will cause the B battery to be short-circuited through the loud speaker and it is possible that the latter will be burned out. A disadvantage of arrangement "A" is that the a.c. current flowing through the loud speaker must flow through the B supply in order to return to the negative filament, and a comparatively small amount of resistance in the B supply will frequently cause a howl in the amplifier. In the arrangement shown in "B," the a.c. currents in the loud speaker return directly to the negative filament and do not have to traverse the B power unit; consequently, with this latter arrangement, there is less danger of oscillation in the audio amplifier.

In one particular case, during experiments in the



Laboratory, a resistance of 37 ohms in the B power unit, using circuit "A," produced continuous oscillations, whereas a resistance of 600 ohms was necessary in circuit "B" before oscillations were produced.

The arrangement at "C" shows an output transformer which is also a satisfactory method of coupling a loud speaker to a tube. It is essential, however, that the transformer be very carefully designed to prevent magnetic saturation because it must carry comparatively large direct current.

No. 114 RADIO BROADCAST Laboratory Information Sheet **August, 1927**

The Transmission Unit

DEFINITION

ANY electrical system having anything to do with the transmission of electrical energy which is finally to be changed into sound energy should have its performance rated in some manner which bears a relation to the sensitivity of the ear. Two audio amplifiers might give power outputs of 800 milliwatts and 1000 milliwatts, and it appears from these figures as though the second amplifier would be capable of giving a considerable increase in volume over that obtained from the first amplifier, but actually this would not be so; the difference between the two amplifiers could hardly be detected by the ear. Evidently it would be of advantage to express the relation between the power outputs of the two amplifiers by some unit which would indicate their relative value as measured by the ear. The telephone companies have worked out such a unit, known as the transmission unit, abbreviated "TU." It is possible for the ear to just distinguish the difference between two powers that differ in intensity by 1 TU.

The two powers mentioned above, 800 and 1000 milliwatts, are in the ratio of 1.25 to 1. The TU difference between these two powers is equal to ten times the natural logarithm of the ratio of the two powers:

$$\text{TU} = 10 \log_{10} \frac{P_1}{P_2}$$

The ratio in this case is 1.25 and the natural logarithm is 0.097, which, multiplied by ten, gives 0.97 TU. The minimum perceptible change in loudness is 1 TU and therefore the difference between the two amplifiers would not be audible.

The equation given in the preceding paragraph gives the TU when two powers, or their ratio, are known. If instead of powers we deal with voltages, E_1 and E_2, then the formula is:

$$\text{TU} = 20 \log_{10} \frac{E_1}{E_2}$$

When using currents, I_1 and I_2, the equation is:

$$\text{TU} = 20 \log_{10} \frac{I_1}{I_2}$$

The logarithm of the ratio of two voltages differing by 12 per cent., is 0.05, and 20 times this gives 1 TU. Therefore, if two audio transformers differ in amplification by 12 per cent., they will give equally good results because a 1 TU change is not audible to the ear.

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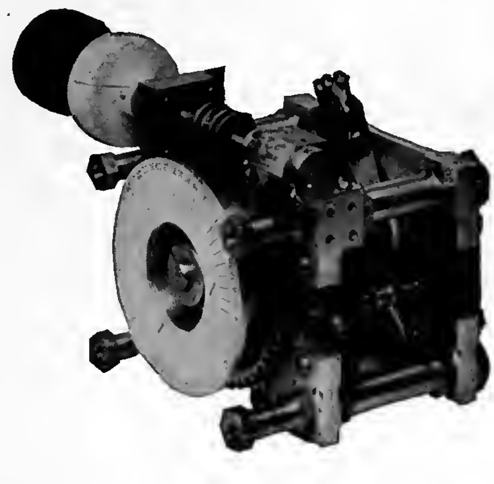

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All NATIONAL RADIO PRODUCTS are made with equal care and adherence to rigid standards.

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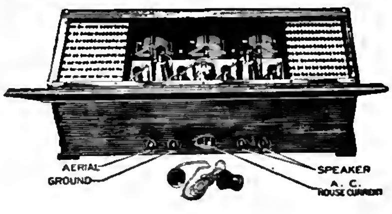


A Real Electric-Power Radio

The New MARTI A-C Receiver

THE performance of this receiver is a revelation. It works direct from your house current. No "A" or "B" batteries. No trickle charging. No eliminators. The Marti is a REAL electric power receiver, using six A-C tubes. Beautifully designed, substantially built. Efficiently selective and has a rich, pure tone. Its cost is surprisingly low.

Naturally, its parts are the best. They must be, because successful A-C operation cannot be obtained with inferior parts.

In the illustration above you will see three Hammarlund "Midline" Condensers. They were selected for the Marti Receiver, because of Hammarlund's established reputation for precision quality.

Write for descriptive Folder

HAMMARLUND MANUFACTURING CO.
424-438 W. 33rd Street New York

For Better Radio
Hammarlund
PRECISION
PRODUCTS

No. 115 Radio Broadcast Laboratory Information Sheet August, 1927

Wave Traps

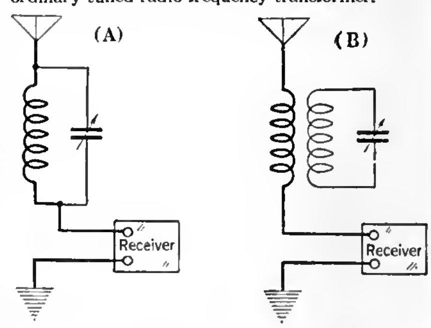
DIFFERENT TYPES

IN MANY cases where difficulty is experienced in eliminating the signals from a nearby powerful broadcasting station it will be found advantageous to use a wave trap in the antenna circuit.

A wave trap is a simple device consisting of a condenser and a coil, the latter with or without a primary, depending upon whether the circuit shown at "A" or "B" is used. In either case the wave trap should be tuned to the frequency of the interfering station. It then offers a very high impedance to the flow of currents of this frequency and in this way reduces their strength.

The circuit shown in "A" will give most complete elimination of undesired signals but has the disadvantage that it will also reduce somewhat the signals from other stations operating on frequencies adjacent to that of the station causing the interference. In cases of severe interference, however, the circuit shown at "A" must be used. The capacity of the variable condenser may be anything from 0.00025 mfd. to 0.001 mfd., and the coil must naturally contain sufficient turns so as to tune the circuit to the frequency of the interfering signals. There is no reason why a standard condenser and coil, designed for reception on the broadcast frequencies, cannot be used and it will then be possible to tune the trap to any frequency in the broadcast band.

The circuit shown at "B" tunes much sharper than the circuit shown at "A" but does not give complete elimination of the undesired signals. This circuit can be used with satisfaction when the interference is not very severe. The coil may be any ordinary tuned radio-frequency transformer.



No. 116 Radio Broadcast Laboratory Information Sheet August, 1927

Static

POSSIBILITIES OF ELIMINATION

NATURAL electrical disturbances occurring in the atmosphere are known as "static" or "strays" and frequently cause serious interference during the reception of signals. The subject "static" has been broken up into the following divisions by DeGroot in an article in *The Proceedings of the Institute of Radio Engineers.*

(A)—Loud and sudden clicks occurring intermittently. These do not seriously affect reception and apparently originate in nearby or distant lightning discharges.

(B)—A constant hissing noise giving the impression of softly falling rain or the noise of running water. This form usually occurs when there are low-lying clouds in the neighborhood of the receiving antenna.

(C)—A third form produces a constant rattling noise which sounds somewhat like the tumbling down of a brick wall!

These three forms can be considered as forms of natural static. The problem of the elimination of static is a difficult one upon which a great deal of work has been done and many different schemes have been devised, most of these schemes making use of two receiving antennas feeding a common receiver. The static signals present in the two antennas are made to balance out each other whereas the desired signals are not balanced out. In Morecroft's book, *Principles of Radio Communication*, it is suggested that one of the most promising lines for the development of a static eliminator has to do with a vacuum-tube detector which can only produce a limited response and therefore even with very heavy static the response cannot be more than the definite peak response of the tube.

Reception is also interfered with to a great extent in many localities by sounds produced by electrical apparatus, in which category can be classed the interference caused by various electrical motors and generators, x-ray apparatus, oil burners, precipitators, electrical transmission lines, etc. Their elimination is best accomplished at the source of the trouble by means of filter circuits such as those described in Laboratory Sheet No. 77, in the March, 1927, Radio Broadcast.

At the present time it appears that the best method to overcome natural static is to use a receiver in conjunction with a loop or a very short antenna, because with a loop or short antenna a high signal-to-static ratio can be obtained. Also, to prevent serious interference with broadcast programs, high power at the transmitting station is coming into more common use so that even under fairly bad conditions of static satisfactory reception can still be had.

No. 117 Radio Broadcast Laboratory Information Sheet August, 1927

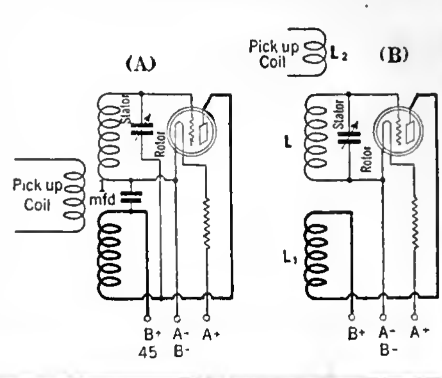
Super-Heterodynes

THE OSCILLATOR

IN A super-heterodyne receiver it is necessary to have one tube acting as an oscillator and functioning to produce radio-frequency energy which, in combination with the incoming signals, will produce a third frequency capable of being amplified by the intermediate frequency amplifier. The amplitude of the locally generated oscillations, in comparison with the incoming signals, has a very definite effect upon the strength of the signal which is finally detected and some care should therefore be taken in adjusting the circuit for most efficient operation, *i.e.*, loudest signals.

In sketch "A" is given the circuit used, probably, in a majority of super-heterodynes. It has the disadvantage that both sides of the variable condenser are at high potential and therefore some hand-capacity effects will be experienced.

In sketch "B" is shown an oscillatory circuit which is not open to the disadvantage of circuit "A" and is capable of giving just as good results in actual practice. In this circuit the rotor plates of the variable condenser connect to the low-potential side of the grid coil instead of across the entire coil. The "low" end of the grid coil connects to the filament and is therefore at ground potential and consequently there is no hand capacity. If a 0.0005-mfd. variable condenser is used, then coil "L" should contain 52 turns of No. 24 wire on a $2\frac{1}{2}''$ tube; for a 0.00035-mfd. condenser the number of turns should be 65. L_1, the plate coil, should consist, in either case, of 60 turns of No. 28 wire wound on the same tube and spaced from the coil "L" by $\frac{1}{4}''$. L_2 is the pick-up coil which should be connected in the circuit of the first detector tube; it should consist of 10 turns of No. 28 wire preferably wound on a tube slightly larger than $2\frac{1}{2}''$ so that it can slide over the other form and the coupling be varied in this way. Either a 201-A or 199 type tube may be used in the oscillator without changing the coil constants.



Now you can build the kind of a radio you have always wanted

This BOOK TELLS HOW

No matter whether you want to improve a set you now have or build a new one—*get this book first.* Tells how to build the latest one, two and three dial receivers—5 to 7 tubes.

10¢ PREPAID

GEARHART-SCHLUETER, *Fresno, Cal.*

Independent Radio Corporation

Manufacturers of

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1516 Summer Street Philadelphia

Why not subscribe to *Radio Broadcast?* By the year only $4.00; or two years $6.00, saving $2.40. Send direct to Doubleday, Page & Company, Garden City, New York.

Convert your radio set into a light socket receiver with Balkite "B" and the Balkite Trickle and High-Rate Charger

Ask your radio dealer

FANSTEEL PRODUCTS CO., INC

North Chicago, Ill.

Only those manufacturers whose power-units have been fully tested and approved by the Raytheon research laboratories are entitled to use Raytheon rectifiers or this symbol in connection with their products.

When You Offer Your Opinion on Light-Socket Power-Units

Amateurs are often called upon to act as "purchasing directors" for neighbors whose knowledge of radio goes no deeper than their tuning dials. And now with light-socket power growing more popular every day you can well expect a request for intelligent advice on what and what not to invest in.

There are many good radio power-units on the market, but, since the performance of all of them depends upon the rectifying element, isn't it showing good judgment to advise a Raytheon-equipped unit? No liquids, no chemicals, no fragile filaments to handicap reliable, noiseless radio power.

Your opinion is backed by a staff of engineers who make it their business to see that every Raytheon-equipped power-unit will prove satisfactory to the final purchaser.

Raytheon B is the original gaseous Rectifying Tube and is standard for most types of B-power service, guaranteed for 1000 hours of service over the period of one year.

Rating: 60 m.a. output at 150 volts.

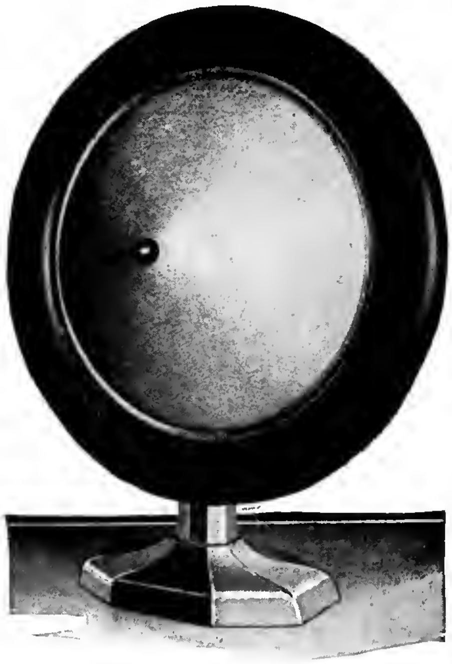
Raytheon B11 is designed for heavy duty applications of light-socket power, supplying complete A.C. power for series-connected tubes and power amplifiers. Guaranteed for 1000 hours over one year.

Rating: 85 m.a. output at 200 volts.

RAYTHEON MANUFACTURING CO., Kendall Square Bldg., Cambridge, Mass.

Raytheon

THE HEART OF RELIABLE RADIO POWER



Model A. C. 20
Height, including base, 21½ in.

Far ahead of to-day's accepted standards—the new Amplion Cone with M.A.1 type unit

In quality of reproduction it sets a new high mark for others to strive for

THIS remarkable reproducer has an unusually wide musical range due to the striking developments embodied in the new Cone Unit.

One important feature of this unit is the *felt-lined stylus protection bar* which serves a double purpose. First, it protects the stylus itself against any possible injury. The felt lining, or stylus anchor, neutralizes the harmonics of the stylus itself.

This model employs a new principle in Cone construction—a 14" cone being mounted on an 18" sound board which extends toward the center in back of the cone to form a resonating chamber. The unit, cone and sound board are assembled on a rigid bronze bracket with a handsome bronze base.

The sound board is finished in dark walnut, which, with the gold-finished cone in the center, gives this instrument both graceful beauty and dignity.

Write to us for price list and literature illustrating and describing the new Amplion line.

THE AMPLION CORPORATION OF AMERICA
280 Madison Ave., New York City

The Amplion Corporation of Canada Ltd., Toronto

AMPLION

No. 118 Radio Broadcast Laboratory Information Sheet August, 1927

Audio Amplifiers

FREQUENCY AND LOAD CHARACTERISTICS

ANY audio amplifying system has two characteristics, equally important, which determine how well it will function. They are generally known as the frequency characteristic and the load characteristic.

The frequency characteristic indicates the relative amplification of the amplifying system of various frequencies between the limits over which the amplifier is to be operated. The frequency characteristic is generally shown in the form of a curve and, of course, a flat curve indicates equal amplification at all frequencies. Slight rises and depressions in the curve in the order of 10 per cent. can be neglected because they are too slight to be noticeable to the ear.

The load characteristic of an amplifier, while not in such common use, is just as important as the frequency characteristic. The load characteristic will show how the total amplification of the system varies with different input voltages at a constant frequency generally of about 1000 cycles. If the amplifier is a good one the amplification will remain constant over the entire range of input voltages at which the amplifier would normally be worked. If a two-stage amplifier is operated with a 201-A type tube in the output with 90 volts on the plate, it will overload very quickly because a 201-A cannot deliver much power. Consequently, the load characteristic curve of such an amplifier would begin to fall off comparatively quickly, but if a 171 tube with the proper voltages were to be used in place of the 201-A, then the load characteristic would indicate that it was possible to obtain much more power from the amplifier without overloading it.

Both of these characteristics depend upon the type of tubes used and the voltages with which they are supplied, and upon the design of the coupling devices connecting the output of one tube to the input of the next. Frequency and load characteristics can be taken on any part of the complete amplifier but such curves may have very little in common with the characteristics of the complete system. Consequently, although curves on individual units are useful in designing an amplifier, curves on the completed system should always be made to make certain that some factor, such as common coupling in the batteries, is not seriously altering the overall characteristic.

No. 119 Radio Broadcast Laboratory Information Sheet August, 1927

Radio-Frequency Choke Coils

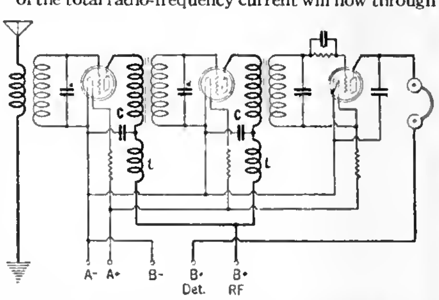
THEIR PLACE IN CIRCUIT

IF A very high-gain radio-frequency amplifier is to be constructed, it is essential that radio-frequency choke coils be used in the amplifier to prevent it from oscillating. Neutralization will prevent the production of oscillations due to feed-back through the tube but will not prevent the production of oscillations due to coupling in the battery leads or in a B socket-power device. To prevent instability due to these effects it is necessary that choke coils, L, and bypass condensers, C, be used in the plate circuits of the radio-frequency tubes, as indicated in the diagram on this Sheet. These choke coils offer a very high impedance to the flow of radio-frequency currents and all these currents therefore flow through the bypass condenser connected between the choke coil and the negative filament, instead of through the plate battery.

What size choke and what size condenser should be used? To keep down the cost they should both be as small as possible whereas their effectiveness becomes greater as their size is made larger.

The plate impedance of a 201-A type tube is about 12,000 ohms and it is essential that the condenser which is incorporated to bypass the r.f. currents does not introduce in the plate circuit any great amount of impedance. A 0.003-mfd. condenser will increase the total circuit impedance from 12,000 to about 12,120 ohms, a negligible amount. This value is correct at 500 kilocycles, the lowest frequency used in broadcasting, and at higher broadcast frequencies the effect of the condenser will be even less.

The choke coil's impedance must be large in comparison with that of the condenser so as to cause practically all the current to flow through the condenser and not through the choke. If the choke coil's impedance is made 1000 times greater than that of the condenser only one-tenth of one per cent. of the total radio-frequency current will flow through



the choke coil and therefore good filtering action will be obtained. If the choke coil's impedance at 500 kilocycles is to be 1000 times greater than the impedance of the condenser then it must be 12,000 ohms. The inductance of a choke coil with an impedance of 12,000 ohms at 500 kilocycles is 38 millihenrys. Most radio-frequency choke coils have an inductance of much more than this.

No. 120 Radio Broadcast Laboratory Information Sheet August, 1927

A-Battery Chargers

TRICKLE VERSUS HIGH-RATE CHARGERS

THERE are many different types of A-battery chargers now available; some of them are satisfactory for use as trickle chargers and others only efficient when used to charge the battery at comparatively high rates of charge. The charger employing an electrolytic type of rectifier, for example, is very well adapted for use in trickle charging. It is very efficient, requires little attention, and has long life.

Another very satisfactory type of rectifier for a trickle charger is the so-called dry crystal, which was developed rather recently. A third type of rectifier that can be used for trickle charging is the Tungar but it is not especially efficient as a trickle charger, because of the comparatively large amount of power required to heat its filament.

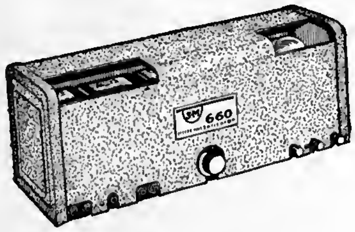
There are three types of rectifiers that are satisfactory for use in high-rate charging. They are the Tungar, the Vibrator type, and the new cartridge recently developed by Raytheon. All of these chargers are capable of delivering fairly large amounts of rectified current for charging a battery and are fairly efficient when delivering these currents.

There is little to be said regarding the comparative efficiency of the two methods of charging. Trickle charging has the advantage that it requires somewhat less attention than does high-rate charging but it has the disadvantage that it is somewhat difficult to determine just what the best rate of trickle charge should be in order to prevent the battery from being overcharged or undercharged; also slow rates of charge used in trickle chargers are hard on a battery. With a trickle charger, a low-capacity storage battery can be used because it is not called upon to supply any great amount of current for a long period of time.

With high-rate charging, on the other hand, it is usual to charge the battery every one or two weeks and also a fairly large storage battery is necessary in order that it will have sufficient capacity to supply the receiver between charges. It seems to be generally agreed among battery manufacturers, however, that the high charging rate is somewhat better for the battery in that it makes possible longer life. For best results the charging rate should gradually taper off as the battery becomes charged.

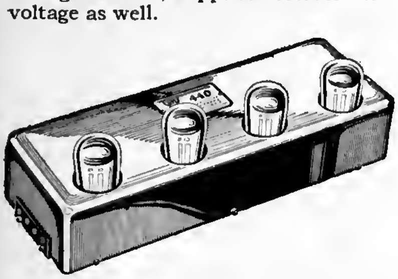
SM

UNIPAC for Power



The Silver-Marshall laboratories now offer a series of power packs absolutely without comparison. Type 660-210 Unipac, a push-pull amplifier using two UX-210 tubes, will deliver from 100 to 300 times more power than a 201-A tube, or from 4 to 17 times more power than average 210 power packs. Type 660-171 Unipac, with two 171 tubes will deliver equal or greater power than average 210 packs at far lower cost!

There is a Unipac for every need, from the most powerful receiving amplifier ever developed down to a low power 171 power pack. There are models for phonograph amplification, turning any old phonograph into a new electric type actually superior to commercial models costing from five hundred to several thousand dollars. And every Unipac, operating entirely from the light socket, supplies receiver "B" voltage as well.



112 K. C. Long Wave Time Amplifier

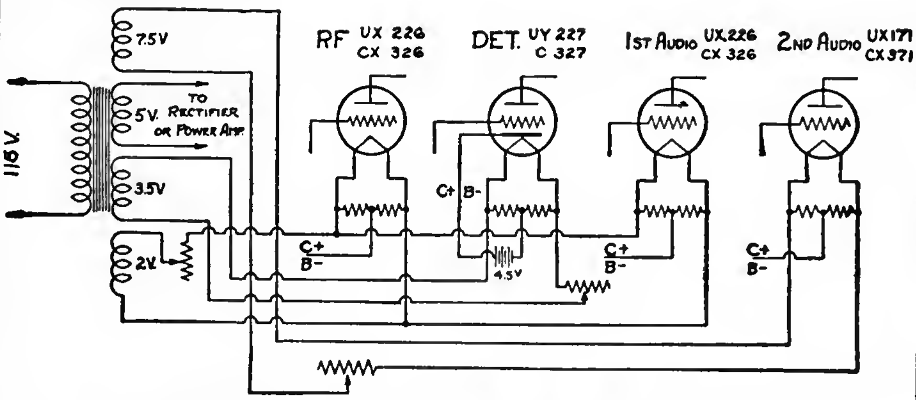
Type 440 Jewelers Time Amplifier, accurately tuned and measured to exactly 112 K. C., 2677 meters (NAA's exact time signal wave) makes available a three-stage R. F. amplifier and detector that is a laboratory product. It simplifies receiver construction, and eliminates all guess work in transformer matching. Price, completely shielded, $35.00.

Silver-Marshall, Inc.
838 West Jackson Blvd.
Chicago, Ill.

Complete A. C. Operation A Practical Reality

For the past several seasons the trend has been toward complete battery elimination. Many satisfactory plate supply units operating from A. C. have been developed but filament operation from an A. C. source has presented more of a problem due to the larger currents required and increased expense in the rectifier and filter circuits.

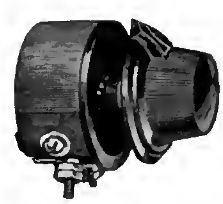
The newly announced A. C. tubes offer an excellent solution to this problem.



The above diagram shows how to adapt the filament wiring of the popular type of receiver to A. C. operation by use of General Radio parts especially designed for this purpose.

Type 410 Rheostats

The new A. C. tubes require low resistance rheostats capable of carrying appreciably more current than those used with D. C. tubes.



Resistance	Current	Price
.5 ohm	3.5 amp.	$1.25
1.5 ohm	2.0 amp.	1.25

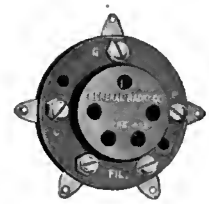
Type 440-A Low Voltage Transformer

The alternating current tubes require a source of low voltage capable of delivering large current. The various types of tubes require several different voltages. The Type 440-A Transformer supplies voltages for all popular tubes and sufficient current for all ordinary receiver requirements. Filament supply is provided for filament, separate heater, power amplifier and rectifier tubes. The following voltages and currents are available. Pri. 115 V (for lines 105-125 volts) 60 cycles.

Sec.	2 volts	8 amperes
	3.5 volts	2 amperes
	5 volts	2.5 amperes
	7.5 volts	2 amperes

Price $10.00

Type 438 Socket

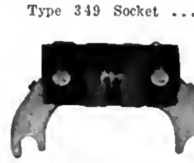


The new type UY-227 or CX-327 detector tube has a separate heating element and requires a socket designed to take the new five prong base.

Type 438 socket ..$.50

The various types of A. C amplifier tubes are designed with standard UX or CX base having four prongs.

Type 349 Socket ....$.50



Type 439 Center Tap Resistance

All the new A. C. tubes require a resistance with center tap across the filament as shown in the diagram. The Type 439 Resistance is adaptable to any socket in which the new A. C. tubes may be used.

Type 439 Center Tap Resistance ....Price $.60

Your local dealer should have the necessary parts in stock.

If he is unable to supply you with all the items required, we shall be glad to send them to you prepaid upon receipt of list price.

GENERAL RADIO CO. Cambridge, Mass.

GENERAL RADIO

PARTS *and* ACCESSORIES

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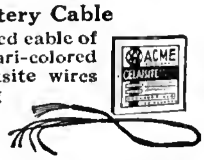
—with
Seven Strands of enameled Copper Wire

Best outdoor antenna you can buy. Seven strands of enameled copper wire. Presents maximum surface for reception, resists corrosion; this greatly improves the signal. Outside diameters equal to sizes 14 and 16. (We also offer solid and stranded bare, and stranded tinned antenna.)

Loop Antenna Wire

Sixty strands of No. 38 bare copper wire for flexibility, 5 strands of No. 36 phosphor bronze to prevent stretching. Green or brown silk covering; best loop wire possible to make.

Battery Cable



A rayon-covered cable of 5, 6, 7, 8 or 9 vari-colored Flexible Celatsite wires for connecting batteries or eliminator to set. Plainly tabbed; easy to connect. Gives set an orderly appearance.

Acme Celatsite Wire

Tinned copper bus bar hook-up wire with non-inflammable Celatsite insulation, in 9 beautiful colors. Strips easily, solders readily, won't crack at bends. Sizes 14, 16, 18, 19; 30 inch lengths.

Flexible Celatsite for sub-panel wiring

A cable of fine, tinned copper wires with non-inflammable Celatsite insulation. Ideal for sub-panel or point-to-point wiring. Strips easily, solders readily. Nine beautiful colors; ***sold only in 25 ft. coils, in cartons colored to match contents.***

Spaghetti Tubing

Oil, moisture, acid proof; highly dielectric — used by leading engineers. Nine colors, for wire sizes 12 to 18; 30 inch lengths. (We also make tinned bus bar, round and square, in 2 and 2½ ft. lengths.)

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ACME WIRE
MAKES BETTER RADIO

Manufacturers' Booklets

A Varied List of Books Pertaining to Radio and Allied Subjects Obtainable Free With the Accompanying Coupon

Readers may obtain any of the booklets listed below by using the coupon printed on page 255 Order by number only.

1. Filament Control—Problems of filament supply, voltage regulation, and effect on various circuits. Radiall Company.

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3. Transformers—A booklet giving data on input and output transformers. Pacent Electric Company.

4. Resistance-Coupled Amplifiers—A general discussion of resistance coupling with curves and circuit diagrams. Cole Radio Manufacturing Company.

5. Carborundum in Radio—A book giving pertinent data on the crystal as used for detection, with hook-ups, and a section giving information on the use of resistors. The Carborundum Company.

6. B-Eliminator Construction—Constructional data on how to build. American Electric Company.

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8. Resistance Units—A data sheet of resistance units and their application. Ward-Leonard Electric Company.

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11. Resistance Coupling—Resistors and their application to audio amplification, with circuit diagrams. DeJur Products Company.

12. Distortion and What Causes It—Hook-ups of resistance-coupled amplifiers with standard circuits. Allen-Bradley Company.

15. B-Eliminator and Power Amplifier—Instructions for assembly and operation using Raytheon tube. General Radio Company.

15a. B-Eliminator and Power Amplifier—Instructions for assembly and operation using an R. C. A. rectifier. General Radio Company.

16. Variable Condensers—A description of the functions and characteristics of variable condensers with curves and specifications for their application to complete receivers. Allen D. Cardwell Manufacturing Company.

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19. Power Supply—A discussion on power supply with particular reference to lamp-socket operation. Theory and constructional data for building power supply devices. Acme Apparatus Company.

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21. High-Frequency Driver and Short-Wave Wavemeter—Constructional data and application. Burgess Battery Company.

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49. Bypass Condensers—A description of the manufacture of bypass and filter condensers. Leslie F. Muter Company.

50. Audio Manual—Fifty questions which are often asked regarding audio amplification, and their answers. Amertran Sales Company, Incorporated.

51. Short-Wave Receiver—Constructional data on a receiver which, by the substitution of various coils, may be made to tune from a frequency of 16,660 kc. (18 meters) to 1999 kc. (150 meters). Silver-Marshall, Incorporated.

52. Audio Quality—A booklet dealing with audio-frequency amplification of various kinds and the application to well-known circuits. Silver-Marshall, Incorporated.

56. Variable Condensers—A bulletin giving an analysis of various condensers together with their characteristics. General Radio Company.

57. Filter Data—Facts about the filtering of direct current supplied by means of motor-generator outfits used with transmitters. Electric Specialty Company.

59. Resistance Coupling—A booklet giving some general information on the subject of radio and the application of resistors to a circuit. Daven Radio Corporation.

60. Resistors—A pamphlet giving some technical data on resistors which are capable of dissipating considerable energy; also data on the ordinary resistors used in resistance-coupled amplification. The Crescent Radio Supply Company.

62. Radio-Frequency Amplification—Constructional details of a five-tube receiver using a special design of radio-frequency transformer. Camfield Radio Mfg. Company.

63. Five-Tube Receiver—Constructional data on building a receiver. Aero Products, Incorporated.

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66. Super-Heterodyne—Constructional details of a seven-tube set. G. C. Evans Company.

70. Improving the Audio Amplifier—Data on the characteristics of audio transformers, with a circuit diagram showing where chokes, resistors, and condensers can be used. American Transformer Company.

72. Plate Supply System—A wiring diagram and layout plan for a plate supply system to be used with a power amplifier. Complete directions for wiring are given. Amertran Sales Company.

80. Five-Tube Receiver—Data are given for the construction of a five-tube tuned radio-frequency receiver. Complete instructions, list of parts, circuit diagram, and template are given. All-American Radio Corporation.

81. Better Tuning—A booklet giving much general information on the subject of radio reception with specific illustrations. Primarily for the non-technical home constructor. Bremer-Tully Manufacturing Company.

82. Six-Tube Receiver—A booklet containing photographs, instructions, and diagrams for building a six-tube shielded receiver. Silver-Marshall, Incorporated.

83. Socket Power Device—A list of parts, diagrams, and templates for the construction and assembly of socket power devices. Jefferson Electric Manufacturing Company.

84. Five-Tube Equamatic—Panel layout, circuit diagrams, and instructions for building a five-tube receiver, together with data on the operation of tuned radio-frequency transformers of special design. Karas Electric Company.

85. Filter—Data on a high-capacity electrolytic condenser used in filter circuits in connection with A socket power supply units, are given in a pamphlet. The Abox Company.

86. Short-Wave Receiver—A booklet containing data on a short-wave receiver as constructed for experimental purposes. The Allen D. Cardwell Manufacturing Corporation.

88. Super-Heterodyne Construction—A booklet giving full instructions, together with a blue print and necessary data, for building an eight-tube receiver. The George W. Walker Company.

89. Short-Wave Transmitter—Data and blue prints are given on the construction of a short-wave transmitter, together with operating instructions, methods of keying, and other pertinent data. Radio Engineering Laboratories.

90. Impedance Amplification—The theory and practice of a special type of dual-impedance audio amplification are given. Alden Manufacturing Company.

93. B-Socket Power—A booklet giving constructional details of a socket-power device using either the BH or 313 type rectifier. National Company, Incorporated.

94. Power Amplifier—Constructional data and wiring diagrams of a power amplifier combined with a B-supply unit are given. National Company, Incorporated.

100. A, B, and C Socket-Power Supply—A booklet giving data on the construction and operation of a socket-power supply using the new high-current rectifier tube. The Q. R. S. Music Company.

101. Using Chokes—A folder with circuit diagrams of the more popular circuits showing where choke coils may be placed to produce better results. Samson Electric Company

Accessories

22. A Primer of Electricity—Fundamentals of electricity with special reference to the application of dry cells to radio and other uses. Constructional data on buzzers, automatic switches, alarms, etc. National Carbon Company.

23. Automatic Relay Connections—A data sheet showing how a relay may be used to control A and B circuits. Yaxley Manufacturing Company.

25. Electrolytic Rectifier—Technical data on a new type of rectifier with operating curves. Kodel Radio Corporation.

26. Dry Cells for Transmitters—Actual tests given, well illustrated with curves showing exactly what may be expected of this type of B power. Burgess Battery Company.

27. Dry-Cell Battery Capacities for Radio Transmitters—Characteristic curves and data on discharge tests. Burgess Battery Company.

28. B Battery Life—Battery life curves with general curves on tube characteristics. Burgess Battery Company.

29. How to Make Your Set Work Better—A non-technical discussion of general radio subjects with hints on how reception may be bettered by using the right tubes. United Radio and Electric Corporation.

30. Tube Characteristics—A data sheet giving constants of tubes. C. E. Manufacturing Company.

31. Functions of the Loud Speaker—A short, non-technical general article on loud speakers. Amplion Corporation of America.

32. Meters for Radio—A catalogue of meters used in radio, with connecting diagrams. Burton-Rogers Company.

33. Switchboard and Portable Meters—A booklet giving dimensions, specifications, and shunts used with various meters. Burton-Rogers Company.

34. Cost of B Batteries—An interesting discussion of the relative merits of various sources of B supply. Hartford Battery Manufacturing Company.

35. Storage Battery Operation—An illustrated booklet on the care and operation of the storage battery. General Lead Batteries Company.

36. Charging A and B Batteries—Various ways of connecting up batteries for charging purposes. Westinghouse Union Battery Company.

37. Choosing the Right Radio Battery—Advice on what dry cell battery to use; their application to radio, with wiring diagrams. National Carbon Company.

53. Tube Reactivator—Information on the care of vacuum tubes, with notes on how and when they should be reactivated. The Sterling Manufacturing Company.

54. Arresters—Mechanical details and principles of the vacuum type of arrester. National Electric Specialty Company.

55. Capacity Connector—Description of a new device for connecting up the various parts of a receiving set, and at the same time providing bypass condensers between the leads. Kurz-Kasch Company.

(Continued on page 253)

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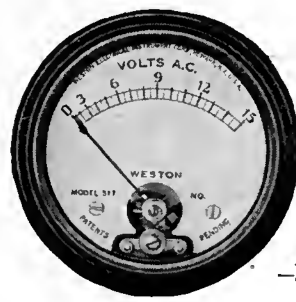

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"RADIO BROADCAST'S" DIRECTORY OF MANUFACTURED RECEIVERS

¶ With this issue of Radio Broadcast, we start a comprehensive listing of manufactured receivers. The listing below will appear regularly in this place, corrected to the day we go to press. The Manufactured Set Directory is an additional service to our readers and takes its place with the "Manufacturers' Booklets" section and the "What Kit Shall I Buy?" department, both of which are already very popular. With these three regular features of Radio Broadcast, the reader can survey the entire field and, with little trouble, secure the information he wants.

A coupon will be found on page 255. All readers who desire additional information on the receivers listed below need only insert the proper numbers in the coupon, mail it to the Service Department of Radio Broadcast, and full details will be sent.

KEY TO ABBREVIATIONS

Key Letters

Ant.—Antenna
r—Radio frequency stage
d—Detector
a—Audio frequency stage
t—Transformer coupled
res.—Resistance
i—Impedance coupled
o—Oscillator
O—Output device
C—C-battery connections
Ca—Cable connections
Bp—Binding posts
M—Meter (instrument)
Sh.—Shielded
H—Headphone connection included
pp—Push pull

m—Meters (wavelength)
TRF—Tuned radio frequency
URF—Untuned radio frequency
Super—Super-heterodyne
Ne—Neutrodyne
bal.—Some means of neutralization
gr—Grid resistances
Br—Bridge neutralization
reg.—Regenerative
int.—Intermediate amplifier
r.f.—Radio frequency
rheo.—Rheostat
mod.—Modulator
pot.—Potentiometer
w—Watts
Wt—Weight in lbs.

Tubes

99—60-mA. filament (dry cell)
01A—Storage battery 0.25 amps. filament
12—Power tube (Storage battery)
71—Power tube (Storage battery)
16B—Half-wave rect. tube
AC—Using a.c. (heater type)
Hmu—High Mu tube for resistance-coupled audio
R—A gaseous rectifier tube
20—Power tube (dry cell)
Tun—Tungar rectifier
MV—Multivalve (several elements in one bulb)
10—Power Tube
00A—Special detector
13—Full-wave rectifier tube
2A—Tungar rectifier

SOCKET-POWER RECEIVERS FOR USE WITH 110–120 VOLTS 60-CYCLE A.C.

No. Model	Price	Accessories Included	Cabinet Size	No. Dials	Vol. Cont.	No. Tubes	Type Tubes	Cur. Req. Watts	Circuit	Remarks
401. AMRAD AC9	142	power unit	27 x 9 x 11¾	2	res. on 1st a	3r, d, 2at (6)	5–99, 1–12. 2–16B	50w	TRF Ne.	Series fil. power unit separate. A, B, and C, supplied
402. AMRAD AC5	125	power unit	27 x 9 x 11¾	2	res. on 1st a	2r, d, 2at (5)	4–99, 1–12. 2–16B	50w	TRF Ne.	Same as above
403. ARGUS 250B	250	none	35⅛ x 14⅝ x 10¾	2	res. on 1st a	3r, d, 2at (6)	5–99, 1–10. 2–16B	100w	TRF gr	2TRF stages, and 1 untuned stage. Series fil. O. Self contained power unit
404. ARGUS 375B	375	none	console	2	res. on 1st a	3r, d, 2a. (6)	5–99, 1–10. 2–16B	100w	TRF gr	See above
405. ARGUS 125B	125	none		2	fil. rheo.	3r, d, 2at (6)	5–99, 1–12. 2–16B	60w	TRF gr	See above
406. CLEARTONE 110	175 to 375	5 a.c. tubes 1 Rectifier	various sizes	1-2	res.	2r, d, 2at (5)	5–AC. 1–Rectifier	40w	TRF	Built in plate supply. A. C. tubes
407. COLONIAL 25	250	none	34 x 38 x 18	1-3	ant. sw. and a pot.	2r, d, 2ares., 1at (6)	2–01A, 3–99, 1–10. 2–16B	100w	TRF bal.	Built in A, B, and C power unit
408. DAY-FAN DE LUXE	350	complete less tubes	30 x 40 x 20	1	pot. across r.f. tubes	3r, d, 2at (6)	6–01A	300w	TRF	Motor Generator supplies d.c. for plate and fil. O
409. DAYCRAFT 5	170	complete less tubes	34 x 36 x 14	1	pot. in plate of r.f. and a	3r, d, 2at (5)	5–AC	135w	TRF	Reflexed. AC tubes. Built in plate rect.
410. LARCOFLEX 73	215	none	30 x 42 x 20	1	res. in r.f. plate	4r, d, 2at (7)	6–01A, 1–71		TRF	Sh.
411. HERBERT LECTRO 120	120	none	32 x 10 x 12	3	rheo in pri. of a.c. trans.	2r, d, 2at (5)	4–99, 1–71. 1–R	45w	TRF	Series fil.
412. HERBERT LECTRO 200	200	none	20 x 12 x 12	1	rheo. in pri. of a.c. trans	2r, d, 1at, pp. (6)	4–99, 2–71. 1–R	60w	TRF	Series fil. Sh. O. Push-pull.
413. MARTI TABLE 414. MARTI CONSOLE 415. MARTI CONSOLE	235 275 325	6–AC tubes and rectifier. Loud speaker with No. 415	7 x 21 panel	2	res. in r.f. plate	2r, d, 3ares. (6)	6–AC. 1–16B	38w	TRF	AC tubes. Built-in plate supply
416. NASSAU POWER		none	28 x 45 x 18	2	res. in r.f. plate	2r, d, 3a (6)	5–99, 1–10. 1–16B		TRF Br.	Series fil. M, O.
417. R.C.A. 28	540	all tubes 104 Speaker	26½ x 63 x 17	1	pot.	2d, o, 2at, 3i (8)	7–99, 1–10. 2–16B, 1–874, 1–876		Super	Model 28 may also be obtained without power units. Loop antenna.
418. RECEPTRAD SUPER-POWER A. C. CONSOLE	390	power unit loud speaker	28 x 50 x 21	2	r.f. res.	(5)	5–01A. 2–2A	90w	Multiflex	Loop or outside antenna
419. SUPERPOWER AC CABINET	180	power unit	27 x 10 x 9	2	r.f. res.	(5)	5–01A. 2–2A	90w	Multiflex, Reg.	See above
420. SIMPLEX B	250	complete	34 x 36 x 14	1	res. in r.f. plate	(6)	6–AC		TRF	H
421. SOVERIGN 238	325	7–AC tubes	37 x 52 x 15	2	res. on 2nd. a	(7)	7–AC	45w	TRF bal.	Uses AC tubes run by small trans. Gas rect. for plate
422. SUPERVOX, JR.	275	complete	28 x 30 x 16	1	ant. coup. and res. in r.f. plate	1r, d, 2at (4)	3–AC, 1–71. 1–16B	40w	TRF	AC tubes, 71 on a.c. O. Sh. d
423. SUPERVOX, SR.	450	complete	28 x 30 x 16	2	ant. coup. and res. in r.f. plate	2r, d, 2at (5)	4–AC, 1–10. 1–16B	60w	TRF	Sh. O.
469. FREED-EISEMANN NR 11	225	NR-411 power unit	19¾ x 10 x 10½	1	pot.	3r, d, 2at (6)	5–01A, 1–71. 1–R	150w	TRF Ne.	Sh. O.

STANDARD RECEIVERS

No.	Model	Price	Accessories Included	Cabinet Size	No. Dials	Vol. Cont.	No. Tubes	Type Tubes	Plate Cur. mA	Circuit	Ant. Length Ft.	Remarks
428.	AMERICAN C6 TABLE CONSOLE	30 65	none Spkr.	20 x 8½ x 10 36 x 40 x 17	3	pot.	2r, d, 2at (5)	5-01A	15	TRF semi-bal.	125	Partially Sh. C, Ca.
429.	KING COLE VII	80-160	none	varies	2	r. f. pri. shunt	3r, d, lai, la res., lat (7)	7-01A	15-45	TRF	10-100	Steel Sh. O on some consoles. C, Ca, and Bp.
430.	KING COLE VIII	100-300	none	varies	1	r. f. pri. shunt	4r, d, lai, la res., lat (8)	8-01A	20-50	TRF	10-100	See above
434.	DAY-FAN 6 DAYCRAFT 6 DAY-FAN JR.	110 145 —	none Spkr. —	— 32 x 30 x 34 15 x 7 x 7	1	fil.	3r, d, 2at (6)	5-01A, 1-12 or 71	12-15	TRF	50-120	Ca, C, Sh, O
435.	DAY-FAN 7		none		1	fil.	3r, d, la res, 2at (7)	6-01A, 1-12 or 71	15	TRF	50-120	Ca, C, Sh, O .
436.	FEDERAL	250-1000	Loop	varies	1	rheo.	2r, d, 2at (5)	4-01A, 1-12 or 71	20.7	TRF bal.	Loop	Ca, C, Sh. Made in 6 models.
437.	FERGUSON 10A	150	none	21½ x 12 x 15	1	rheo. 2r.f.	3r, d, 3a (7)	6-01A, 1-12 or 71	18-25	TRF	100	C; Ca, Sh.
438.	FERGUSON 14	235	Loop	24 x 12 x 16	2	rheo. 3r.f.	6r, d, 3a (10)	9-01A, 1-12 or 71	30-35	TRF	Loop	C, Ca, Sh. Special bal.
439.	FERGUSON 12	85 145	none Spkr.	22½ x 10 x 12	1	rheo. 2 r.f.	2r, d, lat, 2a res., (6)	5-01A, 1-12 or 71	18-25	TRF	100	Ca, C. Partly Sh.
440.	FREED-EISEMANN NR8 NR9 NR66	90 100 125	none none none	19¾ x 10 x 10½ 19¾ x 10 x 10½ 20 x 10 x 12	2 1 1	rheo. r.f.	3r, d, 2at (6)	5-01A, 1-71	30	TRF Ne.	100	Ca. NR8 and 9 chassis type Sh. NR66 individual stage Sh.
441.	FREED-EISEMANN NR77	175	none	23 x 10½ x 13	1	rheo. r.f.	4r, d, 2at (7)	6-01A, 1-71	35	TRF Ne.	Ant. or loop	Ca, C, Sh.
442.	FREED-EISEMANN 800 850		none none	34 x 15½ x 13½ 36 x 65½ x 17½	1	rheo. r.f.	4r, d, 2at (8)	6-01A, 1-71 or 2-01A	35	TRF Ne.	Ant. or loop	Ca, C, Sh. Output stage 2 tubes par. or 1 power tube. O
443.	GREBE CR18 (Short-Wave)	100	Set coils	6 x 7¼ x 7	2	rheo.	d, lat (2)	2-01A	8	3 cir. reg.	100	Wavelength range 8-210 m.
444.	GREBE MUI	155-320	none	22½ x 9¼ x 13	1-2-3	rheo. r.f.	2r, d, 2at (5)	4-01A, 1-12 or 71	30	TRF bal.	125	Bp, C, binocular coils. dials op. singly or together
445.	HARMONIC R	75	none	26 x 9 x 9	3	rheo. r.f.	1r, d, 2at (4)	4-01A		TRF reg. d	100	H, C, Bp.
446.	HARMONIC S	100	none	26 x 9 x 9	3	rheo. r.f.	1r, d, 3a res. (5)	5-01A		TRF reg. d	100	H, C, Bp.
447.	LEUTZ TRANS-OCEANIC	150	none	27 x 8½ x 13 1/16	1-5	special	4r, d, lat, 3a res. (9)	5-01A, 1-00A, 2-Hmu, 1-71 or 10	20-40	TRF gr	Ant. or Loop	Range 35-3600 m M. Sh. C. Bp. O
448.	LEUTZ SILVER GHOST		none	72 x 12 x 20	1-5	special	4r, d, lat, 3a res. (9)	See above	20-40	TRF gr	Ant. or loop	See above
449.	NORBERT MIDGET	12	1-MV	12 x 8 x 9	2	rheo.	d, 2at, (1)	1-MV	3	TRF	75-150	C, Bp.
450.	NORBERT 2	40.50	1-MV 1-01A	20 x 7 x 5½	2	special	1r, d, 2at (2)	1-MV 1-01A	8	TRF	50-100	C, Bp
451.	NORCO 66 CONSOLE	130 250	none Speaker	18½ x 8½ x 13¾	1-3	mod. a.f.	2r, d, 3ai (6)	5-01A 1-71	20	TRF	70-90	Sh, C, Ca, O. Drum control
452.	ORIOLE 90	85	none	25½ x 11½ x 12½	2	rheo. r.f.	2r, d, 2at (5)	5-01A	13	Tiinum	50-100	Ca, C
470.	ORIOLE	185	none	25½ x 11½ x 12½	1	rheo. r. f.	(8)	8-01A	25	Trinum	50-100	Ca, C, Sh
453.	PARAGON		none	20 x 46 x 17	1	res. r.f. plate	(6)	5-01A, 1-71	40	TRF	100	Double imp. Audio C. Ca, Sh
454.	PARAMOUNT V VI	65 75	none none	26 x 7 —			(5) (6)	5-01A 6-01A		TRF	100	Bp, C.
455.	PREMIER 6-IN-LINE	60-150	none	25 x 45 x 16	1-2	rheo. r.f.	3r, d, 2at (6)	4-01A, 1-00A, 1-12	16-18	TRF	100 loop	Ca, C.
456.	RADIOLA 20	115	5 tubes	19⅛ x 11¾ x 16	2	reg.	2r, d, 2at (5)	4-99, 1-20		TRF reg. d	75-150	C, H.
457.	RADIOLA 25	165	6 tubes	28 x 37 x 19	1	pot.	o, 2d, 3int. 2at (6)	5-99, 1-20		Super	Loop	Reflexed, C, H.
458.	RADIOLA 28	260	8 tubes	26½ x 63 x 17	1	pot.	o, 2d, 3int, 2at (8)	7-99, 1-20		Super	Loop	C, H.
459.	STROMBERG CARLSON No. 501 502	180 290	none none	25½ x 13 x 14 28 13/16 x 50 7/8 x 16¾	2	rheo. r.f.	2r, d, 2at (5)	3-01A, 1-00A, 1-71	25-35	TRF Ne.	60-100	Ca, C, Sh, O, M, H.
460.	STROMBERG CARLSON No. 601 602	225 330	none none	27 x 16¾ x 14 3/16 28¾ x 51½ x 19¾	2	rheo. r.f.	3r, d, 2at (6)	4-01A, 1-00A, 1-71	30-40	TRF Ne.	20-60	Ca, C, Sh, O, M, H.
461.	SUN	80	none	23 x 10 x 10	2	res. r.f. plate	2r, d, 2at (5)	5-01A		TRF	100	Bp.
462.	CUSTOM BUILT 7	275	com.	7 x 21 panel	2	special	(7)	5-01A, 1-00A, 1-71	40	TRF	100	Bp. C, O. Built in A and B power

(Continued on page 252)

No.	Model	Price	Accessories Included	Cabinet Size	No. Dials	Vol. Cont.	No. Tubes	Type Tubes	Cur. mA.	Circuit.	Ant. Length Ft.	Remarks
463.	CUSTOM BUILT 9	375	com.	7 x 21 panel	2	Mod.	(9)	8–01A, 1–71	40		Loop	See No. 462
464.	WRIGHT VII	160	none	25 x 15 x 17½	2	res. r.f. plate	3r, d, 3ai (7)	6–99, 1–20	17¼	TRF	80	Ca, C, O. Na-Ald Amp.
471.	VOLTONE XX	50	none	20½ x 8 x 12	2	rheo.	1r, d, 3a res. (5)	1–01A, 1–00A, 2–HMu, 1–71	18	TRF	100	Ca, C, O, Reg
472.	VOLTONE VIII	140	none	26½ x 8 x 12	3	rheo.	2r, d, 3a res. (6)	4–01A, 1–00A, 1–71	20	TRF	100	Ca, C, O, Reg
473.	PRMCO 105	45	none	18 x 7 panel	3	rheo. r. f.	2r, d, 2at, la res. (6)	6–01A		TRF	100	Ca.
474.	PRMCO 110	80	none	18 x 7 panel	1	rheo. r.f.	2r, d, 2at, la res. (6)	6–01A		TRF	100	Ca, C. Drum tuning cont.
475.	PENN-C 5	150	none	24 x 10 x 15	3	pot.	(5)	5–01A	15		75	Bp, C, Console
476.	PENN-C 6	95–165	none	24 x 10 x 15	1	pot.	(6)	5–01A, 1–00A	15		75	Bp, C.
477.	DAVEN BASS NOTE	150	none	23½ x 12 x 16	2	pot.	2r, d, 3a res. (6)	2–01A, 3–HMu, 1–Power	17	TRF	50–100	Ca, C.
478.	ZIMPHONIC TABLE / CONSOLE	90 / 125	none / none	— / 20 x 40 x 15	1	res.	2rd, d 3a (6)	4–01A, 1–00A, 1–12		TRF	100	H, Ca, C, Sh, reg.
479.	ZIMPHONIC TABLE / CONSOLE	140 / 175	none / none	— / 20 x 40 x 15	1	rheo.	3r, d, 3a (7)	5–01A, 1–00A, 1–12	24	TRF	75	H, Ca, C, Sh, reg.
480.	PFANSTIEHL CABINET 30 / CONSOLE 302	99.50 / 165	none / Spkr.	17¾ x 8½ panel	1	res. plate r.f.	3r, d, 2at (6)	5–01A, 1–12 or 1–71	26–32	TRF	Ant.	Ca, C, Sh.
481.	PFANSTIEHL CABINET 32 / CONSOLE 322	135 / 225	none / Spkr.	17¾ x 8½ panel	1	res. plate r.f.	3r, d, 3a (7)	6–01A, 1–12 or 1–71	23–32	TRF	Ant.	Ca, C, O, Sh.
482.	STEWART-WARNER TABLE 705 / CONSOLE 710	Tentative 115 / 265	none / Spkr.	26⅛ x 11¼ x 13 13/16 / 29¾ x 42 x 17⅛	2	res. plate r.f.	3r, d, 2at (6)	6–01A	10–25	TRF. bal.	80	Ca, C, Sh.
483.	STEWART-WARNER TABLE 525 / CONSOLE 520	Tentative 75 / 117.50	none / Spkr.	19¾ x 10 x 11⅞ / 22⅛ x 40 x 14 11/16	2	res. plate r.f.	3r, d, 2at (6)	6–01A	24	TRF	80	Ca, C.

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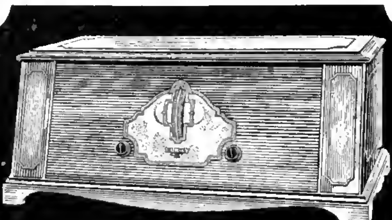

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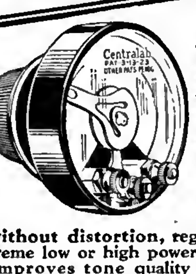

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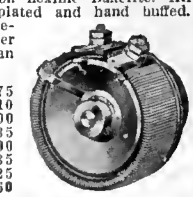

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68. Chemical Rectifier—Details of assembly, with wiring diagrams, showing how to use a chemical rectifier for charging batteries. Cleveland Engineering Laboratories Company.
69. Vacuum Tubes—A booklet giving the characteristics of the various tube types with a short description of where they may be used in the circuit. Radio Corporation of America.
77. Tubes—A booklet for the beginner who is interested in vacuum tubes. A non-technical consideration of the various elements in the tube as well as their position in the receiver. Cleartron Vacuum Tube Company.
87. Tube Tester—A complete description of how to build and how to operate a tube tester. Burton-Rogers Company.
91. Vacuum Tubes—A booklet giving the characteristics and uses of various types of tubes. This booklet may be obtained in English, Spanish, or Portuguese. DeForest Radio Company.
92. Resistors for A. C. Operated Receivers—A booklet giving circuit suggestions for building a. c. operated receivers, together with a diagram of the circuit used with the new 400-millampere rectifier tube. Carter Radio Company.
97. High-Resistance Voltmeters—A folder giving information on how to use a high-resistance voltmeter, special consideration being given the voltage measurement of socket-power devices. Westinghouse Electric & Manufacturing Company.

Miscellaneous

38. Log Sheet—A list of broadcasting stations with columns for marking down dial settings. U. S. L. Radio, Incorporated.
41. Baby Radio Transmitter of 9xh-9ek—Description and circuit diagrams of dry-cell operated transmitter. Burgess Battery Company.
42. Arctic Radio Equipment—Description and circuit details of short-wave receiver and transmitter used in Arctic exploration. Burgess Battery Company.
43. Short-Wave Receiver of 9xh-9ek—Complete directions for assembly and operation of the receiver. Burgess Battery Company.
44. Aluminum for Radio—A booklet containing much radio information with hook-ups of basic circuits, with inductance-capacity tables and other pertinent data. Aluminum Company of America.
45. Shielding—A discussion of the application of shielding in radio circuits with special data on aluminum shields. Aluminum Company of America.
58. How to Select a Receiver—A commonsense booklet describing what a radio set is, and what you should expect from it, in language that any one can understand. Day-Fan Electric Company.
67. Weather for Radio—A very interesting booklet on the relationship between weather and radio reception, with maps and data on forecasting the probable results. Taylor Instrument Companies.
73. Radio Simplified—A non-technical booklet giving pertinent data on various radio subjects. Of especial interest to the beginner and set owner. Crosley Radio Corporation.
74. The Experimenter—A monthly publication which gives technical facts, valuable tables, and pertinent information on various radio subjects. Interesting to the experimenter and to the technical radio man. General Radio Company.
75. For the Listener—General suggestions for the selecting, and the care of radio receivers. Valley Electric Company.
76. Radio Instruments—A description of various meters used in radio and electrical circuits together with a short discussion of their uses. Jewell Electrical Instrument Company.
78. Electrical Troubles—A pamphlet describing the use of electrical testing instruments in automotive work combined with a description of the cadmium test for storage batteries. Of interest to the owner of storage batteries. Burton Rogers Company.
95. Resistance Data—Successive bulletins regarding the use of resistors in various parts of the radio circuit. International Resistance Company.
96. Vacuum Tube Testing—A booklet giving pertinent data on how to test vacuum tubes with special reference to a tube testing unit. Jewell Electrical Instrument Company.
98. Copper Shielding—A booklet giving information on the use of shielding in radio receivers, with notes and diagrams showing how it may be applied practically. Of special interest to the home constructor. The Copper and Brass Research Association.
99. Radio Convenience Outlets—A folder giving diagrams and specifications for installing loud speakers in various locations at some distance from the receiving set. Yaxley Manufacturing Company.

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Equipped with precision, moving coil voltmeter, resistance, 1000 ohms per volt, with knife-edge pointer highly damped, and 3-inch hand calibrated, 3-range scale—0-10 and 0-500 volts and 0-25 M. A. Equipped also with external binding posts, and rubber covered leads with prods, for external tests of batteries and B-Eliminators. Dimensions: 9 by 7 by 3⅜ in. Cased in finished hardwood box with cover and leather carrying handle. Price complete with Adaptors $60.00.

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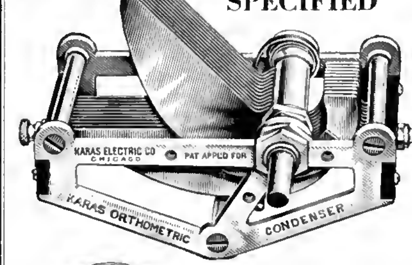

In the 80 Meter Transmitter described in this issue of Radio Broadcast 3 Karas Orthometric .0005 mfd. Straight Frequency Line Variable Condensers are specified. In the Shielded Neutrodyne Receiver, also described in this issue, 3 Karas Micrometric Vernier Dials are specified.
Be sure to use Karas Condensers when you build your short wave transmitter. Their use will add greatly to the satisfaction and enjoyment you will derive from this set. And if you use Karas Dials, with their split-second 1|1000th of an inch control of tuning, when you build your Shielded Neutrodyne Receiver, you will be able to bring in hard-to-tune stations with ease. Karas .0005 Condensers are $7 each, Karas Dials $3.50 each. Order from your dealer to-day. **Write for literature regarding the new Karas products.**

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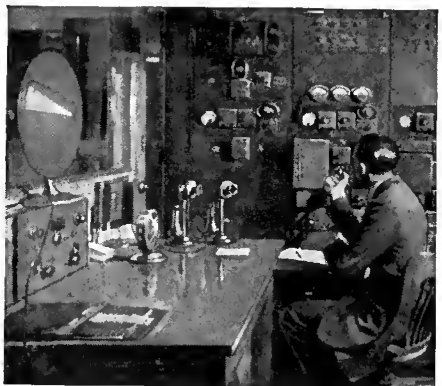

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What Kit Shall I Buy?

THE list of kits herewith is printed as an extension of the scope of the Service Department of Radio Broadcast. *It is our purpose to list here the technical data about kits on which information is available. In some cases, the kit can be purchased from your dealer complete; in others, the descriptive booklet is supplied for a small charge and the parts can be purchased as the buyer likes. The Service Department will not undertake to handle cash remittances for parts, but when the coupon on page 255 is filled out, all the information requested will be forwarded.*

201. SC Four-Tube Receiver—Single control. One stage of tuned radio frequency, regenerative detector, and two stages of transformer-coupled audio amplification. Regeneration control is accomplished by means of a variable resistor across the tickler coil. Standard parts; cost approximately $58.85.

202. SC-II Five-Tube Receiver—Two stages of tuned radio frequency, detector, and two stages of transformer-coupled audio. Two tuning controls. Volume control consists of potentiometer grid bias on r.f. tubes. Standard parts cost approximately $60.35.

203. "HI-Q" Kit—A five-tube tuned radio-frequency set having two radio stages, a detector, and two transformer-coupled audio stages. A special method of coupling in the r.f. stages tends to make the amplification more nearly equal over the entire band. Price $63.05 without cabinet.

204. R. G. S. Kit—A four-tube inverse reflex circuit, having the equivalent of two tuned radio-frequency stages, detector, and three audio stages. Two controls. Price $69.70 without cabinet.

205. Pierce Airo Kit—A six-tube single-dial receiver; two stages of radio-frequency amplification, detector, and three stages of resistance-coupled audio. Volume control accomplished by variation of filament brilliancy of r.f. tubes or by adjusting compensating condensers. Complete chassis assembled but not wired costs $42.50.

206. H & H-T. R. F. Assembly—A five-tube set; three tuning dials, two steps of radio frequency, detector, and 2 transformer-coupled audio stages. Complete except for baseboard, panel, screws, wires, and accessories. Price $35.00.

207. Premier Five-Tube Ensemble—Two stages of tuned radio frequency, detector, and two steps of transformer-coupled audio. Three dials. Parts assembled but not wired. Price complete, except for cabinet, $35.00.

208. "Quadraformer VI"—A six-tube set with two tuning controls. Two stages of tuned radio frequency using specially designed shielded coils, a detector, one stage of transformer-coupled audio, and two stages of resistance-coupled audio. Gain control by means of tapped primaries on the r.f. transformers. Essential kit consists of three shielded double-range "Quadraformer" coils, a selectivity control, and an "Ampitrol," price $17.50. Complete parts $70.15.

209. Gen-Ral Five-Tube Set—Two stages of tuned radio frequency, detector, and two transformer-coupled audio stages. Volume is controlled by a resistor in the plate circuit of the r.f. tubes. Uses a special r.f. coil ("Duo-Former") with figure eight winding. Parts mounted but not wired, price $37.50.

210. Bremer-Tully Power-Six—A six-tube, dual-control set; three stages of neutralized tuned radio frequency, detector, and two transformer-coupled audio stages. Resistances in the grid circuit together with a phase shifting arrangement are used to prevent oscillation. Volume control accomplished by variation of B potential on r.f. tube. Essential kit consists of four r.f. transformers, two dual condensers, three small condensers, three choke coils, one 500,000-ohm resistor, three 1500-ohm resistors, and a set of color charts and diagrams. Price $41.50.

211. Bruno Drum Control Receivers—How to apply a drum tuning unit to such circuits as the three-tube regenerative receiver, four-tube Browning-Drake, five-tube Diamond-of-the-Air, and the "Grand" 6.

212. Infradyne Amplifier—A three-tube intermediate-frequency amplifier for the super-heterodyne and other special receivers, tuned to 3490 kc. (86 meters). Price $25.00.

213. Radio Broadcast "Lab" Receiver—A four-tube dual-control receiver with one stage of Rice neutralized tuned-radio frequency, regenerative detector (capacity controlled), and two stages of transformer-coupled audio. Approximate price, $78.15.

214. LC-27—A five-tube set with two stages of tuned-radio frequency, a detector, and two stages of transformer-coupled audio. Special coils and special means of neutralizing are employed. Output device. Price $85.20 without cabinet.

215. Loftin-White—A five-tube set with two stages of radio frequency, especially designed to give equal amplification at all frequencies, a detector, and two stages of transformer-coupled audio. Two controls. Output device. Price $85.10.

216. K.H.-27—A six-tube receiver with two stages of neutralized tuned radio frequency, a detector, three stages of choke-coupled audio, and an output device. Two controls. Price $86.00 without cabinet.

217. Aero Short-Wave Kit—Three plug-in coils designed to operate with a regenerative detector circuit and having a frequency range of from 19,990 to 2306 kc. (15 to 130 meters). Coils and plug only, price $12.50.

218. Diamond-of-the-Air—A five-tube set having one stage of tuned-radio frequency, a regenerative detector, one stage of transformer-coupled audio, and two stages of resistance-coupled audio. Volume control through regeneration. Two tuning dials.

219. Norden-Hauck Super 10—Ten tubes; five stages of tuned radio frequency, detector, and four stages of choke- and transformer-coupled audio frequency. Two controls. Price $291.40.

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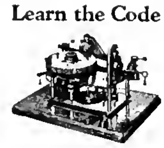

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221. LR4 ULTRADYNE—Nine-tube super-heterodyne: one stage of tuned radio frequency, one modulator, one oscillator, three intermediate-frequency stages, detector, and two transformer-coupled audio stages.

222. GREIFF MULTIPLEX—Four tubes (equivalent to six tubes); one stage of tuned radio frequency, one stage of transformer-coupled radio frequency, crystal detector, two stages of transformer-coupled audio, and one stage of impedance-coupled audio. Two controls. Price complete parts, $50.00.

223. PHONOGRAPH AMPLIFIER—A five-tube amplifier device having an oscillator, a detector, one stage of transformer-coupled audio, and two stages of impedance-coupled audio. The phonograph signal is made to modulate the oscillator in much the same manner as an incoming signal from an antenna

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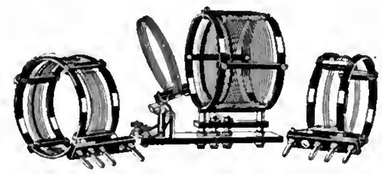

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Flexibility to a degree never before thought possible has been embodied into the new kit so that it has a gapless range (when used with INT. Coils No. 0, 4 and 5) of 13 to 725 meters!

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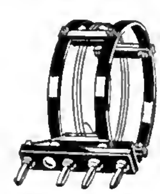
New AERO Interchangeable Coils

Int. No. 0



Range 13 to 29.4 meters. This is the most efficient inductance for this low band. Code number INT. No. 0.

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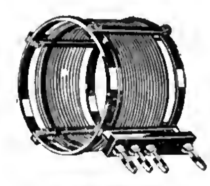

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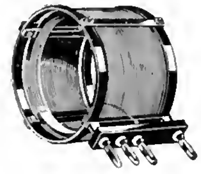

Normal range 235 to 550 meters. However, by using .0001 Sangamo fixed condenser across the rotor and stator of the .00014 variable condenser, the maximum wave band of this coil is increased to 725 meters. This gives you coverage of the following bands: Airplane to Airplane, Land to Airplane, Ship to Shore (Great Lakes) Ship to Shore (Atlantic and Pacific oceans). Code number INT. No. 5.

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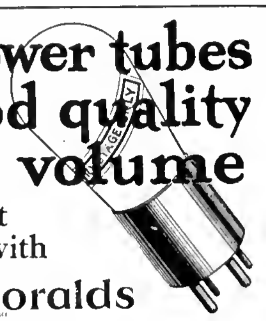

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MERCHANDISING RADIO SINCE 1919

A KEY TO RECENT RADIO ARTICLES

By E. G. SHALKHAUSER

This is the twenty-first installment of references to articles which have appeared recently in various radio periodicals. Each separate reference should be cut out and pasted on 4" x 6" cards for filing, or pasted in a scrap book either alphabetically or numerically. An outline of the Dewey Decimal System (employed here) appeared last in the January Radio Broadcast.

R344.4. Short-Wave Generators. Transmitter, *Short-Wave.*
QST. May, 1927. Pp. 9–14.
"A Complete Inexpensive Transmitter," H. P. Westman.
A short-wave transmitter operating with two UX-171 tubes in a back-to-back Hartley circuit with straight a.c. on the plates, is outlined. Complete construction data, and detailed operating instructions relative to the principle employed in using the full a.c. wave, are given for the benefit of the beginner, who may desire to get into the transmitting game.

R333. Three-Electrode Electron Tubes. *Vacuum Tubes, UX-852.*
QST. May, 1927. Pp. 20–23.
"The UX-852 Transmitting Tube," R. S. Kruse.
Complete tube data relative to the new UX-852 75-watt transmitting tube are presented. These include the oscillating characteristics, filament curves, amplification factor, plate impedance, mutual conductance, and several static grid and plate voltage and current curves.

R281. 71. Quartz. Quartz, *Grinding of.*
QST. May, 1927 .Pp. 24–26.
"A Method of Grinding Quartz Plates," P. Mueller.
A method whereby quartz crystals may be ground to parallelism is outlined. The method consists of mounting nine crystal slabs to one plate and grinding; by frequent transpositions, true crystal surfaces are obtained.

R084. Maps and Charts. Chart, *Tube Characteristic.*
QST. May, 1927, Pp. 48–49.
"A Tube Characteristic Chart."
A chart showing the characteristics of plate resistance, amplification constant, and mutual conductance of vacuum tubes, at a glance, has been devised, and is shown. To illustrate the principle, an example is worked out.

R114. Strays. Static
Popular Radio. May, 1927. Pp. 427–430.
"Static's New Job as a Life-Saver," Com. S. C. Hooper.
The detection, recording, and the analysis of static signals is said to be of material benefit in locating and studying storm areas, especially at sea, where the observations, here referred to, have been made. Experiences while aboard the U.S.S. *Kittery* are related.

R582. Transmission of Photographs. Television, *Baird System.*
Popular Radio. May, 1927. Pp. 447-ff.
"Television and 'Black Light'," John L. Baird.
The experiments carried on by John L. Baird with his television apparatus are enumerated by the inventor himself. Starting with simple apparatus and making use of many new developments in science, his system now employs rays of light in the infra-red spectrum. Although only in the first stages of development, experiments with the so-called "black light" give promise of great strides being made in the perfection of television, as stated.

R343. Electron-Tube Receiving Sets. Receiver, *Short-Wave.*
Radio Broadcast. May, 1927. Pp. 24–25.
"A Balanced Short-Wave Receiver," F. C. Jones.
A non-radiating short-wave receiver, covering the range from 9994 to 5996 kilocycles (30 to 50 meters), is described. A bridge circuit is utilized to prevent the set from radiating. Antenna and ground are connected across the zero potential points of the bridge. Two tubes are found necessary in the described arrangement, the constants of which are discussed in detail.

R343.7. Alternating-Current Supply. A.C. for Filaments.
Radio Broadcast. May, 1927. Pp. 33–35.
"Filament Lighting from the A. C. Mains," R. F. Beers.
The advantages of series rather than parallel arrangement of filaments are stated as: (1) Total current to be filtered is only that taken by one tube, and (2) higher voltages are available for filtering. Circuit diagrams are shown and explained.

R251. Ammeters. Ammeters, *Volume Indicators.*
Radio Broadcast. May, 1927. Pp. 38–39.
"Technical Operation of Broadcasting Stations: No. 15. Volume Indicators," Carl Dreher.
Practical circuit diagram and operating data concerning "volume indicators" as used in broadcasting stations, are given. Use is made of either a d.c. or an a.c. milliammeter connected into the plate circuit of a vacuum tube or coupled to it.

R382. Inductors. Inductors.
Radio Broadcast. May, 1927. Pp. 40–42.
"Some Facts About Coil Design," R. Gunn.
The oscillating circuit, consisting of inductance, resistance, and capacity, is found to be a form of voltage amplifier, its amplification being equal to the generated voltage divided by the applied voltage. This factor is spoken of as the "gain." The "gain" depends primarily on the coil rather than the condenser, the latter having comparatively lower losses. The following points are considered of importance: (1). The gain of the coil should not exceed the limit of 25n for good quality reproduction; (2). the exterior field of the coil should be as near zero as possible; (3). the distributed capacity should be very low; (4) the coil should be mechanically strong.

Designer of Broadcast Station WEMC

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Would you like to tour Europe, inspecting broadcast stations? You would? My friend John Fetzer DID! Maybe you'd like to hold a fine job as Chief Engineer of a widely-known American broadcast station? That's what John Fetzer is right now—Chief Engineer of Station W E M C, "The Radio Lighthouse," located at Berrien Springs, Mich. Read his interesting letter at the right.

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If I offered you a job like John Fetzer's at $100 or $150 a week, would you take it?

If I told you that to get this job you would have to do a little studying, say half an hour a day for a few months, would you do that too?

You bet you would. You probably even think I'm foolish to ask you such questions. But, as a matter of fact, you today have such an opportunity in the same place John Fetzer found his—in the brand-new, growing Radio Industry.

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You'll have to do some studying before you can hold down one of the good jobs—only well-trained men are wanted.

But that part isn't hard—lots of men without a grade school education have done it. And it only takes a comparatively short time, studying about half an hour a day. You can keep right on with your present job, and learn in the quiet of your own home.

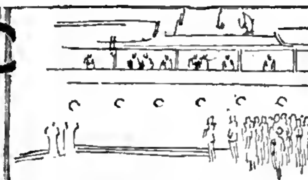
Get My Big Free Book

300,000 new openings have been created by the swift growth of the Radio business in the past few years. During the same years I have helped thousands of men to take advantage of opportunities like these.

John Fetzer, whose picture you see above, is only one man among these thousands I've helped. Lots of the others didn't climb as high as Fetzer, but there are some, too, who have gone higher.

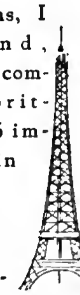
I'm ready to help you, too, if you are looking for a better job and more money. The good jobs in Radio pay from $50 all the way up to $250 a week. And the accomplishment of television, trans-Atlantic Radio telephony, the other new inventions constantly being made, all point to even greater things for the future. If you're ambitious and dissatisfied with your job or your future, let me help you share in the Rich Rewards of Radio.

Mail the coupon below for my big free book about Radio, its opportunities, and how I train you, quickly and easily in your spare time at home, to take advantage of them. No previous experience needed. You learn by doing, with six big outfits of practical experimental material I send you at no extra cost. Mail coupon now for book. Address J. E. Smith, President, National Radio Institute, Washington, D. C.

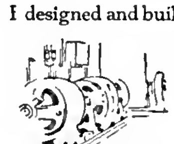


Dear Mr. Smith:

I went to Europe at the expense of my station, WEMC, to learn the best methods used there and bring them back for my station. I found about 20 stations in the British Isles, mostly used to relay programs from 2LO. They were very kind to me at 2LO—their equipment is about like that of our own good stations. French stations, I found, don't compare with the British. There are 6 important stations in France. Eiffel Tower is the best known. I visited Holland, Belgium and Switzerland, and got a real thrill from seeing the big station at



Nauen, Germany. On my return I designed and built the new high power station for WEMC, using best features of what I had seen. Our first program was reported in 40 States. Your training is the way to lasting success in Radio.



John E Fetzer

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RADIO BROADCAST

SEPTEMBER, 1927

WILLIS KINGSLEY WING, Editor

KEITH HENNEY, Director of the Laboratory

EDGAR H. FELIX, Contributing Editor

Vol. XI, No. 5

CONTENTS

Cover Design - - - - - From a Design by *Harvey Hopkins Dunn*

Frontispiece - - - *A Method of Speedy Radio Transmission* 262

A Discovery that Newton Missed - - - - *James Stokley* 263

The March of Radio - - - - - *An Editorial Interpretation* 266

Radio Needs No Yearly Models
Will Telephotography Be the Experimenters' Next Field?
A Prosperous Radio Year Forecast
Discovering Ore Deposits by Radio
Broadcasters in New York Organize
Judge Davis Resigns
Where Are the Listener Organizations?
The Month in Radio

Piezo-Electric Crystals - - - - - - - - *M. Thornton Dow* 271

Home Constructing Transformers and Chokes for Power Supply Devices - - - - - - - - - - - - - *Homer S. Davis* 274

Pictures by Radio - - - - - - - - - - - - - - - - - 279

Building the Laboratory "Super" - - - - *Ernest R. Pfaff* 280

We Need Better Radio Salesmen - - - - - - - *Carl Dreher* 283

Drawing by Franklyn F. Stratford

"Strays" from the Laboratory - - - - - - - - - - - - 284

A Survey of the A. C. Tubes

The Listener's Point of View - - - - - *John Wallace* 286

Why Not Try the Short Waves? - - - - - *Keith Henney* 290

As the Broadcaster Sees It - - - - - - - - *Carl Dreher* 293

Causes of Poor Tone Quality - - - - - - *Edgar H. Felix* 296

New Receiver Offerings for the Fall - - *The Laboratory Staff* 298

Suppressing Radio Interference - - - - - - - *A. T. Lawton* 299

Three-Element A. C. Vacuum Tubes - - - *B. F. Miessner* 302

"Radio Broadcast's" Laboratory Information Sheets - - - - - 308

No. 121. The Hertz Antenna
No. 122. Testing Radio Receivers
No. 123. Characteristics of the 171 Type Tube.
No. 124. Curves of the 171 Type Tube.
No. 125. The Morse Code.
No. 126. Condenser Reactance.
No. 127. Condenser Reactance Table.
No. 128. B Power Units.

Manufacturers' Booklets Available - - - - - - - - - - - 314

"Radio Broadcast's" Directory of Manufactured Receivers - - 316

What Kit Shall I Buy? - - - - - - - - - - - - - - - 324

A Key to Recent Radio Articles - - - - *E. G. Shalkhauser* 326

AMONG OTHER THINGS. . .

SOME may look with critical eye at the leading article this month which delves into the subject of ultra-violet, infra-red, and X-rays, for they may think that field a bit removed from radio. But in these days of scientific advance, many fields of experiment which have heretofore been widely separated, are becoming more closely associated, and anything, therefore, having to do with the generation of short electrical waves, is of interest to those who dabble in radio. James Stokley, who contributes this story on ultra short waves, is on the staff of Science Service, that interesting and important Washington organization devoted to telling the public more about science.

OF OUR other authors, M. Thornton Dow, the writer of the article on the remarkable piezo-electric crystal, is at Cruft Laboratory, Harvard University. Homer Davis, whose calculation charts have appeared in RADIO BROADCAST before, is a graduate engineer and a resident of Memphis, Tennessee. Ernest R. Pfaff, who describes the interesting super-heterodyne which may be made with the Jeweller's Time amplifier, is a radio denizen of Chicago and a frequent contributor to the radio press. B. F. Miessner, the author of the Radio Club of America paper on the a.c. tube, is chief engineer of the Garod Corporation and has had an extensive and varied radio experience. In early radio days, he was associated with John Hays Hammond, conducting radio and other experiments. A. T. Lawton, author of the series on eliminating man-made radio interference, is a Canadian, living in Ottawa. He has been associated with the interference-prevention work now being done in the Dominion.

THE short-waves, long the almost exclusive playground and workshop of the amateurs and commercial and military services, are now beginning to harbor broadcast programs. Some of our own American stations are broadcasting their programs on two waves—the standard broadcasting wave and a short wave. This experiment, long exclusively conducted by WGY and KDKA, is now being shared by several others. There are stations abroad, too, providing voice and music on these bands. The article in this issue by Keith Henney tells something of the traffic in these lesser-known bands.

THE subject of transmission of photographs by radio—wrongly termed television by many, for it is in fact, radio-telephotography—is receiving increased attention, and for the readers of RADIO BROADCAST we have arranged to publish an exclusive series of articles. These stories will describe a practical and inexpensive system which can be attached to any good radio receiver. By its use good pictures will result, as experiments, conducted in RADIO BROADCAST Laboratory over a period of more than three years, have shown. An introductory article appears in this number and others will soon follow.

THE Directory of Manufactured Receivers, which appeared in our August number for the first time, appears in a slightly revised form in this number. The present form is much easier to use. We call especial attention to the fact that the Service Department of RADIO BROADCAST will furnish much more detailed information on any or all of the receivers listed if the coupon on page 328 is filled out and sent to us.

—WILLIS KINGSLEY WING.

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For Perfect Reception

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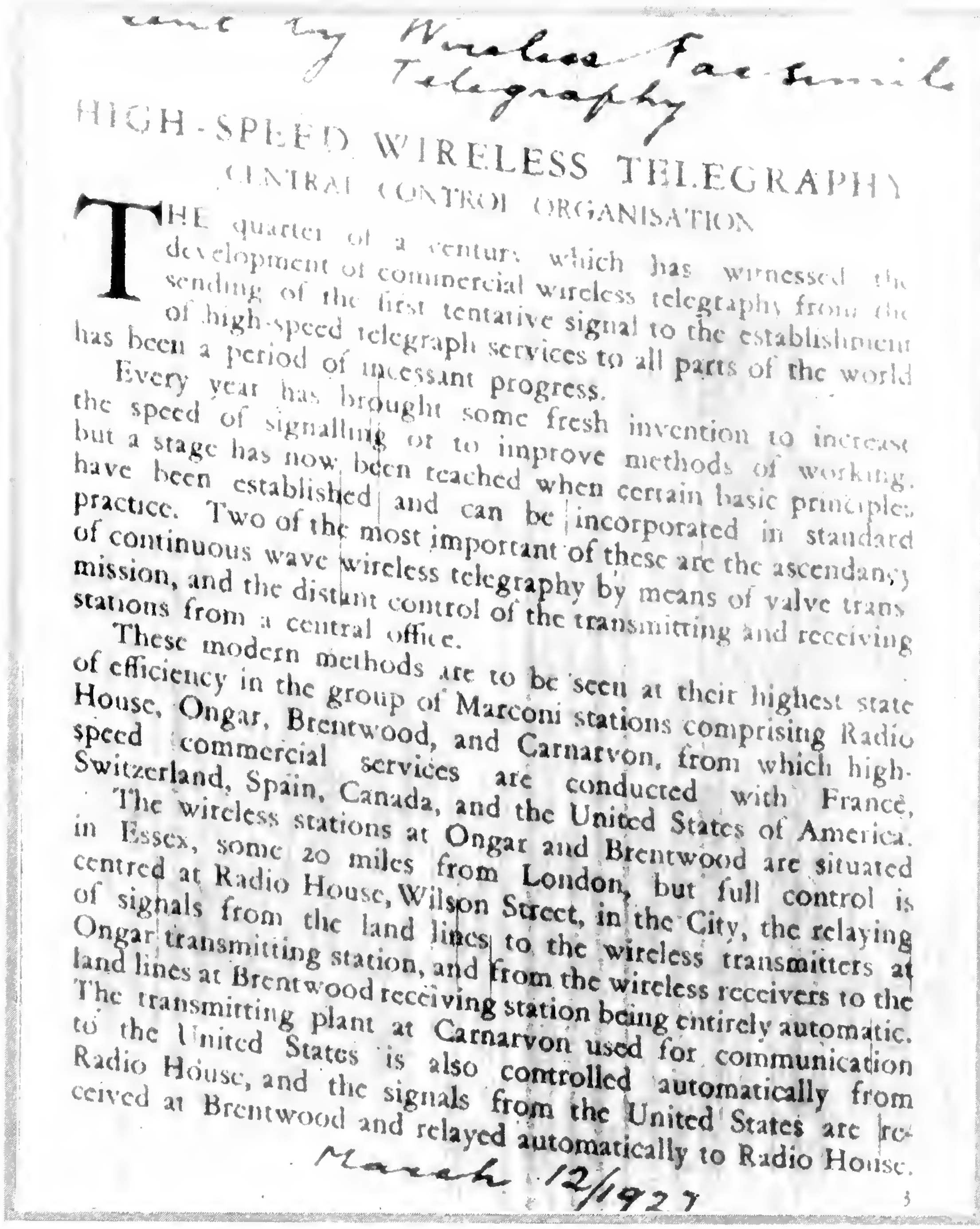
KOKOMO ELECTRIC CO.
KOKOMO, INDIANA

WHAT THE KINGSTON IS

THE KINGSTON will maintain the radio set always at its perfection peak. It contains no acid or solution, operates without vibration or noise and will not heat. There are provided three different voltage terminals, each adjustable over a wide range, making possible any desired voltage from 5 to 200. A fourth variable voltage may be easily had, if desired, by connecting a separate variable resistor to one of the terminals. The primary or main current supply is controlled by a rheostat making it possible to reduce the current entering the unit to the amount actually required for any individual set, thus protecting the set against overload.

For an additional $2.50 an automatic control switch is furnished by which the Unit is switched on or off when switch on the radio set panel is turned.

Handsomely finished in satin black. Size; 9 inches long, $5\frac{1}{4}$ inches wide, $8\frac{1}{4}$ inches high. The Raytheon 85 milliampere type BH tube is used as rectifier. Fully guaranteed.



Sent by Wireless Facsimile Telegraphy

HIGH-SPEED WIRELESS TELEGRAPHY

CENTRAL CONTROL ORGANISATION

THE quarter of a century which has witnessed the development of commercial wireless telegraphy from the sending of the first tentative signal to the establishment of high-speed telegraph services to all parts of the world has been a period of incessant progress.

Every year has brought some fresh invention to increase the speed of signalling or to improve methods of working, but a stage has now been reached when certain basic principles have been established and can be incorporated in standard practice. Two of the most important of these are the ascendancy of continuous wave wireless telegraphy by means of valve transmission, and the distant control of the transmitting and receiving stations from a central office.

These modern methods are to be seen at their highest state of efficiency in the group of Marconi stations comprising Radio House, Ongar, Brentwood, and Carnarvon, from which high-speed commercial services are conducted with France, Switzerland, Spain, Canada, and the United States of America.

The wireless stations at Ongar and Brentwood are situated in Essex, some 20 miles from London, but full control is centred at Radio House, Wilson Street, in the City, the relaying of signals from the land lines to the wireless transmitters at Ongar transmitting station, and from the wireless receivers to the land lines at Brentwood receiving station being entirely automatic. The transmitting plant at Carnarvon used for communication to the United States is also controlled automatically from Radio House, and the signals from the United States are received at Brentwood and relayed automatically to Radio House.

March 12/1927

3

A METHOD OF SPEEDY RADIO TRANSMISSION

Radio telegraph messages, using the present system, when sent must be translated into the code, and at the receiving station, must be decoded and copied. A method has been developed by J. M. Wright of the British Marconi Company for facsimile transmission which eliminates the translation into the code altogether. The sample in the illustration above was transmitted in 100 seconds

RADIO BROADCAST

VOLUME XI — NUMBER 5

SEPTEMBER, 1927

A Discovery That Newton Missed

Something About Waves of One Trillion Kilocycles Frequency—Ritter's Discovery of Ultra-Violet and Herschel's of Infra-Red Rays—The Uses of Ultra-Violet Rays for Their Health Giving Properties

By JAMES STOKLEY

Science Service

ABOUT two and a half centuries ago Sir Isaac Newton performed an experiment. During his life, this greatest scientist of his day and one of the greatest of all time, performed many experiments, but from this one in particular there came many far-reaching results. From it, more or less directly, came much of our knowledge of radio, of X-rays, the radiations of radium, and of the composition of the most distant stars, obtained by spectrum analysis.

Just what did Newton do? It so happens that we have a very complete account in his own words, left in one of his books, which bore the title of: *Opticks: or, a Treatise of the Reflexions, Refractions, Inflexions, and Colors of Light.* The first edition, of this great work, now very rare, was published in 1704, and on page 18 we read:

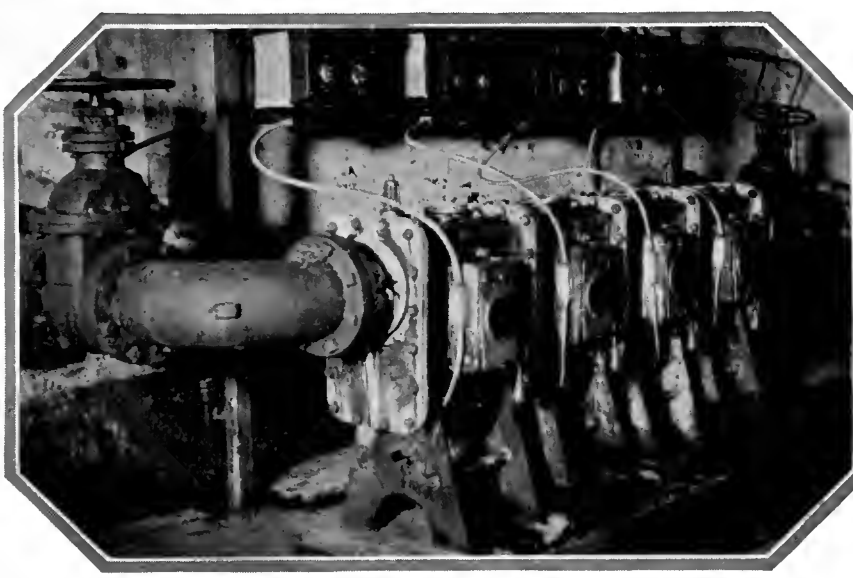
THE LIGHT OF THE SUN CONSISTS OF RAYS DIFFERENTLY REFRANGIBLE

The Proof by Experiments

In a very dark chamber at a round hole about one third part of an inch broad made in the shut of a window I placed a glass prism, whereby the beam of the sun's light which came in at that hole might be refracted upwards toward the opposite wall of the chamber, and there form a colored image of the sun. The axis of the prism (that is, the line passing through the middle of the prism from one end of it to the other end parallel to the edge of the refracting angle) was, in this and the following experiments, perpendicular to the incident rays. . . . I let the refracted light fall perpendicularly upon a sheet of white paper at the opposite wall of the chamber, and observed the figure and dimensions of the solar image formed on the paper by that light. This image was oblong and not oval, but terminated with two rectilinear and parallel sides, and two semicircular ends. . . . This image, or spectrum, was coloured, being red at its least refracted end, and violet at its most refracted end, and yellow, green, and blue in the intermediate spaces.

This experiment of Newton's is a very easy one to repeat, for all you need is a prism. If you have one of the kind that used to hang from chandeliers in mid-Victorian homes, it will serve the purpose admirably.

But there was one important thing that Newton missed. So far as he could detect, the spectrum began at the violet end and ended at the red, which, together with the colors in between, constituted the complete composition of sunlight. That was because he was human, and had only his sense of sight to guide him. Actually the spectrum that he saw was only a small part of the complete spectrum of sunlight and an infinitesimally small part of the total range of radiation that is now known. The complete spectrum ranges from the longest radio waves and the still longer waves of alternating electric currents, down to the X-rays, and the penetrating radiation recently investigated by Professor Millikan. According to a well-known physicist, Dr. M. Luckiesh, if the visible part of the spectrum were one foot in length, approximately the length that Newton saw it, the spectrum of the total range of radiation would be several million miles long!



ONE OF THE USES OF ULTRA-VIOLET RAYS

Quartz tube mercury vapor lamps in use as sterilizers for the water supply of a small city. The ultra-violet rays prevent thriving of germs in the water

When you go to the seashore, and sit on the beach to get tanned by the sunshine, or when you take a snapshot of some member of the family, you demonstrate the presence of one kind of rays that the eye cannot perceive, for many of the chemical effects of sunlight, including that on the skin, and on the photographic film, are due to ultra-violet rays, consisting of waves which are a little

LOOK AT THIS PHOTOGRAPH

A steel surface photographed through a microscope with blue light. Ultra-violet rays would have given a much clearer picture

too short, and vibrate a little too rapidly, to be apparent to the eye.

As radio fans who are familiar with the modern system of designating stations by frequency rather than wavelength are aware, the average broadcasting frequency is in the neighborhood of 1000 kilocycles, which means that the complete vibration which produces the wave occurs 1,000,000 times a second. But the longest of the visible rays, those in the deepest red that the eye can see, have a frequency of 375,000,000,000 kilocycles. The violet rays at the other end of the spectrum vibrate about twice as rapidly, and the ultra-violet rays are between these and those vibrating with a frequency of 24,000,000,000,000 kilocycles!

But Newton, as we have seen, did not know of these invisible radiations. It was not many years after the publication of his *Opticks*, however, that some of their effects were noticed, for in 1727 a German physician, Johann Heinrich Schulze, happened to mix some chalk with nitric acid in which had been dissolved a little silver. At the time, he happened to be standing near a window, and he noticed that where the light fell on the mixture it became dark. The silver had dissolved in the nitric acid forming silver nitrate, and this must have reacted with some of the impurities in the chalk, such as ordinary salt, or sodium chloride, to produce silver chloride, which is one of the chief constituents of modern photographic materials.

However, Schulze also missed the discovery of ultra-violet radiation, for he only tried daylight on his silver chloride mixture. Half a century later, in 1777, its discovery was missed by a still narrower margin. This was by the famous Swedish chemist, Carl Wilhelm Scheele, who in 1774 had discovered the gas chlorine, and, three years before that, another gas—fluorine. Unlike Schulze, who accidentally came across the effect when he was trying to do something else, Scheele was studying the chemical action of light, and he exposed a surface coated with silver chloride to the spectrum obtained from sunlight with a prism.

What must have happened was that the silver chloride under the red and yellow part of the spectrum was not darkened at all, while that under the violet and the part where no color was visible beyond the violet, were darkened most. The experiment is one that is easily repeated; a piece of photographic printing paper may be used as the silver chloride surface.

But Scheele didn't notice this. Probably he was working in a room that was not entirely dark, except for the spectrum, and so the silver chloride was partly darkened all over due to the white light in the room. Anyhow, it remained for a German physicist, named Ritter, to discover that the invisible extension of the solar spectrum, beyond the violet, produced a greater effect on the silver chloride than did the violet itself, and so he discovered the ultra-violet rays, in 1801. Curiously enough, it was at almost the same time that the extension of the spectrum in the other direction, beyond the red, was discovered; the year before, the great English astronomer,

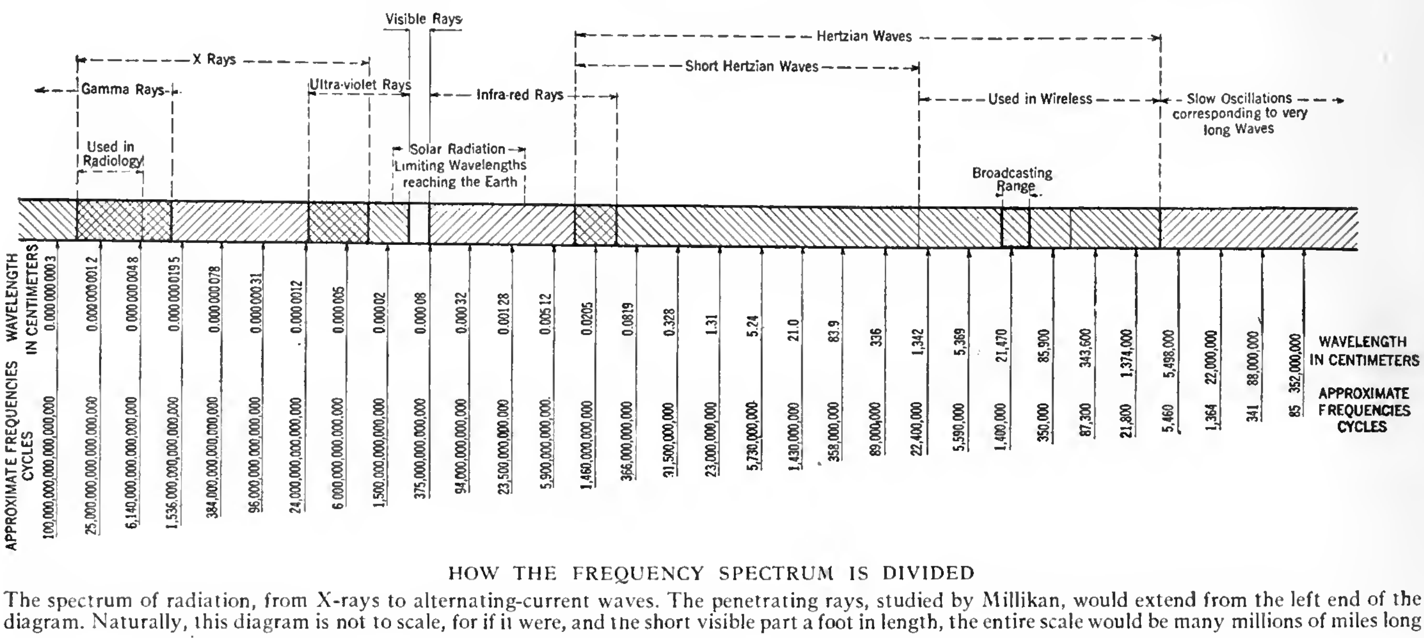
—AND NOW, THIS ONE

The same steel surface photographed with ultra-violet light, and a magnification of 1600 diameters. Notice the great amount of detail that can be seen in this picture as compared with the blue light photograph

Sir William Herschel, discovered the infra-red rays.

In the century following the discovery of the invisible rays, there came many discoveries, such as that of methods by which these rays could be produced artificially. The most copious source of ultra-violet rays known is, of course, the sun itself. On a clear summer day we get great quantities of them, with possibly even painful results if we are at the seashore, lying on the beach. But in winter, even when the sun is shining, it may be low in the sky, and the smoke and dust in the atmosphere may effectually keep most of these rays away from us.

As we shall see a little later, ultra-violet rays are important in keeping people healthy, and in curing various diseases. For this reason, as well as for the accommodation of the physicist who wishes to study the rays in his laboratory, an artificial source is important. The ordinary carbon arc light, particularly if operated at a high voltage, perhaps 120 (which is high for an arc light), is rich in these invisible rays;



HOW THE FREQUENCY SPECTRUM IS DIVIDED

The spectrum of radiation, from X-rays to alternating-current waves. The penetrating rays, studied by Millikan, would extend from the left end of the diagram. Naturally, this diagram is not to scale, for if it were, and the short visible part a foot in length, the entire scale would be many millions of miles long even larger quantities result if we substitute rods of iron for the carbons. When the iron arc is used in laboratories, it is necessary to protect the eyes from its light. Many a physicist making experiments with the iron arc has got as nice a case of sunburn as if he had been at the seashore.

Other metals can be used instead of iron and even more copious quantities of ultra-violet light result, for example, if the electrodes are of silicon. In this case the visible light is reduced nearly to a minimum, and the output of the lamp is almost entirely invisible light. But mercury, or quicksilver, is most commonly used, particularly in the form of the mercury vapor lamp, where an electric discharge is made in an atmosphere of the vapor of mercury instead of air.

As mercury vapor is a gas, it is necessary to completely enclose such a lamp in a transparent tube. Glass, of course, is often used, and the glass-tube mercury vapor lamp is a common light source in photographic and movie studios, as well as in many factories, because it is a very efficient illuminating device. The incandescent gas mantle takes the equivalent of about nine watts of electric power to produce one candle power, the tungsten filament electric lamp about a watt, and the ordinary arc lamp about nine-tenths of a watt; but the glass tube mercury vapor lamp produces the same amount of light with about two-thirds of a watt. Of course the purple color of the light, and the lack of red rays, gives the skin a ghastly pallor, but the light is not harmful to the eyes and is said to be pleasant to work under after one gets used to it.

Such a light doesn't give off much ultra-violet radiation, because these rays are absorbed by glass, but by making the tube of quartz, large amounts of ultra-violet radiation are emitted, and then the lamp gives one candle power for every quarter of a watt. This is the most convenient source of the rays, and is the one now most generally used in laboratories and hospitals. Such lamps are often used for sterilizing water and various food products as the action of ultra-violet light is fatal to many germs. A common use is in swimming pools, for the same water can be filtered and purified by passing it and re-passing it through apparatus which exposes it to ultra-violet rays. The water in a pool so equipped can really be kept purer than if it were emptied and refilled daily.

ULTRA-VIOLET RAYS IN PHOTOGRAPHY

BECAUSE the ultra-violet rays are so short they have an important application in photography of minute objects through the microscope. In modern optical factories it is possible to make lenses for microscopes which will theoretically magnify almost without limit. Actually, such lenses are limited, because a structure must be as large as a wave of light is long in order to reflect it.

If you toss a tennis ball against a wall it bounces back, but if you throw it against a spider web it passes right through. This is because the mass of the wall compared with the ball is very great, but that of the spider web is very small. The case is somewhat analogous to light. The object that reflects it must compare favorably in size with the length of one of the waves.

Since the waves of ultra-violet light are shorter than those of visible light, structures that are too small to be seen under the microscope with ordinary illumination may be seen, or rather photographed, in the ultra-violet ray. It was with a method such as this that the English biologist, Gye, with the assistance of the expert microscopist, J. E. Barnard, was able to make photographs through the microscope of the germs which caused cancer in chickens, and which were beyond the limits of the ordinary microscopic methods. In metallurgical laboratories, ultra-violet microscopic apparatus is used in photographing steel and other metals. As glass stops most of the ultra-violet rays, such a microscope must use lenses made of quartz.

Since ultra-violet light may be used so advantageously in photomicrography, a natural idea is that of using X-rays, the waves of which are much shorter than the ultra-violet. If X rays could be used, structures could be photographed a thousand times smaller than with the visual rays, instead of, perhaps, half the size, as with the ultra-violet. But though X-rays can be deflected through crystals, they can't be focussed, like light, by means of a lens; so X-ray photomicrography is one of the yet unsolved riddles that are so numerous in science.

One of the most important uses of ultra-violet light is its effect on the body. We hear a great deal nowadays about vitamins, those mysterious substances in food about which so little is known, but that are so necessary if we are to keep healthy. One of these vitamins prevents a disease which in some localities is very common among children, namely, rickets. Few people realize just how common this ailment is, but Dr. Alfred Hess, a prominent New York specialist on children's diseases, has estimated that seventy-five per cent. of the children in New York City have at one time or another had at least a mild case of rickets.

However, though there are not many diseases for which the medical profession knows any practically sure-fire remedies, rickets is one of them, for it may be cured with either cod liver oil, which is rich in the anti-rachitic vitamin, or with treatment by ultra-violet light.

The ways of the vitamins, like the "heathen Chinee," are peculiar. But rickets is a disease of the bones, due to lack of salts of calcium, especially calcium phosphate, and the action of the anti-rachitic vitamin seems to be to hasten the deposition of calcium. Cod liver oil normally contains the vitamin, and so it can be used as a cure. Other oils, like cotton-seed oil, or foods such as milk or flour, do not ordinarily contain it, but if they are exposed to ultra-violet light the vitamin seems to be formed, for then the anti-rachitic powers are bestowed on them.

Then also, by exposing the child afflicted to the disease to the beneficial rays of the sun, or of the quartz tube mercury vapor lamp, the calcium deposition is also hastened and the disease relieved. Since egg shells consist largely of calcium, exposure of chickens to ultra-violet light hastens egg laying in the same way that it prevents or cures rickets in children. Such eggs also have anti-rachitic powers, so we may expect to see "eggs from sun-kissed hens" a common article in our markets of the future!

In order that the ultra-violet rays may reach the body, it is necessary that they have an unobstructed path to the skin. Glass stops the rays, so that a sun bath indoors behind ordinary windows is of little value. Windows made of quartz, which can now be fused and made into a variety of shapes, including large windows, will let the rays through. Several kinds of glass have recently appeared on the market which are much less expensive than quartz, but still let the beneficial rays through in large quantity. Ordinary clothing also is opaque to the rays, so that at a sanitarium such as that of Dr. Rollier, in Switzerland, the patients, both children and older people, spend most of their time outdoors with a minimum of clothing. However, the so-called "artificial silk" or rayon, which is so much used, for hosiery and other articles of apparel, is partly transparent to the rays. We can conform with all the standards of modesty, and still get the ultra-violet rays.

Unlike X-rays, ultra-violet rays are not very penetrating. They do not go very deep into the body, but reach only the outer skin, and it has been a puzzle how they have their effect on the bones. Doctor Hess has suggested an explanation which fits in pretty well with the observed facts.

There is a substance known to the chemists as cholesterol, which is found in practically every living animal, especially the skin and brain, a similar substance, phytosterol, being found in plants. Doctor Hess has found that when cholesterol is placed under ultra-violet rays, it achieves the power of preventing rickets, so he believes that this same process takes place in the skin when exposed to ultra-violet light. The radiated cholesterol is then carried by the blood to other parts of the body. To confirm this idea, Doctor Hess took pieces of animals' skins and fed them to rats, as their main article of diet. When the skin had been exposed to ultra-violet rays, the rats remained healthy but another group that were fed with skin that had not been radiated soon developed rickets.

So another step has been made in understanding how these rays work on the body. Beginning over two centuries ago with Newton, continuing with Ritter's discovery of the rays, our knowledge of them has gradually advanced. Though their medical uses are important, they are not the only applications, and the physicist constantly makes use of them. Just what part these rays play in the daily life of the physicist we shall see in a subsequent article.

The March of Radio
News and Interpretation of Current Radio Events

Radio Needs No Yearly Models

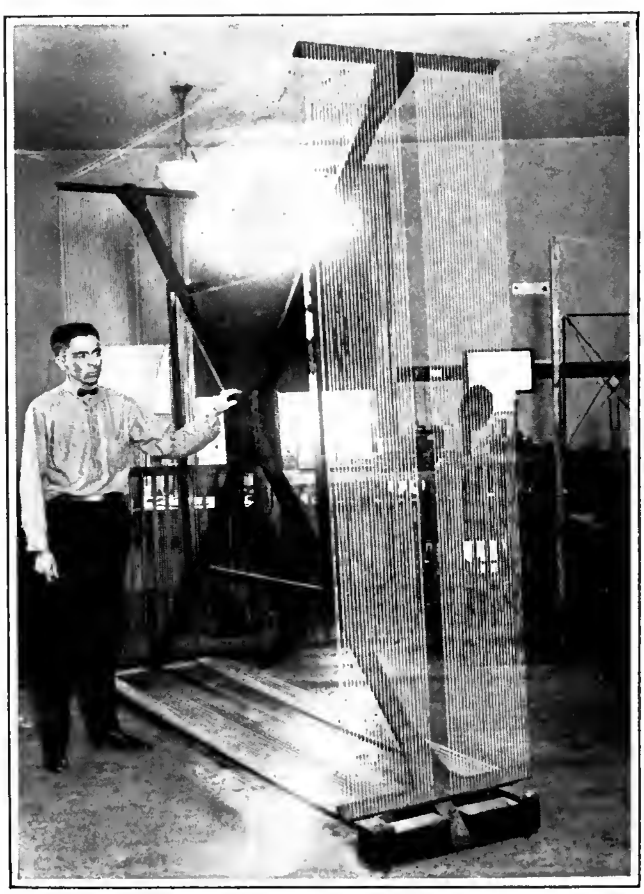
THE success of the June Chicago Trade Show establishes that function as an annual custom. It gives the manufacturers opportunity to introduce their wares to the trade so that, when the Radio World's Fair in New York and the other fall shows take place, distribution of the new models will be an accomplished fact. The 1927 Trade Show was marked principally by advances in the alternating-current tube sets, deriving their A, B, and C potentials direct from the power mains. Last season might have been styled single-control year; this season marks the beginning of a general market for the a.c. set.

We do feel, however, that the yearly model business cannot long continue to be an advantage to the radio industry. One of the best ways to establish the summer slump as a permanent institution is to promise new and revolutionary changes each fall. Naturally, the public will stop buying about January 1 to await the year's developments. Yearly models are justified if, each year, advances are made of such significance that all the products of the preceding years are justifiably obsolete and the public adopts the custom of scrapping their radio sets every year or two. But the radio ship is approaching a more even keel. Refinement is already replacing revolution in improvement. The purchase of a radio receiver is becoming a four- or five-, and perhaps even a ten-year investment. Consequently, it is of advantage, both to the owner and the manufacturer, to work toward constant refinement and improvement, embodying developments in production as soon as they are perfected rather than annually disrupting the market by "yearly models."

It took the automobile industry twenty years to learn the fallacy of the yearly model plan and we hope that the radio industry will be quick to perceive the hazards and pitfalls of that system. Let us put a stop to the yearly model plan lest it bring us that millstone of the automobile industry—the used model business. A radio receiver does not seriously depreciate in use and hence a used receiver business, the inevitable by-product of the yearly model plan, is of advantage neither to the dealer nor to the set owner.

Will Telephotography Be the Experimenters' Next Field?

A PHOTOGRAPH received by radio in your own home! That is a reward worth working for! We have been watching the efforts of many experimenters in telephotography, hoping to bring a new and alluring field of activity to the home constructor. Essentially, the spirit of the set builder is that of the conqueror who faces and overcomes mechanical and electrical difficulties. When broadcasting first began, the man who built his own receiver was regarded as a sort of wizard among his friends. And indeed, considering the difficulties under which he then labored, he was worthy of that title.

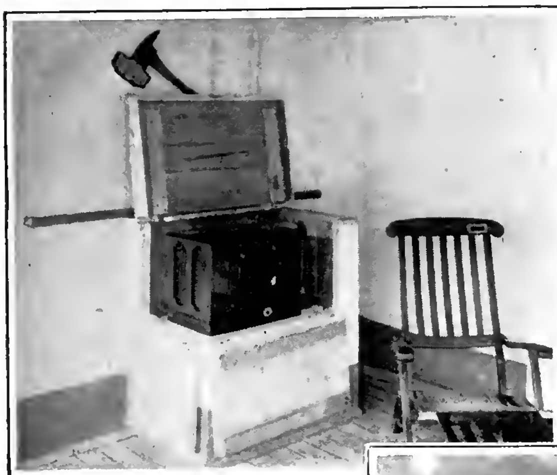


LOOPS THEY USE IN WASHINGTON
Morris S. Strock of the Bureau of Standards radio laboratory with one of the large coil antennas used in experimental work at the Bureau. This coil is employed in receiving long-wave European radio telegraph stations

But set building has lost a little of its glamour. It is still, by a wide margin, the most satisfying hobby for one with a flair for electrical experiment. At first, it had, as an additional incentive, the fact that the home-built set was much better and cheaper than anything that could be bought on the market. Competition and technical development, however, have brought such great improvements in the manufactured set, both from the standpoint of price and performance, that the home constructor finds his economic advantage and his pride of achievement both measurably diminished. He must content himself with the fascination of building as his return for the time and money he puts into set making.

And now comes telephotography! Will it be the experimenter's next hobby? It offers a pride of accomplishment which will again make the home constructor a genius among his fellows. And, as for economy, it is impossible to buy telephotographic apparatus; hence, only the home constructor can now possess a telephoto receiver.

In other pages of this issue, we discuss a system of phototelegraphy which seems, from the home constructor's standpoint, to be the most promising development in telephotography. It does not enable the experimenter to secure *perfect* pictures, but it has the great and outstanding advantage of simplicity and low cost. When we are satisfied—and from every indication, it is a matter of weeks



and months rather than years—that the apparatus will give the experimenter a pleasing and satisfactory field in which to exercise his ingenuity and to secure results commensurate with the effort and expense involved, we will describe the new apparatus with full constructional details. From present estimates, the cost of a complete set of parts will be in the neighborhood of seventy-five or a hundred dollars. No special transmitting apparatus will be required to put photographs on the air because the picture is embodied in an audio-signal which modulates the carrier, as do the speech currents of the studio microphone. Consequently, the only equipment needed by broadcasting stations to put pictures on the air, is a phonograph and a phonograph record of a picture transmission.

RADIO ABOARD PACIFIC LINERS

The Panama-Pacific Line, has installed long- and short-wave broadcast receivers with power loud speakers located at various points on the ship. The view at the upper left shows one of the 104 loud speakers on deck and the other view shows a public room in which is an electric radio-phonograph — part of the entertainment system

Our editorial in June regarding the relation of the set constructor to the set buyer, has aroused a great deal of comment, both from home constructors and from leaders in the industry. Many of our readers have written us in approval of the statement that the parts manufacturer must offer new fields to conquer for the set constructor—new designs and new ideas. We believe the trend is toward new fields and toward improved and economically justifiable combinations of parts for broadcast receiver building. The latter will always interest the home builder, but telephotography, short- and long-wave radio, laboratory experiments and measurements, and ingenious methods of installation, will command ever increasing attention.

A Prosperous Radio Year Forecast

THE fourteen thousand radio manufacturers and dealers who attended the Trade Show were uniformly optimistic. The radio receiver has emerged from a puny complexity to a magnificent simplicity. That large element of the general public which has been awaiting the perfection of radio and the elimination of all maintenance problems has at last been provided with the receiving set which it desires. High quality of reproduction, tuning reduced to the manipulation of a single calibrated control, and maintenance troubles virtually eliminated, have made radio attractive to millions who, in the past, felt faint at the thought of a hydrometer. That terror of the housewife, three dials which must be turned in the correct ratio to bring in a station, is a bugaboo of the past.

Prosperity to the radio industry and a vastly increased number of listeners mean not only an aggressive and prosperous industry but, much more than that, the establishment of broadcasting in a healthy and wholesome condition. When the ether is cleared so that every station on the air can be received clearly and without interference, throughout its service range, and the number of listeners doubles and triples, the increased income of broadcasting stations will justify tremendously improved programs. Consequently, every owner of a receiving set profits as the art advances. Broadcasting will enjoy a re-awakening of such proportions that any home without a radio will soon be regarded as an object of sympathy and commiseration.

Discovering Ore Deposits By Radio

ALTHOUGH many devices have been announced, alleged to discover the presence of metallic ore under the ground by magnetic or electromagnetic means, until quite recently very little practical use has been made of them. When ground currents of radio frequency are transmitted from one point to another, the strength of the received impulse is dependent upon the power of the transmitter, the sensitivity of the receiver, the distance, and the conductivity of the soil. The presence of metallic ores exhibits itself by an unusually strong signal for the transmitting power and distance involved. However, no means has yet been developed for identifying the kind of metal involved so that the principal value of such observations has been rather the elimination of unpromising ground than the identification

BEAM SERVICE FROM ENGLAND TO AUSTRALIA IS OPEN

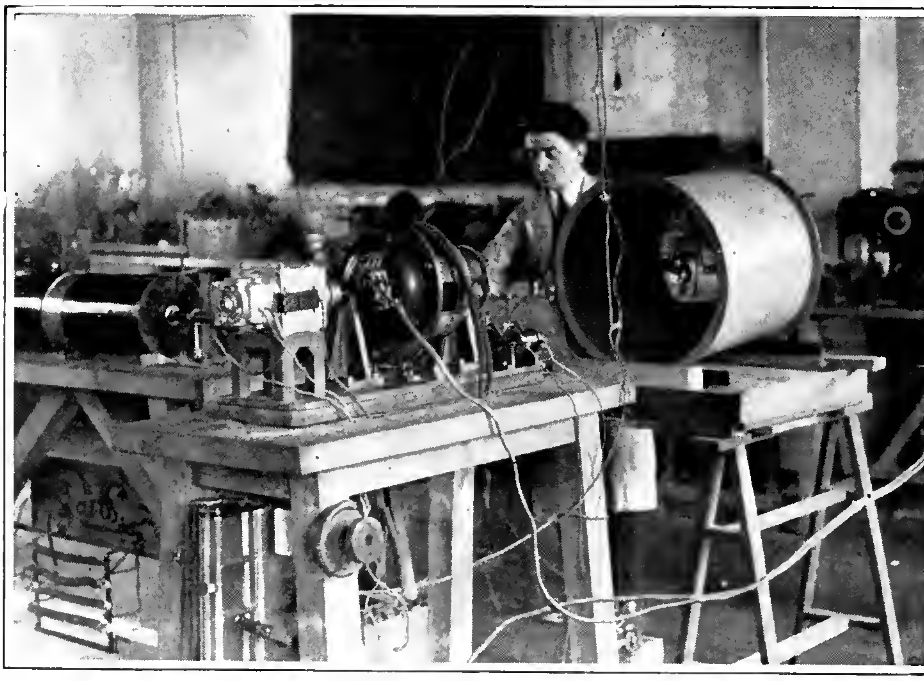
After long tests, the Marconi short-wave beam transmitter has been turned over to the British Post Office. Reliable two-way communication at the rate of 200 words per minute has been established for some time. The antenna system shown is so arranged, that, according to the time of day, the beam signals are sent to Australia either by the eastward route (left of illustration), or the antenna at the right is used in which case the signals are sent to Australia in the direction of America. Beam service between England and Canada has been in operation since October, 1926, and announcement of the New York-London beam service is expected shortly. Engineers of the Radio Corporation and the British Marconi Company are understood to be at work with tests and developmental work now of valuable mineral ores. Recent experiments with portable seismographs, however, have been used with some success in locating salt domes and oil domes in the Southwest. A charge of dynamite is set off and the different sound vibrations are recorded by the seismograph. The relative rate of sound transmission has been used in locating ore bodies.

Sulphide ore bodies are good conductors of electricity and hence act like antennas. The radio waves set up in these subterranean antennas create an oscillating current of electricity. These re-radiated waves, however, are so feeble they cannot easily be detected.

In prospecting, a specially designed transmitter is set up in the immediate neighborhood to be prospected. A wavelength is used which will most easily penetrate the earth. The ore body receives strong radio waves from the near-by transmitting station and therefore re-radiates a fairly strong wave. The latter is picked up by a loop receiving outfit stationed close by.

The loop receiver is capable of being rotated around a horizontal and a vertical axis. Telephone receivers are connected with the apparatus and, as the loop is rotated, the position of maximum and minimum sound in the telephone receivers is determined and the instrument readings are recorded. The direction and location of the ore body can then be computed from these readings.

In practical prospecting, when there is an indication of an underground conductor, such as an ore body, and it is desired to make the information as definite as possible, a large number of readings are taken at intervals of twenty-five to fifty feet across the suspected axis of the ore body, and for a distance along the axis as far as it is desired to investigate. These readings are then correlated on paper and cross sections made. The location of the ore body shows up quite plainly on such cross sections.



SOME OF THE BELIN TELEVISION APPARATUS

The Belin system of television is not radically dissimilar from other systems. In this illustration, a beam of light is reflected from the arc lamp at the left, reflected by a pair of oscillating mirrors, one to send the beam in a horizontal motion, the other for vertical motion. The mirrors (behind the dynamo and the large cogged wheel) throw the beam across the image to be transmitted and on to a photo-electric cell in the large cylinder. These varying light impulses then operate a transmitter

Broadcasters in New York Organize

WE HAD the pleasure of attending one of the early meetings of the New York Broadcast Owners' Association and observing the altruistic attitude of some of the small protesting broadcasters. It was announced in the press that thirty-three New York stations had combined to offer a united protest to the Federal Radio Commission because they had been compelled to split time and to go on the higher frequencies. The meeting was called to organize these thirty-three into a powerful association to present a united protest. Seventeen, as we recall it, attended and, of these, only seven agreed on roll call to protest. Some of these first insisted upon a promise that the constitutionality of the Radio Act would not be questioned but that the committee would confine itself to attempting to seek a better frequency and less division of time for the stations involved. We understand that, after the meeting, one or two additional stations joined.

When we read of the glorious speeches made before the Commission as to the service rendered the public by these stations, it was interesting to recall that the owners had to say regarding their service to the public at their own little meeting. Not once was the matter of serving the public mentioned. The only thing that they whined about was that they could not hope to make as much money out of advertisers if they could not broadcast whenever they pleased. Apparently, the lack of audience has not discouraged these stations, possibly because their sales representatives have succeeded in inducing advertisers to use their facilities in spite of a well nigh non-existent audience. And, when we say advertisers, we do not mean goodwill broadcasters, but broadcasters of the direct advertising which is characteristic of this sort of station.

IN THE CAPTAIN'S SUITE ABOARD THE "LEVIATHAN"

Captain Herbert Hartley uses his own radio receiver in his moments of leisure from his duties. European and American stations are heard with ease at all times during the transatlantic passage. The receiver is displayed among autographed photographs of President Coolidge, General Pershing, Secretary of the Navy Wilbur, and Sir Thomas Lipton

Judge Davis Resigns

JUDGE STEPHEN B. DAVIS announced his resignation from the Department of Commerce after four years of praiseworthy service as administrative supervisor of the Bureau of Navigation, Bureau of Fisheries, Steamboat Inspection Service, Patent Office, and Coast and Geodetic Survey. His service to the Department of Commerce will, however, be most widely remembered by the public for his direction of broadcasting matters. Judge Davis' new book, *The Law of Radio Communication*, recently published, is the only volume on the subject available and discusses the legal phases of radio control with complete competence and thoroughness.

Where Are the Listener Organizations?

ONE of our readers, Mr. R. L. Hitchcock of Detroit, Michigan, suggests that RADIO BROADCAST start an association of listeners among its readers and offers also to pay annual dues of one or two dollars. We had hoped that our recent editorial on this subject would bring out some strength in existing listener organizations but, aside from a few letters from indignant executive secretaries immediately following it, there have been no signs of activity. Considering that, at the moment, the very foundations of broadcasting are threatened by the effort of a few inferior pirate stations to set aside the Radio Act, certainly, if the listener organizations had the slightest voice or influence, there should be some manifestation of activity at this time. While we are pleased at this suggestion as expression of confidence on the part of our readers, we would certainly rather see an independent outside organization formed. Only if the demand were insistent and widespread, would we consider any such task. Why do not some of the existing organizations get busy? We would be glad to help any meritorious listener group to the best of our ability.

The Month In Radio

UNPOPULAR BROADCASTING STATIONS

THE Federal Radio Commission has been haled into court and application for an injunction to set aside its powers has been made. At present the action is pending. We are very doubtful that an injunction will be granted but, if it ever is, the result will be nothing less than a catastrophe to the radio industry. It will interest the protesting stations that 11.2 per cent. of the listeners who responded to our questionnaire, which appeared in the May issue, demanded the elimination of WJAZ because it started the radio chaos last season by tieing up the regulatory power. Seven times as many listeners demanded its elimination as considered it a favorite local or out-of-town station.

"If the report is true," writes one of these in a letter accompanying his questionnaire, "that WJAZ has been assigned a desirable wavelength, then the radio public has been not only insulted, but outraged, as this is the station that brought us the whole mess of trouble and should be made to take the leavings, if any."

This is the tenor of many written complaints which we have received, which indicate the permanent unpopularity which accrues to any station or organization which destroys the public's radio entertainment. If any other station again succeeds with a similar move, it will incur the violent hatred of the radio audience, regardless of any noise about martyrdom which it may make. Station WJAZ was not the most unpopular station in the United States, KFNF being the winner of our unpopularity contest. One hundred and four out of each 500 answering our questionnaire demanded the elimination of that station. This is almost 100 per cent. of those within its range. Actually one listener in 500 called KFNF a sixth local favorite and three named it as an out of town favorite. The public knows what stations it likes to listen to, even if the broadcasters and their commercial sponsors do not.

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DR. LOUIS COHEN

Washington, D. C.

Consulting Radio Engineer. A special statement prepared for RADIO BROADCAST:

"Standardization may be very desirable from an economic and commercial standpoint, but if the standardization process sets in prematurely it may be a serious handicap to the further growth and development of an art. The radio broadcasting art illustrates this. We have come to regard the broadcast frequency band, 500 to 1500 kc., as being more or less fixed, and all broadcasting is confined to channels within this band of frequencies. The extension of the frequency range to, say, 2000 kc., which would greatly increase the number of channels for broadcasting, is being opposed on the ground that the receivers have been standardized to cover only the present limited range, which was done at a time when it was considered very difficult to design a commercial receiver suitable for the higher frequencies. Engineering development, however, has since progressed to a point where it is entirely feasible to build a receiver suitable for the higher frequencies as well as the lower frequencies, but because of the standardization which has set in altogether too early in the art, we are reluctant to take advantage of the new developments which would benefit the entire art."

HAZELTINE PATENTS SUSTAINED

FEDERAL JUDGE GROVER N. MOSKOWITZ handed down a decision recently in the Hazeltine-Grebe suit, favorable to the former. The defense was based largely on the grounds that prior inventions displaced those of Professor Hazeltine and that his original patent, filed shortly after he had left the employ of the Navy in radio work, contained a clause permitting the general use of his invention. An accounting of the profits received by the defendant during the period of the alleged infringement was ordered.

R. C. A. VS. HAZELTINE PATENTS

A DECISION favorable to the Radio Corporation of America, which sued the Twentieth Century Corporation for selling radio receivers in violation of the Hartley and Rice patents, was handed down in the Circuit Court of Appeals, to which it had been brought from a district court. This decision is of the utmost importance and should be studied closely by every manufacturer in the field. It establishes the relation of the R. C. A. patents to those held by the neutrodyne group. As we understand it, the patent establishes the basic nature of Hartley and Rice's work in preventing the generation of oscillatory currents through neutralization methods and that the Hazeltine inventions are, in effect, a practical and improved method of utilizing the Rice and Hartley inventions. Since the Hazeltine method of neutralization is a simple and effective one, we would not be surprised if many manufacturers find it desirable to secure licenses under both the R. C. A. patents and the Hazeltine patents. License under the R. C. A. patents does not necessarily imply, under this decision, freedom from suit for infringement under the Hazeltine patents.

The patent situation is too complex to be accurately summed up briefly. It is clear, however, that stability in the radio industry would be fostered if it were made convenient for set manufacturers to obtain blanket licenses at a sufficiently low rate to permit them to utilize all the necessary inventions in the field. If Hazeltine licenses are valuable, and it appears under the recent decision that they are, some form of combination license ought to be worked out. Manufacturers ought to be free to develop the radio art, designing, building, and selling better receiving sets, rather than squandering time in conferences with patent lawyers.

NEW R. C. A. LICENSEES

ADDITIONAL licensees under the R. C. A. patents are the powerful Crosley Radio Corporation, the Splitdorf Company, the F. A. D. Andrea Company, the Charles Freshman Company, and the Freed Eisemann Company. By the time this appears in print, there will be many others. The Crosley contract is said to provide for a seven and a half per cent. royalty and the statement is made that more than half a million dollars has already been paid to the R. C. A. by the Crosley Corporation and an additional three quarters of a million by other concerns.

SAN SALVADOR boasts of a broadcasting station, installed in its national theater, with the call letters AQN. It broadcasts three evenings a week on 482 meters, 625 kilocycles

UNFINISHED BUSINESS FOR RADIO

IN HIS address before the Radio Manufacturers' Association, assembled at the Chicago Trade Show, Federal Radio Commissioner Orestes H. Caldwell pointed out that, in six years of broadcasting, the radio industry had succeeded in placing radio equipment in but one fourth of the twenty-two million homes of the United States. Considering that there are eighteen million pleasure automobiles, sixteen million wired homes, sixteen million telephones, and eleven million phonographs, the radio industry has a lot of unfinished business ahead of it. The 1927–1928 season will see a marked change in the ratio of radio to non-radio homes.

SHORT-WAVE TELEPHONES FOR FREIGHT TRAINS

THE General Electric Company recently demonstrated its short-wave radio telephone equipment designed for use on long freight trains for communication between engineer and conductor. Although the train was a mile and a quarter long, not the slightest unreliability was observed, the signals being loud and clear under all conditions. Up to this time, it has been necessary for the conductor to use the emergency brake to stop the train or to rely on whistles or flare lights which often fail because of bends in the tracks or poor weather conditions.

WE HAVE before us the souvenir booklet sent by the National Carbon Company to those who write in comment on its Eveready Hour programs. It is a twenty-page booklet, neatly bound, and nicely printed, with an absorbing intimate story of the famous people and the regular artists with Eveready Hour. The character of printed matter sent out by the important commercial broadcasters is of suficient merit and deserves wider circulation than it now enjoys. Listeners who have not tried the experiment of commenting on the better programs have a pleasant surprise in store for them.

CONGRESSMAN EMMANUEL CELLER, who is very expert in getting large publicity out of small matters, again calls attention to the abuses of radio censorship. Some of the cases cited by him in a story in the New York Sunday *World* are such outrages as the refusal of KOA to broadcast an inflammatory address by De Valera, a pacifist address by Mrs. Mary H. Ford, an address by a Smith College professor, criticising the policy of the Government in its Near East diplomacy, and various similar matters. When one considers what proportion of audiences of millions are interested in the opinions of the persons named, no serious injustices have been done. Since there is a limit to the time which can be devoted by the larger stations to expressions of private opinions, this so-called censorship must be exercised. Stations have been moderately intelligent in their discriminations and the attempt to make this a burning question, considering the insignificance of the cases cited, is either a publicity stunt or a marked failure to appreciate how liberal the broadcasting stations have been with their facilities.

LISTENERS all over the country report a marked improvement in receiving conditions as a result of the allocations made effective June 15. Many individual cases of interference are noted and the Commission is doing its best to adjust them by shifting station assignments. But until there is a radical reduction in the number of stations, or time splitting is more widely practiced, the ether will never be entirely cleared. The Radio Commission has done extraordinarily well with its problem. Had any one predicted at the Washington hearings last spring, that it would eliminate practically no stations, there would have been few ready to say that the Commission could effect any material improvement in broadcasting conditions. That it has done so, under the conditions, shows that the President appointed a committee of ingenious and hardworking men who have taken upon themselves the most difficult method of solving a well nigh impossible problem.

SENATOR EDWARDS of New Jersey has formulated a verbose protest about the Federal Radio Commission's treatment of station WAAT, which a few listeners in its immediate vicinity may be familiar with. The Commission, fortunately, has turned a deaf ear to strictly political pressure and has based its ratings of stations upon expressions of broadcast listeners. Under the circumstances, WAAT has not fared badly. RADIO BROADCAST readers, in their 452 listings of favorite local New York stations, give five votes to WAAT, approximately one per cent.

DR. L. W. AUSTIN, physicist of the Radio Transmission Research Laboratory of the United States Bureau of Standards, was awarded the 1927 medal of honor by the Institute of Radio Engineers. This is the highest recognition which the radio engineering fraternity can offer its fellows.

THE Ninth Radio District, with Chicago as its headquarters, boasts of 233 active broadcasting stations out of a grand total of 694 now on the air. This is approximately 34 per cent. of the stations. Chicago may pride itself on being the noisiest place on earth.

THE French inter-colonial radio service has been extended to equatorial Africa by the opening of a radio telegraph station at Brazzaville. The system consists of a station at Banako, West Africa; Tananarivo, Madagascar; Saigon, Indo-China; Bijbouti, Somaliland; and the new station in western Africa. Owners of long-wave receivers now have some new marks to shoot for.

FAILURE to obtain a receiving license in Greece, as required by the Director of Greek Telegraphs, Telephones and Posts, may result in twelve months' imprisonment and a fine of 100,000 drachmas. Licenses are somewhat less expensive.

THE meeting of the stockholders of the Marconi Wireless Telegraph Company, held in London recently, was a stormy scene, well attended by hundreds of stockholders. The company has undergone a drastic financial reorganization, including such measures as a reduction of nearly 46½ per cent. in its total outstanding stock. These courageous steps, coupled with the economy and extensions of short-wave beam telegraphy, may quite conceivably make future stockholders' meetings much happier affairs.

FIELD strength measurements made in the Eighth Radio District by Radio Supervisor S. W. Edwards have revealed the now oft-confirmed fact that location is of as great importance as antenna power in determining the service area of a broadcasting station. The most serious factor which prevents equal radiation in all directions from a radio antenna is the shadow effect of large surrounding masses of both conducting and non-conducting materials. As the cost of transmitting installations goes up, portable transmitters will be used to determine the characteristics of any transmitting point before a station is erected. It appears that irregularities in transmission characteristics, due to location, can be analyzed with a portable low-power transmitter and that great increase of power does not change the general nature of shading effects. It is not unusual to find that a broadcasting station of considerable power may serve only fifty or seventy-five miles in one direction, but is easily heard four or five hundred in another.

A TELEPHOTOGRAPHIC radio line (erroneously called television transmission by wireless in the Department of Commerce's Trade Commissioner's report) has been placed in operation between Vienna and Berlin, the time required for transmission being only twenty seconds, considerably faster than any commercial system we know of on this side of the Atlantic.

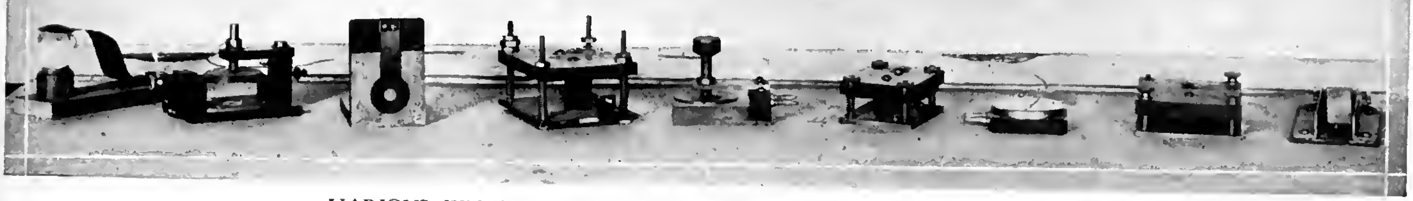
THE Hydrographic Office of the Navy Department, in collaboration with various other branches of the Navy, has announced further results in their study of weather forecasting methods, based on observation of the strength and direction of static through loop receivers. The study has indicated that the use of new devices which have been developed, to measure static intensity in standard units, will make it possible to plot the highs and lows of static in the same way that we now plot barometric pressures. Static intensity is said to bear a definite relation to barometric pressure, thus offering a valuable aid to reliable weather forecasting.

THE Bakelite Corporation of New York has succeeded in inducing the Tariff Commission to recommend to the President that the importation of certain forms of synthetic, phenolic resin be no longer permitted. Apparently this material made it impossible for the complainants to exercise their rights under certain of their patents, because the material could be used in violation thereof without difficulty.

COMMERCIAL beam wireless service between Great Britain and Australia was recently begun at rates lower than the existing cable rates.

PRESIDENT COOLIDGE has appointed the personnel of the United States delegation to the International Radio Telegraph Conference, to be held in Washington during October. This body, in spite of its name, which was adopted before radio telephony had been invented, will discuss broadcasting problems. The members of the American delegation are Herbert Hoover, Secretary of Commerce; Senator James E. Watson of Indiana; Senator Ellison D. Smith of South Carolina; Representative Wallace H. White, Jr., of Lewiston, Maine.; William R. Castle, Jr., Assistant Secretary of State; Alternate, William R. Vallance, Assistant Solicitor of the Department of State; Maj. Gen. Charles M. Saltzman, Chief Signal Officer, U. S. A.; Capt. Thomas T. Craven, Director of Naval Communications, U. S. N.; W. D. Terrell, Chief of Radio Division, Department of Commerce; Owen D. Young, Chairman of the Board of Directors, General Electric Company; Alternate, Samuel Reber, Colonel, U. S. A., retired; John J. Carty, Chief Engineer, American Telephone and Telegraph Company; Stephen Davis, former Solicitor, Department of Commerce; John Beaver White, Electrical Engineer, and John Hays Hammond, Jr.

Piezo-Electric Crystals



VARIOUS KINDS OF MOUNTINGS FOR PIEZO-ELECTRIC CRYSTALS
The mounting at the extreme left holds a spherical crystal

A Simple Explanation of the Theory Involved in Quartz Crystal Applications—Their Use for Precision Calibration of Wavemeters

By M. THORNTON DOW

CONSIDERING the very large number of radio sets in use to-day, it is not surprising that there exists a national irritation over the uninvited and exasperating whistlings which intrude at many inopportune moments during otherwise enjoyable radio programs. Though the whistling has been dignified by the descriptive term "heterodyning," under any name it must be universally unpopular.

Very often, however, the phenomenon of heterodyning is a most useful one to scientists and in the laboratory. For instance, the information obtainable by this means makes it possible to find with precision the number of times per second piezo-electric crystals oscillate when excited electrically. Among the crystals illustrated in an article entitled "Piezo-Electric Crystals" in RADIO BROADCAST for January, 1927, was one which vibrates at the strikingly high rate of 6,000,000 times per second. It is quite usual for interested persons to ask the question: "How do you know that the crystal oscillates with a frequency of 6,000,000 times per second?" A truthful but uninstructive answer is: "The whistles tell us." How these whistles are made to divulge these secrets of the crystal is somewhat briefly described in what follows.

As pointed out in the previous article, a single quartz crystal, or some other piezo-electric crystal, can be used with a vacuum-tube circuit to act as an oscillator giving any one of two or three (or more) principal frequencies which hold remarkably constant; and when an oscillator, either an electric or crystal-electric one, is operating at some one principal frequency, called the fundamental, there are usually simultaneously available in effect numerous other frequencies which are whole number multiples of the fundamental. These other frequencies are often spoken of as "the harmonics" but in order to specify them clearly it is best to assign to each frequency a number which, if multiplied by the frequency of the fundamental, gives the frequency of the harmonic. On this basis the fundamental is harmonic number one; twice the fundamental frequency is harmonic number two; and so on. If, then, the fundamental, the predominant frequency of the oscillations, is known, the simple multiplication by a whole number gives the frequency of any chosen harmonic. In the case of a crystal oscillator it is easy to see that, since the fundamental frequency is very nearly constant, all the harmonic frequencies are likewise just as constant.

WITHIN A CRYSTAL OSCILLATOR
When compared with the wiring of many radio sets this looks simple indeed

With these facts in mind, we can rightly inquire what they have to do with the whistling notes originating at times in radio circuits. A familiar fact is that whistling notes, called beat notes, are heard in any oscillating tube circuit whenever its frequency (a harmonic or fundamental) differs by an audible amount (that is, within the range of audible frequencies) from some fundamental or harmonic frequency of another oscillating tube circuit which is near enough to the first for the requisite transfer of energy. Although each tube itself may be producing oscillations which are inaudible, yet the interaction between the two circuits results in a beat note which may be adjusted to an audible frequency.

To illustrate the facts noted, we may consider a crystal-controlled circuit giving a fundamental inaudible frequency of 100,000 cycles per second set up, as in the diagrams of Fig. 1, in the vicinity of an oscillator having variable frequency. In a telephone receiver in one of the plate circuits we should hear a beat note of 1000 oscillations per second when the variable oscillator had been adjusted to give 101,000 cycles per second. Thus, the frequency difference between the two inaudible frequencies was made audible, in the form of a beat note.

By further adjusting the variable oscillator toward 100,000 cycles per second the beat note can be decreased in frequency until it is so low as to become inaudible, under which conditions we may be certain that the variable frequency is within, say, 50 cycles or less of 100,000 cycles per second. To decrease the variable frequency further, to 99,000 cycles per second, would again

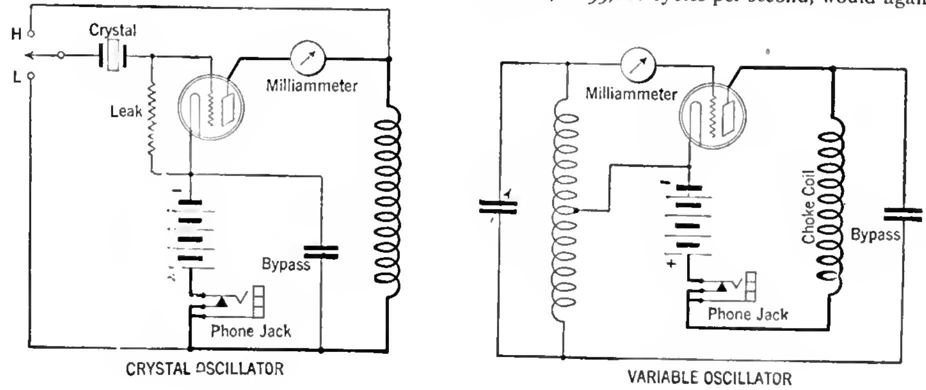


FIG. 1

bring in a beat note of 1000 cycles per second. The width of the region of inaudible (subaudible) beats just passed through is determined by the limitations of the human ear and of the apparatus used. In most cases a beat note below about 50 cycles per second would not be heard. In practice it is posible to approximate closely to *zero beat* (that condition existing when the two notes are of exactly equal frequency and no beat note is heard) by setting the dial at the middle of the silent region which is confined, often narrowly, between the two regions of clearly audible beats whose frequencies decrease as the inaudible band is approached from either side. Examine Fig. 2.

If the occasion demands, it is possible to actually make the *zero beat* frequency audibly evident by employing a third oscillator to give an auxiliary constant audible beat note whose intensity varies except when the variable frequency oscillator gives zero beat with the first oscillator.

All that has been said above regarding frequencies is true of every frequency, whether fundamental or harmonic, having the requisite amount of energy; when we hear a beat note, therefore, we are not at once certain which pair of frequencies from the two harmonic systems of the oscillators is producing the beats. We can be certain, however, that the audible beat frequency is the difference in frequency between some harmonic of one oscillator and some harmonic of the other oscillator, and, by methods described in part farther on, we can determine the respective harmonic numbers in question. The important thing to remember is that the audible beat note is used to indicate a very definite relation between frequencies which in themselves may be far above the range which is audible.

These indicators bridge the gap between such frequencies as fall above a few thousand cycles per second, which by any stretch of the imagination could not be measured by simple mechanical means, and those frequencies in the few hundred cycles per second class which are readily measured by mechanical-photographic means. An adaptation of the familiar telephone receiver, for example, makes it possible to photograph oscillations of a few hundred, or say for instance, a thousand cycles per second. It is a familiar fact that the metal diaphragm just back of the hole in the ear piece of the telephone receiver can be made to vibrate audibly at this frequency. If the vibratory motion of the diaphragm were made to operate a small mirror suitably, a spot of light reflected from the mirror would be deflected with a vibratory motion. A photographic record could be made by the spot of light, simultaneously with a similar record from the motion of the pendulum of an accurately regulated clock, upon a moving photographic film. The resulting print would look like the illustration of Fig. 3. The time represented by the distance between any two lines made by the swinging pendulum could be read from the clock. The number

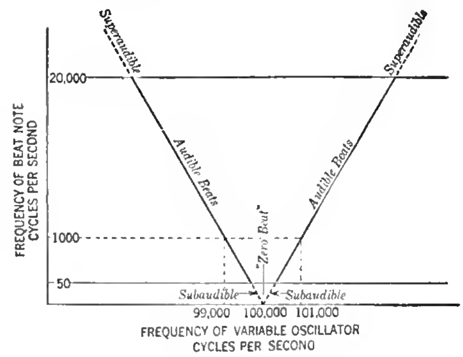


FIG. 2

of oscillations of the mirror within the boundaries set by any two time-lines can be counted, just as the number of box-cars between the locomotive and caboose of a long freight train can be counted. The number of oscillations per second can then be computed from the information so obtained.

CALIBRATING CRYSTALS

TO PUT the facts outlined in the preceding paragraphs to work to tell us the frequency of piezo-electric or other electric oscillating circuits, a series of oscillators are set up as suggested

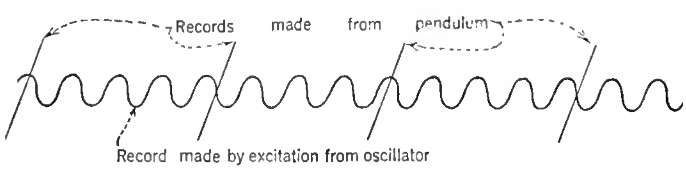


FIG. 3

by Fig. 4. Suppose that "A" is the crystal oscillator which we had suspected of giving oscillations of frequency in the neighborhood of 6,000,000 cycles per second. "D" is a variable low-frequency oscillator which can be photographically calibrated as above described. "B" and "C" are two other variable oscillators. The fundamental frequency of "B" may be adjusted until its harmonic number 10 gives zero beat with the fundamental of "A"; harmonic 20 of oscillator "C" may be similarly set against the fundamental of "B"; harmonic 30 of oscillator "D" may be set to equal the fundamental of "C." Under these conditions we now know that the fundamental frequency of "A" is 10 x 20 x 30 = 6000 times the fundamental frequency of "D." If a photograph of "D" shows its frequency to be 1019.8 cycles per second it is safe to believe that the frequency of A is 6000 x 1019.8=6,118,800 cycles per second, which would certainly justify the nickname "six-million cycle crystal." Thus we can measure extremely high frequencies by first measuring in an electro-mechanical way a much lower frequency which has some simple and definite relation, as indicated by beat notes, to the very high frequency.

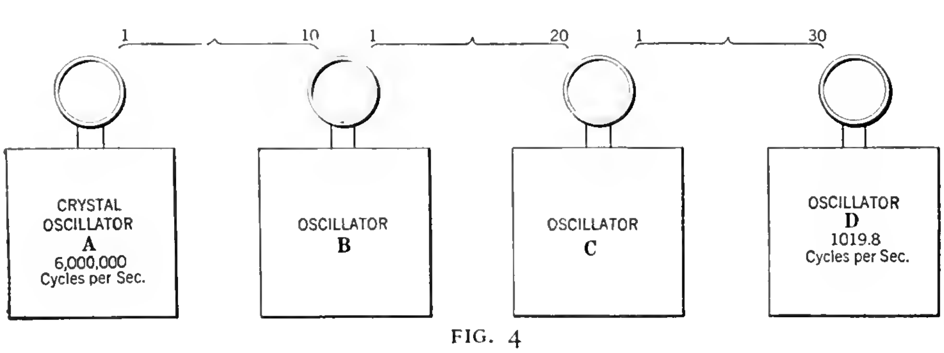


FIG. 4

For an instructive and very interesting article which describes unusual results of some recent experiments of Professor Wood of Johns Hopkins University with piezo-electric crystals, readers would do well to read "A New Magic," by Frank Thone, in the *Century Magazine*, for February, 1927. A scientific report on methods of using the piezo-electric crystal for precision wavemeter calibration was published in 1923 by Prof. G. W. Pierce of Harvard University in the *Proceedings of the American Academy of Arts and Sciences*. Since that time frequency meters covering the range from more than 150 million cycles per second down to audible frequencies have been built and crystal-calibrated at Cruft Laboratory, Harvard. Another paper by Professor Pierce on the measurement of the velocity of sound at high frequencies, published in October, 1925, by the American Academy of Arts and Sciences, includes a detailed description of some of the methods noted here for calibrating crystals and for using them in precision work.

When once a crystal has in the above manner been calibrated it is a standard against which other instruments for measuring frequency may be checked by methods much simpler in procedure but which in many instances again make use of the whistle of beat notes. Other crystals, by chance or by careful cutting, giving beats with the standard, may be precisely calibrated in short order. The case, however, of precision wavemeter calibrations against a standard crystal is typical of what may be done with, and represents one of the earlier laboratory uses for, the piezo-electric crystal; methods for such work developed in the university laboratory a few years ago have now become common and are regarded as standard practice.

CALIBRATING WAVEMETERS

A WAVEMETER is essentially an instrument for measuring frequency and therefore may better be called a frequency meter. Consisting merely of a coil connected to a condenser, the latter usually variable, a wavemeter gives a marked response at each setting of the condenser to a particular frequency. The response takes the form of a very rapid increase in the current circulating in the wavemeter when the condenser setting is adjusted toward a value at which the wavemeter is in tune to the frequency of the oscillator inducing the current. The evidence of the response may be given by a current meter built into the wavemeter, by a meter in a circuit of the oscillator to which the wavemeter is being tuned, or by other means.

Although for many wavemeters calculation will give the approximate range of frequency, or wavelength, covered by the scale of the instrument, only an experimental comparison against frequencies already known can give a dependable calibration. The frequencies for comparison may be determined by using another wavemeter which has already been standardized, but in any case the frequencies must at one time or another have been measured by some such methods as described for the case of the crystal. Because the frequency of the piezo-electric oscillator depends almost wholly upon the physical dimensions of the crystal, it is especially well adapted for meeting the requirements of a standard of frequency. So, ultimately, if our needs demand frequent measurement of frequency with high accuracy we shall find it necessary to calibrate a wavemeter against a piezo-electric crystal. The wavemeter is the instrument of greater utility in radio work in general, while the crystal is the more highly dependable as a standard of frequency. In this particular connection then, what is usually needed is not an original determination of unknown frequencies but, rather, the *corrections* applicable to frequencies already known approximately. The fact that corrections to a calibration, which through frequent use has come to be held somewhat in doubt, are about to be carried out, greatly simplifies the experimental procedure and is justified as an illustrative case because it is so common in practice.

The procedure may be most briefly indicated by recollecting two facts before mentioned: A variable electric oscillator can be adjusted to give subaudible, or zero, beat note when in proximity to a piezo-electric crystal oscillator; a wavemeter (having the required range) can be adjusted to respond to the fundamental frequency of the electric oscillator. Thus, through the intermediary of the variable oscillator, the wavemeter calibration can be compared against the crystal frequencies. Suppose that there are 40 harmonics developed in the crystal circuits and 40 harmonics also developed in the variable oscillator circuits, then there are 40 x 40 = 1600 different settings of the variable oscillator which will give subaudible, or zero, beat notes, since each harmonic of the latter may in turn be adjusted by beats to equal in frequency each one of the 40 harmonics of the crystal oscillator. There is, therefore, the possibility of obtaining 1600 different settings on the scale of the wavemeter, each setting representing a definite frequency related to the fundamental standardized frequency of the crystal. There may be more than, or less than, 40 harmonics available from each circuit; for any given case there usually are more than enough for a satisfactory calibration.

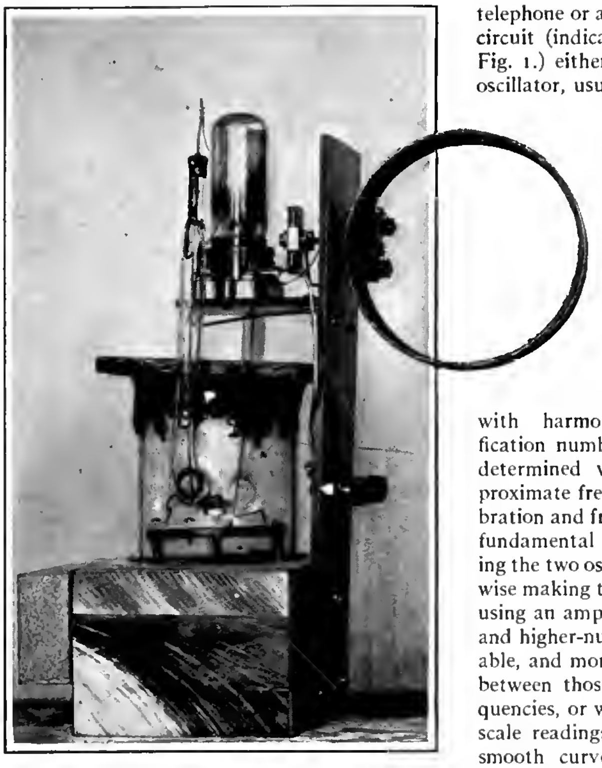
And now, in deciding upon which pair of harmonics is in each case fixing the setting, we utilize to the fullest extent the old calibration of the wavemeter which we are correcting. We note, furthermore, whether at each setting the beat note obtained is strong, medium, or weak in intensity, for as a general rule the smaller the number specifying the harmonic involved the more intense is the beat note response, and this information aids in identifying the harmonics. To illustrate we shall assume that a standard crystal fundamental frequency is 100,000 cycles per second and that for a setting of a frequency meter, when tuned to an oscillator which had been set against the crystal by the beat method, the older calibration reads 134,670 cycles; this reading is presumably in error by some small amount, since it is taken from the previous calibration now being corrected. The question is, "what is the *correct* reading?" In the course of the experimental work we had noted that by comparison with beats obtained on the average this beat note had been among the louder ones. This leads us to suspect that the harmonic numbers associated with the case were rather small. Proceeding blindly we might calculate that:

$$101 \times 100{,}000 = 75 \times 134{,}667 \text{ (Very nearly)}$$

which indicates that if the variable oscillator fundamental were 134,667 cycles per second then its 75th harmonic equalled in frequency the 101st harmonic of the crystal. But when we note

$$4 \times 100{,}000 = 3 \times 133{,}333 \text{ (Very nearly)}$$

we can feel safer in believing that the auxiliary oscillator stood not at 134,670 cycles per second as indicated on the doubted calibration of the frequency meter, but at 133,333 cycles since, in this case, harmonics 3 and 4 would have been used as against harmonics 75 and 101 in the other computation; this recognizes the spirit of our memorandum which showed that the beat note was among the louder ones observed. The old calibration was, then, at this point, in error by 1340 cycles in a total of 133,333, an error of nearly one per cent., which past experience, we will say, has shown to be not unreasonable.



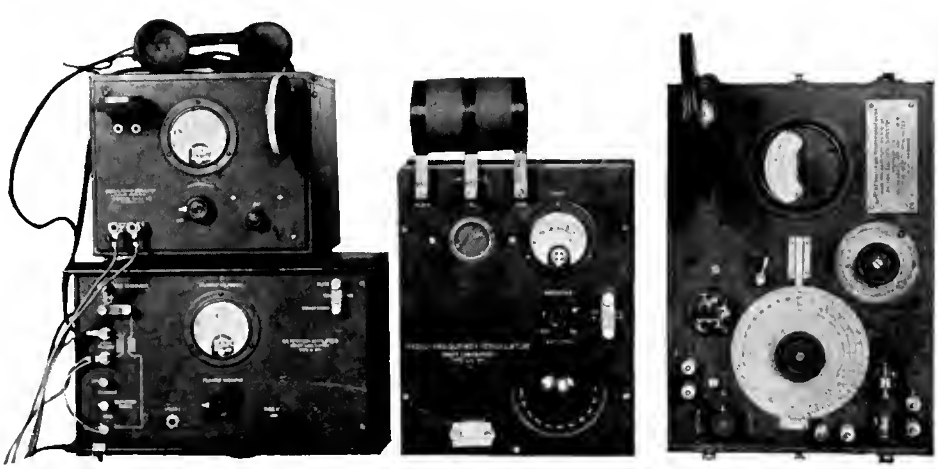
A PRECISION CRYSTAL OSCILLATOR

This instrument is being used at Cruft Laboratory, Harvard, and is making possible some very accurate measurements

Having looked at an illustrative example of an isolated calibration point let us get a better view of actual experimental procedure, tie in a few odds and ends of useful information, and thus better understand how the process of calibrating a wavemeter against a piezo-electric crystal may be methodically carried out with a minimum of difficulty from doubtful points which arise for the novice, and even for the expert, at times.

A photograph on this page was taken in a college laboratory. It shows a typical arrangement of apparatus for students' use in the calibration of a wavemeter by means of a crystal. A crystal is chosen which gives as one of its *fundamental* frequencies a frequency not too near the range covered by the wavemeter; the telephone or amplifier is connected into the plate circuit (indicated as possible in the diagram of Fig. 1.) either of the crystal or of the auxiliary oscillator, usually but not necessarily in the circuit having the lower fundamental. To begin with, settings of the variable oscillator giving only loud beat notes are chosen throughout the range of the wavemeter; to suppress the weaker responses the distance between the crystal oscillator and the variable oscillator is, for the time being, reasonably increased, or the coils of the two oscillators may be oriented to give the same result. Since these loud responses are surely associated with harmonics having the lower identification numbers, the correct frequency can be determined without ambiguity from the approximate frequency taken from the earlier calibration and from calculation based on the known fundamental frequency of the crystal. By placing the two oscillators closer together or by otherwise making the coupling closer and, possibly, by using an amplifier to the telephones, the weaker and higher-numbered harmonics are made available, and more data are taken to fill in the gaps between those at first recorded. When the frequencies, or wavelengths, are plotted against the scale readings of the wavemeter, some orderly smooth curve should result. Points much in error become evident at once and the correct assignment of harmonic numbers for these points is now easily made.

A little experience soon dispels the bewilderment which the novice usually feels at the beginning. It soon teaches him the difference between the lively well-behaved whistle of the beat notes which hold the key to all the data of the experiment, and the liquid transitory chirps which speak of the crystal's willingness to oscillate in other ways but which are useful only under other circumstances. He learns that to place the variable oscillator too near the crystal oscillator, or the wavemeter too near the variable, causes undue reactions in the circuits, evidenced by their meters, and is, so far as practicable, to be avoided. A lesson or two makes it an easy matter to pick out many harmonics as individualities, their characteristics of mark being tied up with their intensity and breadth of audible band. A harmonic of small index, in addition to its marked intensity, results in a more leisurely "running of the scale" when the beat note is tuned-in and out by the dial of the auxiliary oscillator.



A TYPICAL SET-UP

Apparatus in a students' laboratory for calibrating a wavemeter by means of a crystal. On the left is the crystal oscillator, on top of the amplifier cabinet. In the center of the photograph is the auxilliary oscillator. The wavemeter to be calibrated stands at the right

Home-Constructing Transformers and Chokes for Power-Supply Devices

How the Number of Turns, Dimension of Core, Gauge of Wire, Etc., May Be Determined Without Resorting to Complicated Mathematical Calculations

By HOMER S. DAVIS

WITH steady improvements being made in the perfection of socket power-supply devices, there is hardly any doubt that they will eventually be even more widely used than at present. The building of these power devices offers an interesting field to the home constructor, resulting in a demand not only for data on the complete assemblies, but also for information about the actual design and construction of the individual units in these devices. In this article, dealing with power transformers and iron-core choke coils, the mathematical complexities of design are reduced to simple arithmetic by means of the calculation charts, and practical information is at the same time offered about the more common methods of construction.

The power transformer is an alternating-current device for changing electric power at one voltage to electric power at another voltage. It consists of two coils of wire wound upon a magnetic core. The winding which receives electric power from the source is called the primary winding, and the winding which delivers electric power to the load is called the secondary winding, the function of the core being to transmit the electric energy from the primary to the secondary, through the medium of magnetic energy. The voltage available at the secondary terminals depends upon the ratio of turns in the two windings. That is to say, if the secondary has, for instance, twice as many turns as the primary, the secondary voltage will be twice as great as that impressed upon the primary; conversely, if the secondary has half as many turns as the primary, its voltage will be only half as great. If the transformer serves to increase the voltage, it is called a step-up transformer; if to decrease the voltage, a step-down transformer.

A small part of the power put into the transformer is used up in overcoming the losses. The copper losses are due to the resistance of the windings, and may be reduced by choosing wire of reasonably ample size. Other losses are due to hysteresis and eddy currents in the core, and may be reduced by the proper choice of flux density, and by using a laminated core of sheets of silicon steel. The power consumed in overcoming these losses is dissipated in the form of heat, so that when the transformer is put under load, the core and windings will slowly warm up to some steady value above room temperature. Although it is possible to design transformers to operate at comparatively cool temperatures, a certain amount of heating is permissible, and transformers that run warmer can be built somewhat cheaper and made more compact. The temperature rise, however, should not be so great as to damage the insulation.

When the transformer is put under full load the voltage across the secondary terminals will drop a small amount. This is what is referred to as voltage regulation, and is expressed by the percentage of ratio of the ratio of this drop in voltage to the original, or no-load, voltage. Good regulation in a transformer is desirable, and depends upon the resistance of the windings and the leakage of magnetic energy between them. The magnetic leakage may be reduced by arranging the transformer as compactly as possible with the winding adjacent and close to the core, by keeping the path around the core as short as possible, and by making good neat joints in the core. As will be shown later, it is possible to use either a large core with relatively few turns of wire, or a small core with many turns. For good regulation, the larger core with fewer turns is preferable.

In general there are two types of transformers, differing chiefly in the arrangement of their cores. One is known as the shell type, the other, the core type; both are shown in Fig. 1. The core type is the simpler of the two to construct, and is the one considered in this article.

Turning now to the design, the fundamental formula for the transformer is:

$$E = 4.44 \frac{BANF}{10^8} \qquad (1)$$

where E is the supply voltage, B the flux density in lines per square inch of core area, A the net area of a cross section through one leg of the core, N the number of turns in the primary winding, and F the frequency of the supply voltage. To avoid the labor of solving formulas such as this, the calculation charts accompanying this article have been prepared, the above formula being represented by Chart III. Flux density is the measure of magnetic energy used in the core to link the primary and secondary coils. Its magnitude depends upon the material used in the core, and for the silicon sheet steel commonly used it is taken as 60,000 lines per square inch. This value was used in the right hand scale, Chart III.

Information as to the supply voltage and frequency may be obtained from the local electric light company. With these values known, and the flux density assumed, it can be seen from formula (1) that it is possible to use either a large core with few turns, or a small core with many turns. To establish a working ratio, the number of turns may be figured from the following formula, corresponding to Chart II:

$$\text{Turns per volt} = \frac{C}{\sqrt{\text{Watts Output}}} \qquad (2)$$

where C is a constant, the value of which may be so chosen as to give any desired proportion between core and copper. The number of turns in any coil is then the product of the turns per volt and the voltage of that coil. In order to obtain better regulation, and also because wire, especially in the smaller sizes, is much more expensive than core material, the transformer with a larger core and fewer turns is preferable. A value of 35 for C will give a good ratio from the home constructor's standpoint and has been used in Chart II. If for any reason the reader wishes to use a different ratio, the new value of turns per volt must be figured from formula (2) and then employed in Chart II to find the total turns in each winding. The larger the value of C used, the greater the ratio of copper to iron, and vice versa.

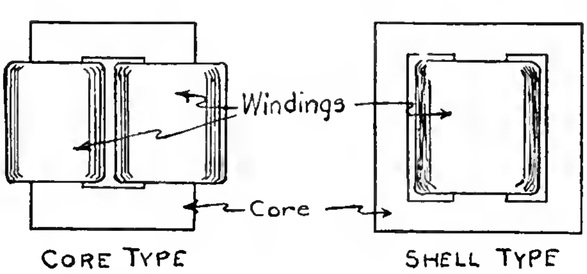


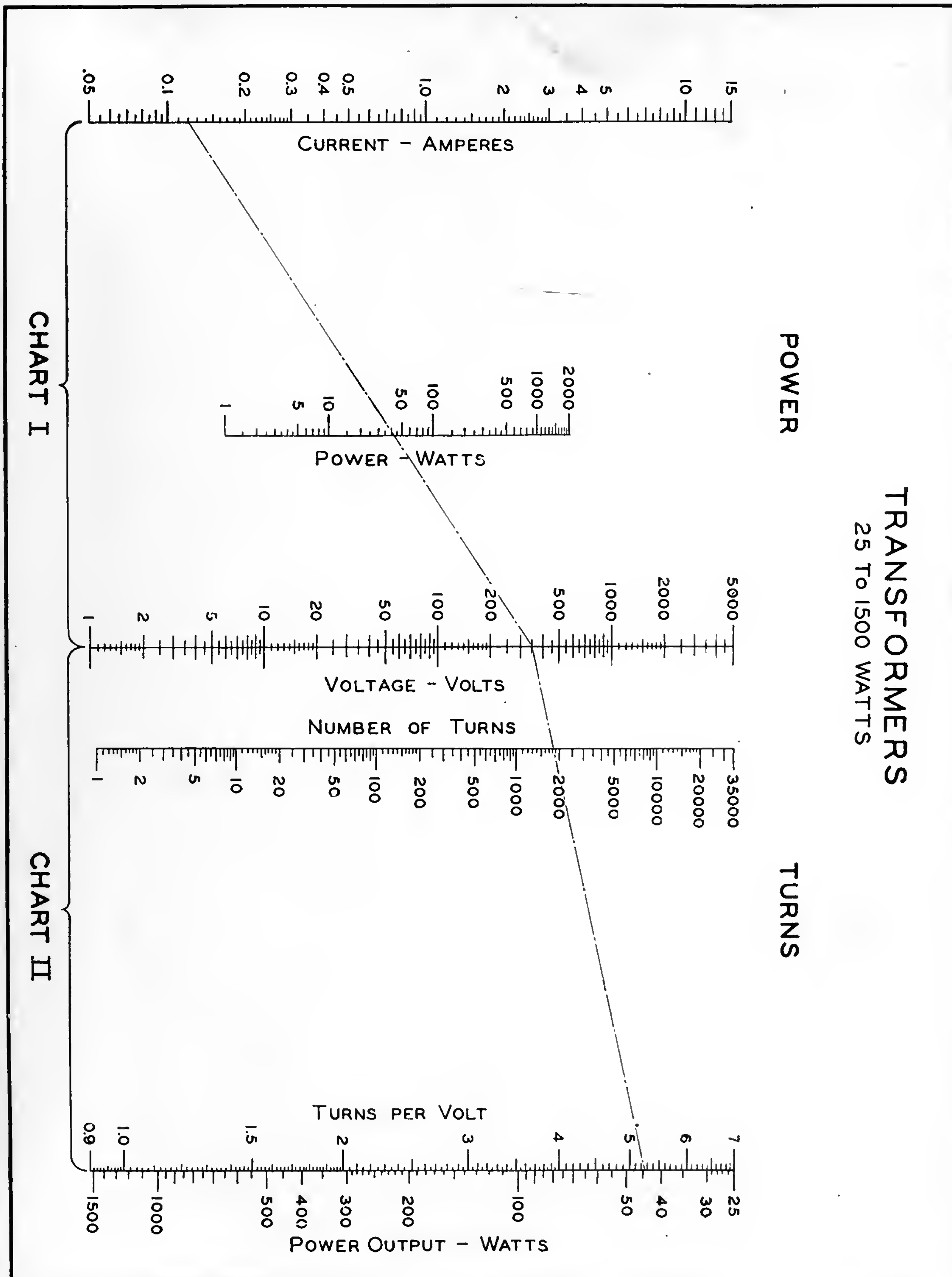
FIG. 1

PROCEDURE IN TRANSFORMER DESIGN

BEFORE taking up the solution of a typical example, it is advisable to have in mind a general idea of the proper procedure to follow. The first step is to ascertain the output rating, or secondary voltage and current, as required by the apparatus to which the transformer is connected. Then the power output in watts is the product of the voltage and the current in amperes, and may for convenience be obtained from Chart I. If there is more than one secondary winding, the total output, of course, is the sum of them all. The number of secondary turns to give the required voltage may be figured by multiplying the turns per volt, from formula (2) by the secondary voltage, or it may be obtained from Chart II. About five per cent. more turns should actually be used on the secondary, to compensate the voltage drop under full load due to losses and regulation. The number of turns required for the primary winding is then found from Chart II in the same manner.

The next thing to be determined is the size of the core. The cross section area may be obtained from formula (1) or from Chart III. The net area is usually assumed to be about 90 per cent. of the gross area, to allow for oxide coating or other insulation between the core laminations. The use of a square core is advisable, to facilitate the winding of the coils as well as the general construction.

The subsequent step is to choose a size of wire for each winding large enough to carry the current without objectionable heating. It is customary in figuring wire sizes to use a unit of area called the circular mil, which is the area of a wire one thousandth of an inch in diameter. For steady loads, (continuous over a period of hours), 1500 circular mils of area should be provided for each ampere of current; if the load is intermittent (in use over short periods of time), this may be reduced to 1000 circular mils per ampere. The current-carrying capacities of the different sizes of wire have been set down


TRANSFORMERS
25 TO 1500 WATTS
POWER
TURNS
CHART I
CHART II
CURRENT - AMPERES
.05
0.1
0.2
0.3
0.4
0.5
1.0
2
3
4
5
10
15
POWER - WATTS
1
5
10
50
100
500
1000
2000
VOLTAGE - VOLTS
1
2
5
10
20
50
100
200
500
1000
2000
5000
NUMBER OF TURNS
1
2
5
10
20
50
100
200
500
1000
2000
5000
10000
20000
35000
TURNS PER VOLT
0.9
1.0
1.5
2
3
4
5
6
7
POWER OUTPUT - WATTS
1500
1000
500
400
300
200
100
50
40
30
25

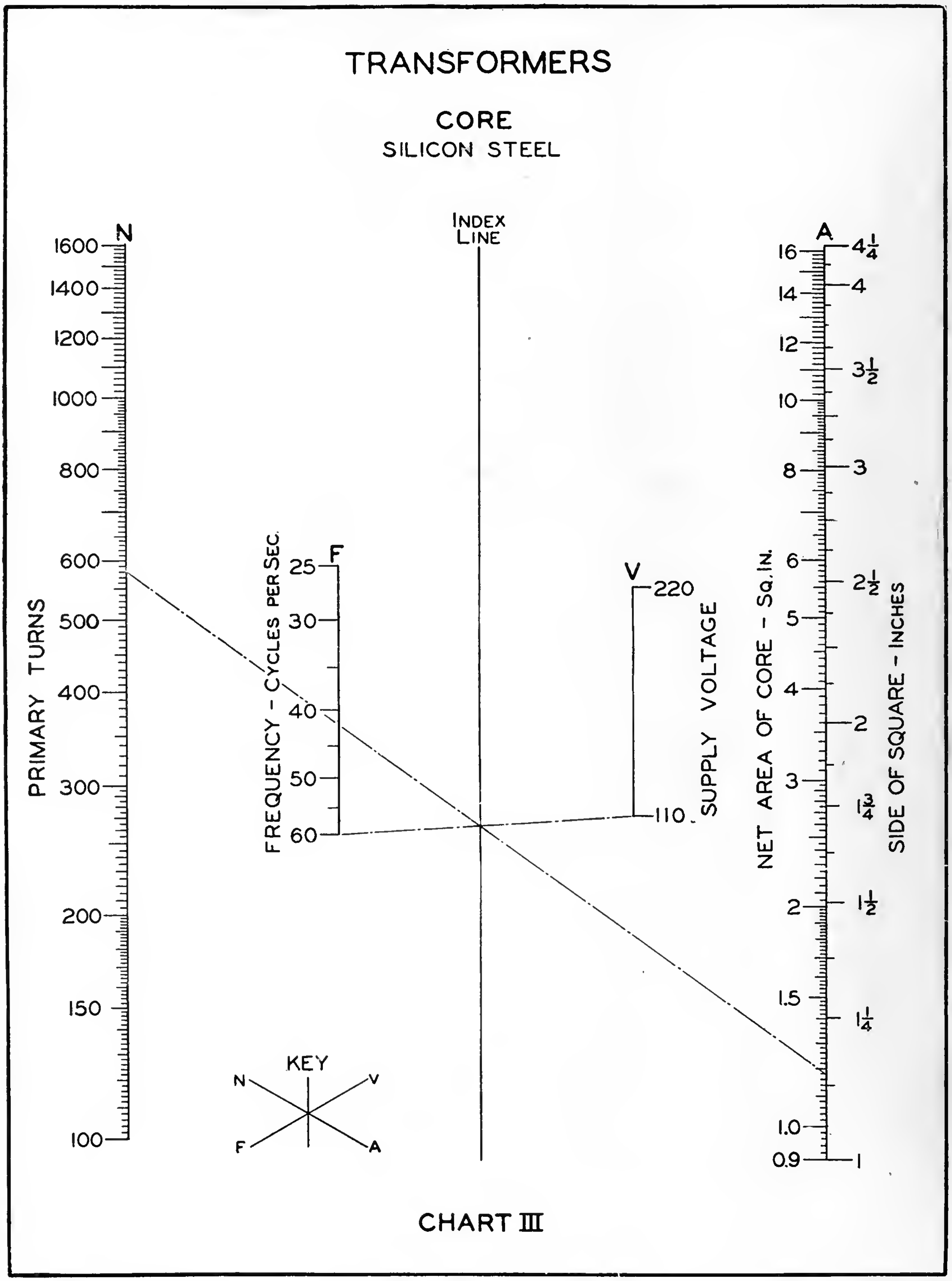

TRANSFORMERS
CORE
SILICON STEEL
INDEX LINE
N
PRIMARY TURNS
1600
1400
1200
1000
800
600
500
400
300
200
150
100
F
FREQUENCY - CYCLES PER SEC.
25
30
40
50
60
V
SUPPLY VOLTAGE
220
110
A
NET AREA OF CORE - Sq. In.
16
14
12
10
8
6
5
4
3
2
1.5
1.0
0.9
SIDE OF SQUARE - INCHES
4¼
4
3½
3
2½
2
1¾
1½
1¼
1
KEY
N
V
F
A

CHART III

in the copper wire table accompanying this article. The secondary current having been previously determined, the correct size of wire may be found by referring to the second or third column of this table. The primary current may be obtained from the primary, or input, power, which exceeds the output power by an amount sufficient to overcome the transformer losses. The percentage ratio of output to input is the measure of efficiency of the transformer. Home constructed transformers of about 1500 watts rating may be as high as 95 per cent. efficient, decreasing to about 90 per cent. at 100 watts, and then probably dropping to about 80 per cent. at 50 watts, or even lower for smaller sizes. To find the primary current, therefore, first divide the power output by the probable efficiency, which gives the power input; the primary current is then equal to this input power divided by the supply voltage, or it may be found by means of Chart I. The proper size of wire for the primary may now be obtained from the table.

All that remains is to design a core of required cross section, with an opening or window in it large enough to contain the windings. This is most readily done by making a full size pencil drawing of the transformer, similar to Fig. 2. (on this page). After drawing in one leg of the transformer, choose a tentative width for the windings and from the wire table, "turns per linear inch" columns, figure how many turns per layer may be wound in the primary coil. Either double cotton-covered wire or single cotton-covered enameled wire may be used. Except in the smaller sizes, the use of plain enameled wire in transformers is not advisable, and then only is it permissible when a layer of paper is placed between each layer of wire. Enameled wire has the added disadvantage that it cannot be shellaced in place. The number of layers is then found by dividing the total number of turns by the number of turns per layer. From this the depth of the winding may be estimated, allowing for any insulating paper between layers, if used. The primary coil may now be put on the drawing, leaving at least an eighth of an inch for insulation between it and the core. The depth of the secondary winding may be found in the same manner, using the same width as the primary. In placing the secondary on the drawing, allow about a quarter of an inch between it and the primary winding, to take care of insulation and discrepancies in actual construction; or if it is planned to wind it directly over the primary on the same leg of the core, allow for about an eighth of an inch of insulation between them. Then draw in the rest of the core, allowing about a quarter of an inch clearance between it and the ends of the windings.

It can be readily seen from such a drawing whether the transformer is well proportioned from the standpoint of good voltage regulation. If it looks like either A or B in Fig 3, assume a different value for the width of the windings and try another layout. A little care and judgment here will be well repaid in final results.

The solution of a typical example will better illustrate the use of the calculation charts. Suppose a transformer to operate from a power supply of 110 volts and 60 cycles, is to be designed for use in a plate supply unit employing a Raytheon type BH rectifier. A secondary voltage of 350 is required by this tube; its capacity is 85 milliamperes of direct current, but it is safer to design the transformer to handle about 120 milliamperes (0.12 amperes) of alternating current to allow for that bypassed by the filtering system. If a power amplifier stage is to be included, a filament winding delivering 0.5 amperes at 5 volts will be required for, say, a UX-112 (CX-312) or UX-171 (CX-371) type tube.

The power output of the high-voltage winding is found from Chart I by drawing a straight line from 0.12 on the current scale to 350 on the voltage scale, which will be found to cross the middle scale at 42 watts. The power output of the low-voltage winding is similarly found to be 2.5 watts. The sum of these gives 44.5 watts as the power output of the transformer. The number of turns to put on each winding is found from Chart II. For the 350-volt winding, draw a line from 350 on the voltage scale to 44.5 on the power output scale, intersecting the third scale at 1850 turns. Five per cent. more turns should be added to take care of the voltage drop due to regulation, making 1940 turns for the 350-volt winding under full load. Since the Raytheon tube is a full-wave rectifier, two 350-volt windings, or one 700-volt winding (3880 turns) with a center tap, will be required. Using the chart in the same manner for the filament winding gives 26 turns, and adding about five per cent. makes 27 turns. Similarly, the primary will be found to require 580 turns; the allowance for regulation is not used here of course, as the voltage of the supply mains is fairly steady and independent of the transformer.

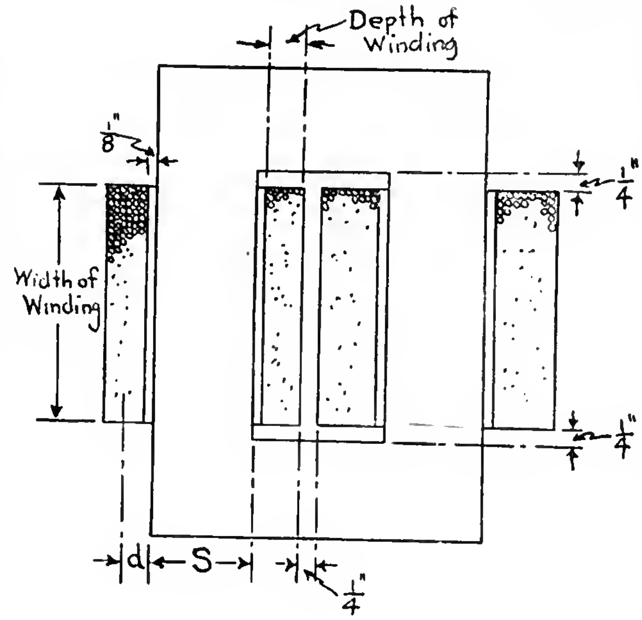


FIG. 2

With the number of turns for each winding determined, the next step is to find the size of core cross section from Chart III. The four scales of this chart are to be used as shown in the key; that is, the inner or frequency and voltage scales are always connected together, and likewise the outer two scales are always used together. With a power supply of 110 volts and 60 cyles, a line is drawn between these two points. Through the point at which this line intersects the index line, draw a second line from 580 on the primary turns scale until it meets the core area scale. This shows that a core having a net cross section area of 1.18 square inches is required; the nearest size is $1\frac{1}{8}''$ square.

In determining the size of wire for the secondary, it is noted that each 350-volt winding delivers current only half the time, and therefore a wire of half the area might be used. However, the resistance of the winding would thereby be doubled, introducing a detrimental effect upon the voltage regulation, and for this reason it would be better to compromise on a larger size. With a secondary current of 0.12 amperes, choose a size of wire to carry, say, 0.10 amperes, which, at 1500 circular mils per ampere, requires a No. 28 wire as shown by the wire table. For the filament winding delivering 0.5 amperes, No. 21 wire would be satisfactory.

Before the size of wire for the primary can be found, the primary current must be known. Assuming an efficiency of 75 per cent. for this size of transformer, the power input to the primary will be 44.5 divided by 0.75, or about 60 watts. The current is then found from Chart I by drawing a line from 110 on the voltage scale through 60 on the power scale until it meets the current scale, at 0.54 amperes. From the table, No. 21 wire is required for the primary.

The rest of the design consists in laying out the full size drawing of the transformer as described earlier. This layout being completed, it is often desirable before ordering the material, to estimate the weights of wire and core steel required.

COPPER WIRE TABLE

Size B & S	Current Capacity Amperes		Res. per 1000 Ft. Ohms	Turns per Linear Inch			Weight—Lbs. per 1000 Ft.		
	1000 C. M. per Amp.	1500 C. M. per Amp.		D. C. C.	S. C. E.	Enam.	D. C. C.	S. C. E.	Enam.
8	16.5	11.0	.628	7.1	7.3	7.7	51.2	51.2	50.6
9	13.1	8.7	.792	7.8	8.1	8.6	40.6	40.6	40.2
10	10.4	6.9	1.00	8.8	9.0	9.6	32.2	32.2	31.8
11	8.2	5.5	1.26	9.8	10	11	25.6	25.6	25.2
12	6.5	4.4	1.59	11	11	12	20.4	20.4	20.0
13	5.2	3.5	2.00	12	12	13	16.2	16.2	15.9
14	4.1	2.7	2.52	14	14	15	12.9	12.9	12.6
15	3.3	2.2	3.18	15	16	17	10.3	10.2	10.0
16	2.6	1.7	4.02	17	18	19	8.21	8.14	7.93
17	2.0	1.4	5.06	18	20	21	6.54	6.47	6.28
18	1.6	1.1	6.38	20	22	24	5.24	5.14	4.98
19	1.3	.86	8.05	22	24	27	4.22	4.09	3.96
20	1.0	.68	10.2	24	27	30	3.37	3.26	3.14
21	.80	.53	12.8	28	30	34	2.68	2.60	2.49
22	.64	.43	16.1	30	33	38	..17	2.07	1.97
23	.51	.34	20.4	33	36	42	1.73	1.66	1.56
24	.40	.27	25.7	36	40	47	1.40	1.33	1.24
25	.32	.21	32.4	38	44	53	1.13	1.06	.988
26	.25	.17	40.8	42	48	59	.914	.849	.784
27	.20	.13	51.5	45	52	66	.756	.678	.622
28	.16	.11	64.9	48	57	74	.608	.543	.494
29	.13	.084	81.8	52	62	82	.489	.433	.392
30	.10	.067	103	56	67	92	.396	.346	.310
31	.080	.053	130	60	73	103	.326	.281	.246
32	.063	.042	164	63	79	116	.270	.228	.196
33	.050	.033	207	66	86	130	.227	.185	.155
34	.040	.026	261	70	92	145	.193	.150	.123
35	.032	.021	329	73	99	164	.160	.123	.098
36	.025	.017	415	77	105	182	.136	.101	.078
37	.020	.013	523	80	113	206	.120	.084	.062
38	.016	.010	660	84	120	235	.105	.071	.049
39	.012	.008	832	90	128	261	.094	.061	039
40	.010	.007	1050	95	136	290	.084	.053	031

The weight of each size of copper wire is approximated by first finding the total length of wire in each winding. The mean or average length of a single turn may be found from Chart IV. Here the left-hand scale represents the width of the square side of the core, shown as "S" in Fig. 2, while the right-hand scale is the distance from the edge of the core out to the center layer of the winding in question, as "d" in Fig. 2. To use the chart it is necessary merely to measure these two distances on the full-size drawing of the transformer, locate each of these values on their respective scales on the chart, and draw a line between these two points; the point at which this line crosses the center scale is the average length of a turn in feet. For instance, if a 1$\frac{1}{8}$″-core has a 2000-turn winding, the center layer of which is $\frac{11}{16}$″ out from the core, a line drawn between these two figures on the chart will intersect the center scale at 0.505 feet, the average length of a turn. Multiplying this value by the total number of turns, 2000, gives 1010 feet as the length of wire in the winding. The weight of the wire may be found from one of the last three columns of the copper wire table; the length of wire in feet divided by 1000 and multiplied by the weight per thousand feet gives the total weight.

The weight of the core is obtained by subtracting the area of the window in square inches from the gross area of the core as it appears on the drawing, multiplying by the depth, and then multiplying this result by the factor 0.28, which gives the weight in pounds. For example, suppose a 1″ core measures 3″ by 4″ along its outside edges. The window will then measure 1″ by 2″, with an area of 2 square inches. Subtracting this from the gross area of 12 square inches leaves 10 square inches of net area. Multiplying this by the depth, 1″, gives 10 cubic inches as the volume of the core. The volume multiplied by 0.28 gives 2.8 pounds as the weight of the core. If the number of laminations is desired, it may be calculated by dividing the depth of the core by the thickness of a single sheet, which is usually 0.014 inches. The shape to cut the laminations will be discussed later.

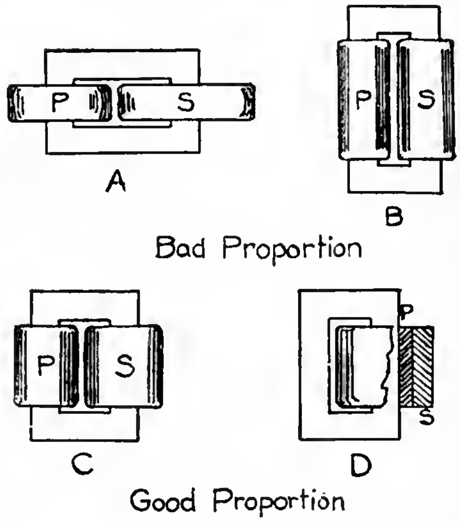


FIG. 3

As a final operation it may be desirable to check the resistance of each winding to make sure it is not excessive. Knowing the length of wire and looking up the resistance per thousand feet in the wire table, the total resistance is a matter of simple arithmetic. The voltage drop under full load due to resistance (exclusive of flux leakage, etc.) is then the product of the resistance and the current.

Summarizing, the general procedure to follow in designing a transformer may be outlined as follows:

(1.) Characteristics of secondary windings, *i. e.*, voltage, current and power.
(2.) Total number of turns in each winding.
(3.) Size of core cross section.
(4.) Wire sizes.
(5.) Physical dimensions from full-size drawing.
(6). Amounts of wire and core material.

The next and final article will take up the actual construction of the transformers, and the fundamentals of choke coil design will also be discussed in detail.

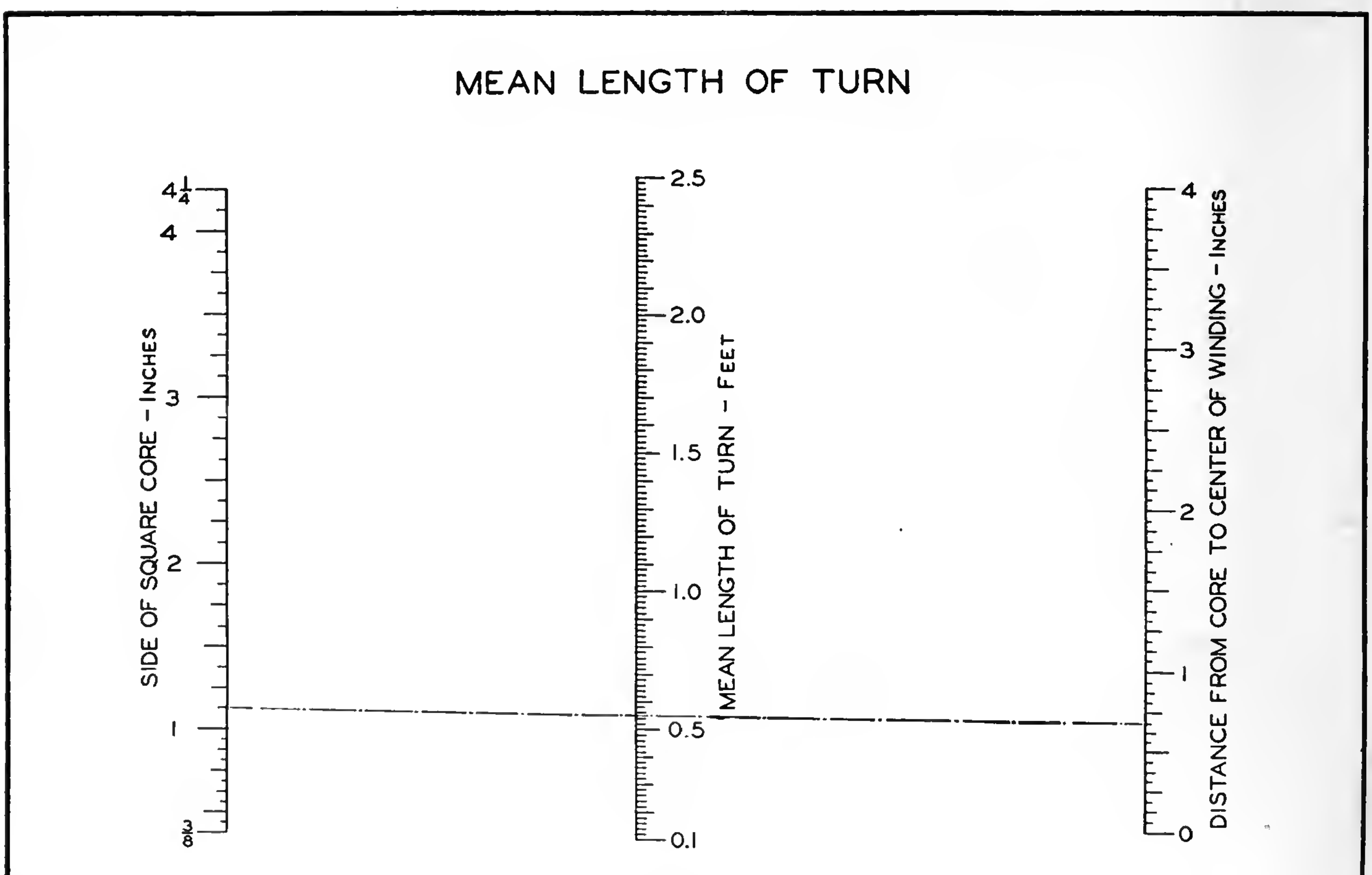
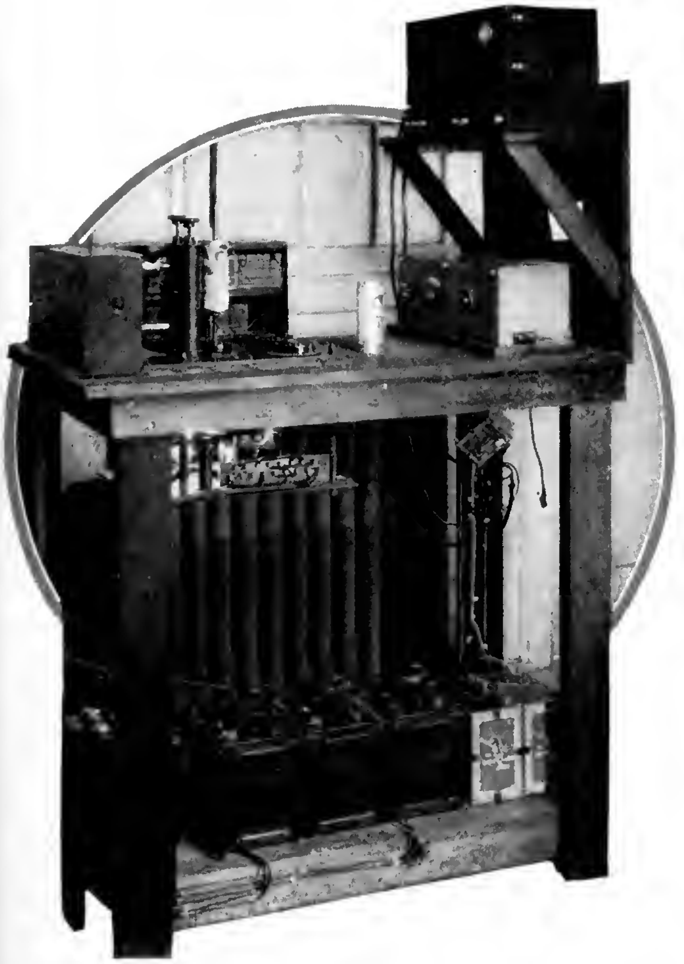
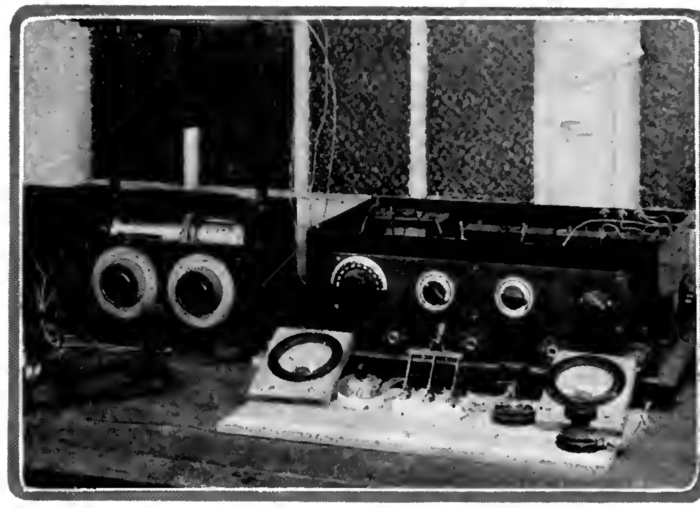


CHART IV





Radio Broadcast Photographs

RADIO PICTURE EQUIPMENT IN THE LABORATORY

These two photographs give some idea of the compactness of the radio photograph equipment which has been in the course of development in the Ratio Broadcast for some time. Left, the transmitter, above, the receiver

Pictures by Radio

What Radio Broadcast *Laboratory Is Doing to Aid the Home Constructor to Develop Phototelegraphy*

DURING the years of 1924 and 1925 two demonstrations of phototelegraphy were given, one by radio and the other by wire. These were milestones in the progress of the art of transmitting pictures to distant points by electricity. The first demonstration, making use of the system developed by R. H. Ranger of the Radio Corporation of America, was given on December 2nd, 1924, when pictures were transmitted from New York to London utilizing a mechanism with which the picture is produced by means of a pen making ink marks on paper. In 1925, a second system, developed in the Bell Telephone Laboratories, was demonstrated, and the system was adapted to use to full advantage the facilities of the Bell system. It made use of photo-electric cells which are sensitive to light and which are capable of controlling electric currents in accordance with the strength of the light impressed on the cell. The Bell system is similar in many ways to the Korn system with which, in 1907, some very good pictures were transmitted from Paris to London.

A great deal of valuable, and not too technical, information on picture transmission is given in a book recently published by the D. Van Nostrand Company, entitled *Wireless Pictures and Television*, and in this book will be found fairly complete descriptions of both the RCA and Bell Laboratory systems. The author is Mr. T. Thorne Baker, himself a scientist who has been actively interested in phototelegraphy, and anyone interested in the subject will find the book well worth reading.

Most of the press accounts describing the Ranger and Bell Laboratory demonstrations have made some reference to the possibility that perhaps, at some later date, means will become available to the general public of receiving, via radio, photographs of important public events, news items, etc., as well as ordinary broadcasting. In order for such a use to become common it is, of course, essential that the system used be simple to operate and fairly cheap in first cost and upkeep. How soon can such a development of picture transmission be expected?

IS AMATEUR PICTURE RECEPTION NEAR?

READERS of Radio Broadcast will be interested to know that during the last four years or so experimental work has been going on in the Laboratory on a system of picture ransmission which has the essential characteristics of simplicity and low cost that make it especially well adapted for use by amateurs and home-constructors. No technical knowledge is required in order to use the system and it is hardly more difficult to operate than the tricky squealing radio receiver of four years ago. Photographs on this page show the picture transmitting and receiving apparatus in use in the Laboratory.

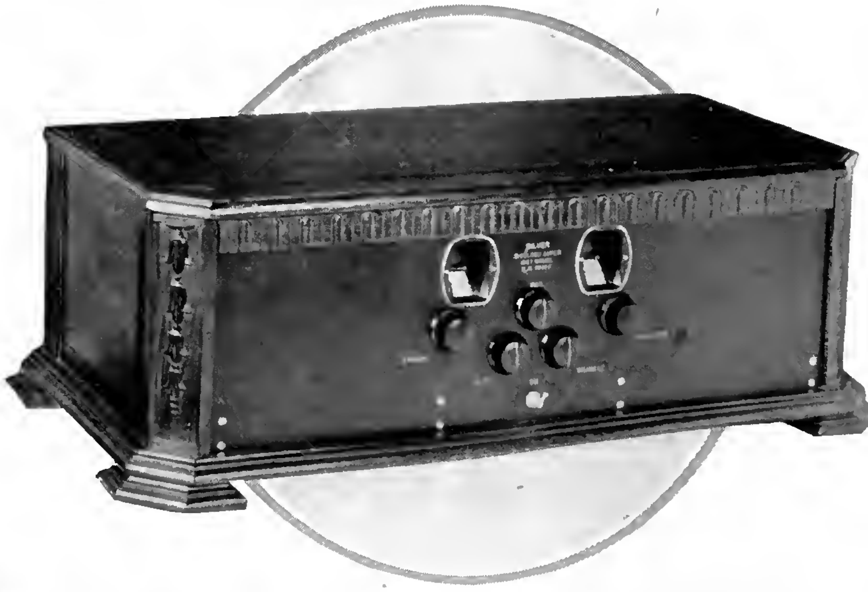
The system used in Radio Broadcast Laboratory has been developed to the point where good pictures can be transmitted by either wire or radio. To transmit a picture 4″ x 5″ requires about two minutes. The picture is received on a piece of ordinary photographic paper which is finally developed like an ordinary photographic print. There is more "kick" in producing a picture which has been received by radio in your own home than there ever was in "pulling in" the Coast at 2 A. M.

It is quite possible that picture transmission by radio will follow, to a certain extent, the same course that radio followed only a comparatively few years ago when it first became popular. The first picture receivers will probably be home constructed and the home-constructor will, at the beginning, take an important part in stimulating the rapid development of picture transmission. The first users of picture receivers will be the same persons who, when radio first started, constituted the larger part of the radio audience.

The problem in picture transmission with which the Laboratory is concerned at present, is the development of apparatus easily constructed and operated at home. The various parts must be manufactured and made generally available so that their assembly into a complete unit will not be difficult. Radio Broadcast is making extensive arrangements to present workable plans to the home constructor, and the latter may expect reasonably soon to see a most interesting series of articles in this magazine which will open this new and fascinating field to him. Complete constructional information will aid the experimenter to start work with no delay. The pictures will be transmitted by broadcasting stations and will be received on a small unit which can be attached to any efficient radio receiver. The number of experiments that can be made with a small picture transmitter costing not more than $100.00 is practically unlimited.

The amateur experimenter has long looked to the transmitting of photographs by radio with envious eyes. Up to the present, experiments of this sort have been confined to luxurious laboratories bristling with engineers and a wealth of apparatus. But now it will shortly be possible to assemble a picture receiver which will not cost much more than $100.00, attach it to a good broadcast receiver, and jump into what will soon be an enthralling hobby. In the meantime we invite correspondence from our readers who have already given thought to this new field of experiment or who have perhaps done some experimenting on their own in picture transmission.

An Eight-Tube Receiver Which Is Remarkably Sensitive, Has Knife-Like Selectivity, and Is Simple to Construct



The Intermediate Frequency Used, 112 Kilocycles, Is Unusual but Has Considerable Advantages

THE LABORATORY "SUPER" AS IT LOOKS AFTER COMPLETION
Compactness is one of the features of this exceptionally efficient eight-tube super-heterodyne. Many five or six tube receivers require just as large a cabinet

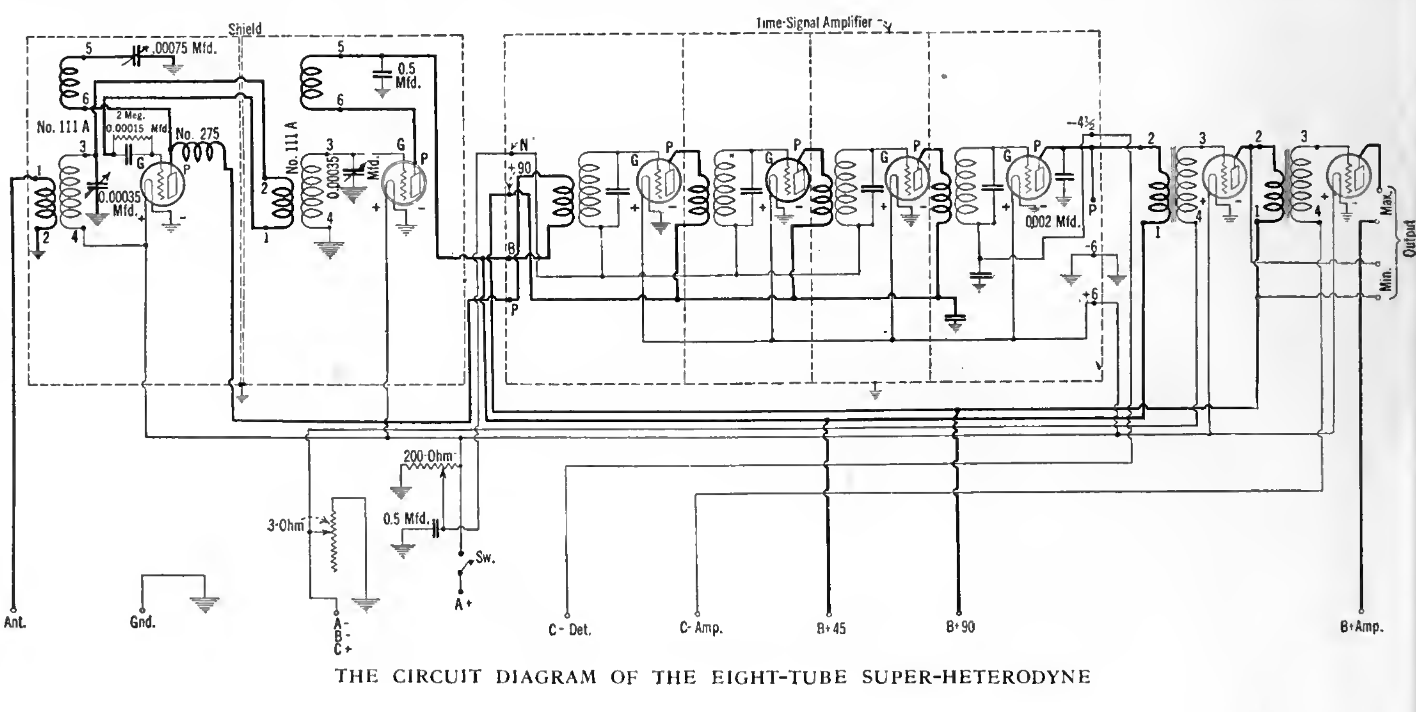
Building the Laboratory "Super"

By ERNEST R. PFAFF

WHEN McMurdo Silver described a super-heterodyne receiver in the January, 1925, Radio Broadcast, it represented about as satisfactory a receiver of that type as could then be built. In the intervening two and one-half years, many thousands of these receivers have been constructed, and while the design was not blessed by an absolute freedom from the vicissitudes that often attend the building of radio sets at home, many builders have reported truly remarkable reception records, while as far as is known, practically all have enjoyed quite satisfactory results. In the meantime, many experiments have been carried on in an endeavor to improve the original receiver, and a new model has finally been developed which, judging from comparative tests, bids fair to eclipse the very best performance of the original circuit. In the design of the latest improved model, described herewith, cognizance has been taken of the engineering advances made since the development of the first circuit, as well as of the many helpful comments and suggestions of the builders of the original receiver.

The improved Laboratory model super-heterodyne employs eight tubes in a comparatively conventional arrangement—a first detector, an oscillator, three long-wave (intermediate) amplifiers, a second detector, and two audio stages. The first detector circuit is very similar to the conventional short-wave regenerative circuits now so popular. The circuit is regenerative, a small 75-mmfd. midget condenser controlling regeneration, while a 0.00035-mfd. condenser does the tuning. The coil system consists of a conventional Silver-Marshall plug-in coil, so connected that both regeneration and tuning condensers are at ground potential, with consequent total absence of hand-capacity effect. No provision is made to use a loop, as it has been found that, for extreme selectivity, the use of an antenna, the coupling to which is variable, provides for greater flexibility than a loop.

The oscillator circuit is very similar to that of the first detector, and offers few unusual points



THE CIRCUIT DIAGRAM OF THE EIGHT-TUBE SUPER-HETERODYNE other than that it is grid-tuned with a 350-mmfd. condenser and there is complete absence of hand-capacity effect. Its output at different wavelengths is sufficiently constant for practical requirements, as is its calibration, while the coupling to the first detector is variable.

The long-wave, or intermediate, amplifier is possibly the most unique and interesting part of the receiver, for it is a completely shielded assembled unit, or catacomb. The copper can 15 inches long, 5 inches wide, and 3 inches deep, contains four individual stage compartments, each holding an r. f. transformer and its attendant tuning capacity, a tube socket, and the necessary wiring and bypass condensers. Three r. f. stages and a detector are employed, and the whole unit is tuned to exactly 112 kilocycles. The reason for the selection of this intermediate frequency is that very satisfactory low-resistance air-core tuned r. f. transformers may be built for operation there.

Another reason for the selection of the odd 112-kilocycle amplifier frequency is because of decreased interference possibilities. Normally, in a super employing, say, a 50-kilocycle intermediate frequency, two stations 50 kilocycles away will heterodyne each other and ber eceived without the use of the local oscillator at all, selectivity being dependent upon the selectivity of the antenna tuner and the local coil pick-up. As the intermediate frequency is increased, this possibility decreases, since it is far easier for an antenna tuner to discriminate between stations 112 kilocycles apart than between powerful locals 30, 50, or even 60 kilocycles apart. Further, powerful stations are generally spaced on even 10-kilocycle separations, so that the odd 112-kilocycle frequency is a greater aid to selectivity.

Coil pick-up is, of course, absent in the shielded amplifier, and wiring pick-up is almost negligible since all wiring is very close to the grounded metal panel or chassis. Complete shielding of the first detector and oscillator sections prevents pick-up of strong local stations on the coil systems themselves, though in receivers to be operated in the country, or in non-congested broadcasting centers, these two shields might be omitted.

The audio amplifier offers no unusual points except one of very great value in an ultra-selective receiver. This is the 5000-cycle cut-off, or fall-off in amplification, which occurs in this amplifier. Normally, frequencieas bove 5000 cycles do not contribute to realism of reproduction, according to no less an authority than the Bell Telephone Laboratories, while in the range above 5000 cycles lie practically all parasitic amplifier noises, atmospheric disturbances, and the only too prevalent heterodyne squeals. These the 5000 cycle cut-off tends to decrease very markedly, and almost entirely eliminate.

The amplification possibilities of the receiver are interesting, as compared to, say, a good bridge-balanced or neutralized eight-tube r. f. receiver. Such an r. f. set would employ, perhaps, four r. f. stages, a detector, and three audio stages, and would cost from $250 to $1000. The probable r. f. gain at best would be 10 per stage (including the detector for simplicity), while the assumption of three impedance-coupled audio stages would allow 8 per stage as an average audio gain with a 112 output tube. Thus, the overall voltage amplification would be about $10^5 \times 8^3$, or 51,200,000 times amplification for a weak signal. In the Laboratory Super, it is safe to assume a voltage amplification of, say, 25 times for the first detection and frequency conversion. The overall amplification of the intermediate amplifier is problematical, but the normal computed, and actual, gain of an r. f. stage such as is used in the Laboratory Super is about 20. Thus four tubes (three amplifiers, and a detector, coupled by four similar tuned circuits), might conservatively be counted on for a total gain of 10 to the fourth power. The audio gain is about 20 per stage or 20^2 overall, so the total gain may be assumed to be $25 \times 10^4 \times 20^2$, or 100,000,000.

These figures seem borne out in practice, for the Laboratory Super will bring in on the loud speaker signals inaudible on a good seven-tube shielded and neutralized r. f. receiver. The selectivity appears sufficient to allow reception of out-of-town stations 10 kilocycles away from locals in Chicago, and, in fact, is so great as to allow the reception of a frequency band only three to four kilocycles wide if desired.

The wavelength range of the receiver with standard coils is from 30 to 3000 meters (10,000 to 100 kc.). Regular broadcast range coils cover the range of 200 to 550 meters (1500 to 545 kc.), but it can be seen that the receiver is adapted to any class of broadcast reception by virtue of its wavelength flexibility.

The assembly of the Laboratory Super is very simple if the standard parts recommended for its construction are procured. The completely pierced and decorated steel panel and chassis can be obtained as a standard foundation unit which reduces the whole assembly operation simply to one of mounting parts with a screw driver, machine screws, and nuts. If preferred, a bakelite or wood chassis might be employed with slight alterations in design, but the change is not recommended unless the receiver is to be located well away from powerful broadcasting stations, since the steel chassis and panel contribute materially to the wiring shielding of the receiver. The whole construction is very simple and the one big hugaboo of super construction—uncertainty as to long-wave-transformer matching and operation under varying conditions of home assembly—is totally eliminated. The assembled intermediate amplifier recommended, known as the 440 "Jewelers' Time Signal Amplifier," is a laboratory-calibrated amplifier, the operation of which will not vary appreciably even with the widest variation of standard tube characteristics to be encountered in practice. The original Laboratory Super was constructed with the following parts:

1—Van Doorn Panel and Chassis Unit, with Hardware	$ 8.50
1—Carter 0.00015-Mfd. Grid Condenser, with Clips	.50
1—Carter M-200 Potentiometer	.75
2—Carter 0.5-Mfd. Condensers	1.80
1—Silver-Marshall 275 R. F. Choke	.90
1—Silver-Marshall 342 0.000075-Mfd. Regeneration Condenser	1.50
1—Carter 3-Ohm Rheostat	.50
1—Carter Battery Switch	.50
4—Carter No. 10 Tipjacks	.40
1—Polymet 2-Megohm Leak	.25
2—Silver-Marshall 220 Audio Transformers	16.00
4—Silver-Marshall 511 Tube Sockets	2.00
2—Silver-Marshall 805 Vernier Drum Dials	6.00
1—Silver-Marshall 440 Time-Signal (Intermediate) Amplifier	35.00
2—Silver-Marshall 515 Coil Sockets	2.00
2—Silver-Marshall 111A Coils	5.00
9—X-L Binding Posts	1.35
2—Silver-Marshall 320 0.00035-Mfd. Variable Condensers	6.50
Total	$89.45

(If shielded oscillator and first detector are desired, add $4.00 for two Silver-Marshall 631 stage shields)

METAL PANEL AND CHASSIS ARE SPECIFIED ALTHOUGH THEY ARE OF BAKELITE IN THIS PHOTOGRAPH

The assembly of the set may be accomplished very easily if the following suggestions are carefully watched.

Upon the chassis should be mounted the detector and oscillator assemblies—inside the stage shield pans if shields are to be used. The end mounting screw of each 511 tube socket is used to join the A minus to the chassis, so a lug should be placed under the screw head, to be soldered to the F minus socket terminal, and the under side of the chassis scraped bright for good contact with the fastening nut. One terminal of the 0.00015-mfd grid condenser should be bent at right angles and fastened directly under the "G" terminal screws. The single long screw holds the 275 choke coil in the detector stage assembly.

The binding posts should be mounted in the nine holes at the rear of the chassis using the insulating washers to positively insulate them from the chassis. The "Ground" post grounds to the metal chassis, and the fastening screw of this post holds one end of the second 0.5-mfd. condenser tightly to the chassis, while the free end must be bent up clear and free of the metal chassis. The four tipjacks mount, using insulating washers, at the right rear of the chassis.

The intermediate amplifier mounts with four 8-32 screws, the chassis being scraped bright for good contact with the screws (the A minus connection is made to the amplifier through the contact between the amplifier shield and chassis). The two audio-amplifier tube sockets mount using their rear fastening screws to connect the F minus posts to the chassis.

All possible wiring should be done on the chassis before proceeding further, leaving free the wire ends that will connect to the instruments on the front panel, and to the two audio transformers, as, if they were put on first, it would be impossible to make the three connections to the right end of the intermediate amplifier.

The potentiometer should be mounted as shown, using insulating washers to thoroughly insulate its frame from the panel. The rheostat and the midget condenser are similarly mounted, except that care is taken to make good contact between them and the panel.

The drive mechanisms of the dials should be dropped into the bracket bearings intended for them, the shafts pushed through the holes in the front panel, and the two brackets bolted to the panel, using the screws provided. One variable condenser fastens to either bracket, using the shaft mounting nut provided. A drum should be slipped over each condenser shaft, with set screw loosened, and pushed up until the drum scale edge is just ready to enter the crack in the drive mechanism shaft. With a knife blade this crack should be widened to receive the drum scale edge, and the drum pushed well up on the condenser shaft. The scale should then be adjusted to read 100 degrees against the indicator points in the panel windows, when the condenser plates are entirely disengaged, upon which the set screw in the drum dial hub should be tightened on the condenser shaft. With the knobs fastened on the drive shafts, the condenser dials should rotate if the knobs are turned.

The connections to the condensers, rheostat, and potentiometer should be made before fastening the panel to the chassis. After they have been put in, machine screws and nuts serve to hold panel and chassis together. The "On-Off" switch mounts in the one remaining panel hole, with insulating washers to thoroughly insulate it from panel and chassis (it may previously have been connected in circuit, and allowed to hang on the wiring until ready to be mounted).

TESTING AND OPERATING

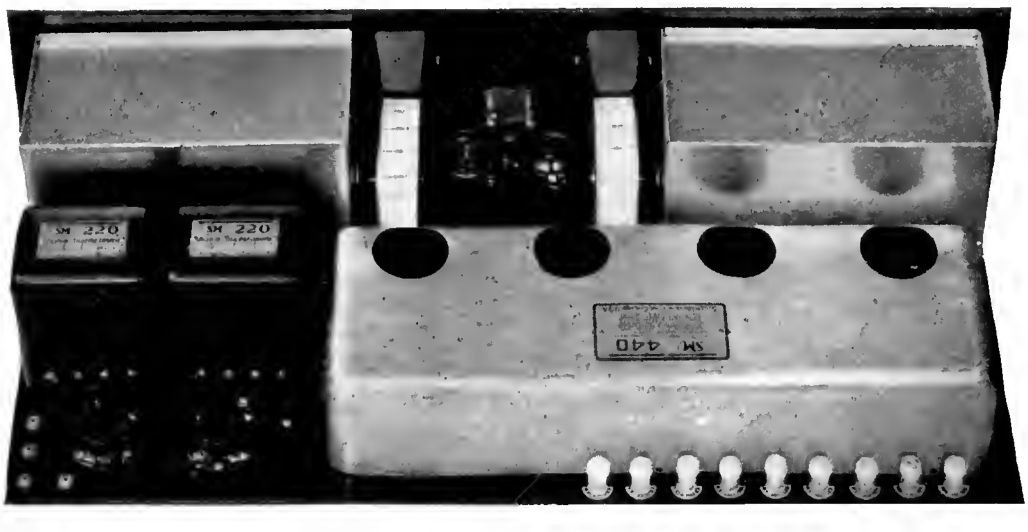
BEFORE actually hooking up the set for test, or before cabling and lacing the under chassis wiring, the set should be carefully checked. The A battery alone should be connected, a single tube inserted in any socket, and the "On-Off" switch and the rheostat turned on. The tube should light in any and all sockets, with brilliancy slightly varied by rheostat adjustment. The A plus wire should be successively connected to the plus 45, plus 90, plus Amp., minus $4\frac{1}{2}$, and minus Amp. binding posts. If the wiring is correct, the tube will light with the A battery connected only to the proper posts. The remaining batteries should be connected. A B socket-power device may be used, but only a good model employing a glow tube voltage regulator, such as the one described by Howard E. Rhodes in the June RADIO BROADCAST.

To operate the set, all tubes should be inserted, except the first detector tube. A CX-371 (UX-171) goes in the right rear socket; a CX-340 (UX-240) in the adjacent rear socket. The rest of the tubes are CX-301-A's (UX-201-A's). With the "On-Off" switch on, the rheostat should be turned to within $\frac{1}{8}$ inch to $\frac{1}{4}$ inch of the full right position. If the potentiometer ("Gain" knob) is turned to the right, a "plunk" will be heard at some point. This can be detected by varying the oscillator drum, which should cause a number of shrill whistles to be heard. The "Gain" knob should always be operated just to the left of the "plunk" point, *i. e.*, to the right of which squeals were heard when the "Oscillator" dial was varied. The receiver is least sensitive when the "Gain" knob is at the left, and most sensitive when the "Gain" knob is just to the left of the "plunk" point.

The first detector tube should be inserted and the midget condenser set all out. The antenna coil rotor should be set at 45 degrees, and the oscillator rotor should be all in. A small antenna, 30 to 60 feet long, should be used, or even a larger one if the set is not too close to powerful local stations. Stations may be tuned-in using the two drum adjustments only. Weak stations may be intensified by turning up the "Regeneration" condenser on the front panel. This condenser functions similarly to the "Gain" knob, in that, as it is turned to the right to interleave the plates, signal strength on weak stations will increase up to the point where the first detector oscillates, and the signal turns into a squeal. Adjusting the midget condenser will react slightly on the setting of the "Antenna" drum.

Tuning operations for weak out-of-town stations are as follows: With the rheostat to within $\frac{1}{8}$ inch to $\frac{1}{4}$ inch of the extreme right position (adjusted to give 5 volts to the filaments of all tubes), the "Gain" knob should be turned to the right until it is just below the "plunk" or oscillating point for the intermediate amplifier. This adjustment is independent of the wavelength of any signal being received. The two drum dials should then be varied to tune-in stations. In order to cover the entire broadcast band, the "Antenna" dial should be varied in steps of one degree at a time, and for each one-degree step the "Oscillator" should be varied over a range of 15 degrees above and below the "Antenna" dial setting. Once a weak station is heard, it may be strengthened by turning the midget condenser farther in and resetting the "Antenna" dial slightly. Each station should be tuned-in at one point on the "Antenna" dial and at either one or two points on the "Oscillator" dial. If stations are heard at two or more points on the "Antenna" *and* "Oscillator" dial, it is not the fault of the receiver, but is probably due to re-radiation of the transmitted signal from local steel structures, etc., which energy, while very weak, may nevertheless be picked up by the Laboratory Super and amplified as it would be on no other receiver. It is just this sensitivity that accounts for the set's remarkable long-distance performance.

The position of the antenna coil rotor should generally be at about 45 degrees. With a small antenna, it may work best all in; with a large antenna, it should be at nearly right angles. The sharpness of tuning of the antenna dial depends upon the setting of this rotor, as well as that of the midget condenser. The oscillator rotor should be adjusted once on a very weak signal at about 300 to 350 meters, and, once set for maximum volume, may be left alone.



A BEHIND-THE-PANEL VIEW

In this photograph the Laboratory Super has been completely wired and is now ready for connection to the necessary source of A, B, and C power

We Need Better Radio Salesmen

The Sheep and the Goats of the Radio Sales Fraternity—The Goats Need Better Preparation for their Job Which is Not a Simple One

By CARL DREHER

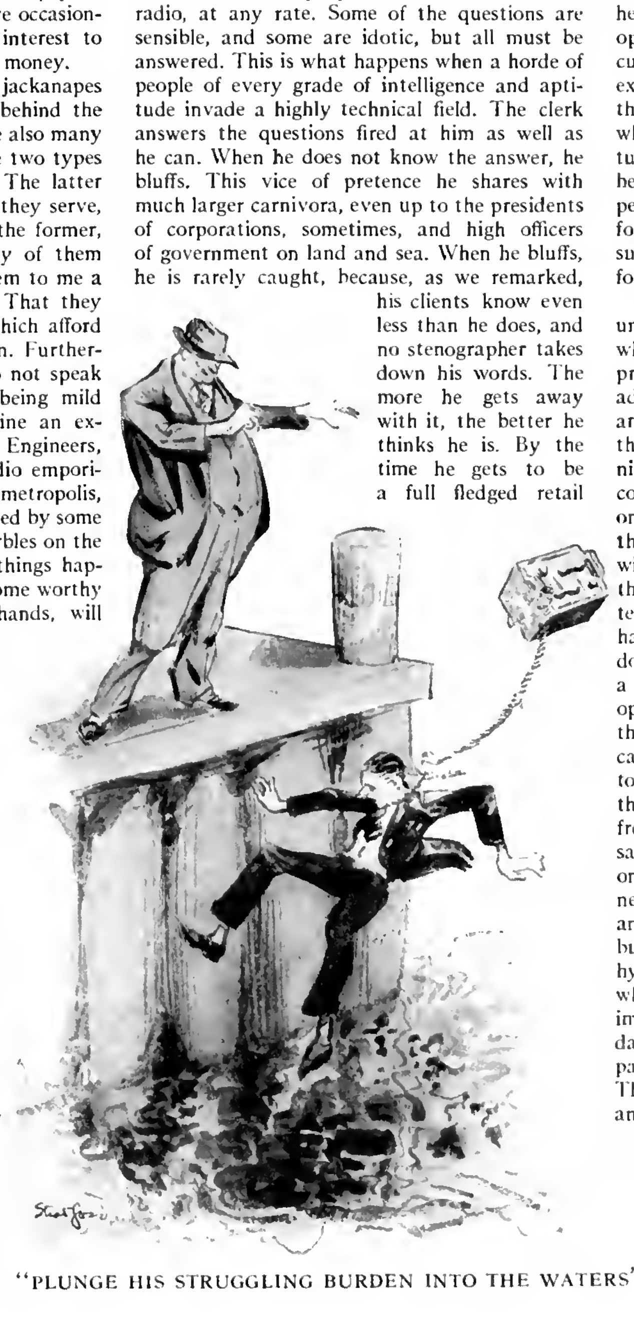
Drawing by Franklyn F. Stratford

I KNOW little about the mystic process of selling radio equipment to the ultimate user, and disclaim, at the beginning of this discussion, any idea of instructing experts in the merchandising art. My experience has all been in other directions. By these modest words, I hope to avoid harsh looks and nasty expressions from the commercial gentlemen on whom my sustenance depends, although, happily, theirs depends equally on me. With all this ignorance, occasionally I do venture into a radio store in order to purchase some trifle which I am unable to cadge lawfully from the company whose payroll I adorn. On these pilgrimages I have occasionally made observations of possible interest to radio men engaged in trying to earn money.

Some of the most insufferable little jackanapes ever expelled from high school are behind the counters of radio stores, and there are also many decent, sober, competent fellows, the two types being found, often, five feet apart. The latter make money for the stores in which they serve, and, I hope, for themselves. As for the former, I should be sorry to hear that any of them starved, but, abstractly, it would seem to me a highly salutary social phenomenon. That they are not an asset to the businesses which afford them shelter is a foregone conclusion. Furthermore, their lives are in danger. I do not speak of myself, my homidical impulses being mild outside of family circles, but imagine an ex-president of the Institute of Radio Engineers, for example, entering one of the radio emporiums on Cortlandt Street in the dizzy metropolis, to buy a grid leak, and being patronized by some beardless youth who was playing marbles on the Brooklyn lots two years ago. Such things happen, and is it not conceivable that some worthy pioneer, taking the law into his hands, will reach behind the counter, carry off one of these lightweights, and, declining the polite offers of the porters at the foot of Liberty Street, plunge his struggling burden into the waters of the Hudson?

The development of these radio counter boys and sales clerks is not hard to visualize. The process starts with a young fellow of high school graduation age, no worse and no better than thousands of others, faced with the necessity of earning his living. He has built a few receiving sets, and, as his education has not trained him for anything in particular, and the sets work part of the time, he decides that radio must be his forte. Through an advertisement or otherwise he secures a job in a radio store of the sort which sells everything from rubber overcoats designed to cure vacuum tubes of the notion that they are microphones, to $600 phonograph-radio combinations in Louis XV cabinets. His responsibilities and authority are ill defined, the principal idea being that he is to do whatever he is told and act as a door-mat for the rest of the staff. He unloads thousands of loud speakers from trucks, crates and uncrates sets, hunts through mountains of excelsior for missing parts, and sweeps out the store. In time he learns something about the business and is promoted to an assistant sales clerk in charge of the binding post counter. He now faces the public. And now something happens to him, inwardly.

All day long people come in and ask him questions. Our hero doesn't know much, but it is clear that lots of people know even less, about radio, at any rate. Some of the questions are sensible, and some are idotic, but all must be answered. This is what happens when a horde of people of every grade of intelligence and aptitude invade a highly technical field. The clerk answers the questions fired at him as well as he can. When he does not know the answer, he bluffs. This vice of pretence he shares with much larger carnivora, even up to the presidents of corporations, sometimes, and high officers of government on land and sea. When he bluffs, he is rarely caught, because, as we remarked, his clients know even less than he does, and no stenographer takes down his words. The more he gets away with it, the better he thinks he is. By the time he gets to be a full fledged retail salesman, with shiny current supply sets, amplifying transformers containing a pound of iron, and variometers colored like a pair of pajamas, loading down the shelves behind him, he feels like the Oracle of Delphi. And like the priestess who intoned her prophecies above the cavern of noxious vapors, he is mainly a fraud.



"PLUNGE HIS STRUGGLING BURDEN INTO THE WATERS"

For, when you come down to it, this business of selling radio is intricate enough, and as yet there is little systematic preparation for the job. When the job is well done, it is merely the result of a fortunate accident. There are some qualified, resourceful men selling radio parts and sets here and there—the fortuitous combination of opportunity, experience, and aptitude. When a customer enters, not knowing what he wants except that he doesn't wish to pay much for it, they cross-examine him skillfully and give him what he needs, within the limits of his expenditure, carefully explaining what he is not getting before he leaves the store. Encountering an experienced radio man, they secure what he asks for without loss of time, perhaps dropping a deft suggestion which, very likely, it will be profitable for him to listen to.

The job being complicated, and the results, under present conditions, decidedly haphazard, why should not more attention be given to this problem? A well-known chain of barber shops advertises the claim that its tonsorial employees are trained in a school which it maintains, that they may become adept in the superior technique of the establishment. I presume that the course is a brief one, that few of the professors on the faculty have Heidelberg Ph. D.'s, and that the whole advertisement is ninety per-cent wind. Even so, my observation has been that the barbers afore-mentioned are decidedly better than the average run, that they wash their hands at the proper time, cut hair neatly, and do not take the skin with the beard. If it profits a barber establishment to select and train its operating personnel with some care, should not the same principle apply to a far more technical business like radio? There is money in radio, too, and there might be more if we looked out for these little things. We should discard, also, several freight-train loads of the current bunk about salesmanship. A good salesman is primarily one who knows his goods, senses accurately the needs of his clients, and has the normal energy and social qualifications required in any other business. To the devil with personal magnetism, hypnotism, the psychological approach, and the whole bag of tricks, if he only knows that a high impedance speaker will work across a low impedance output, but not vice versa, and that a paper grid leak will not carry fifty milliamperes. There are plenty of ex-commercial operators and zealous amateurs who can do good work as radio salesmen, although they know nothing about salesmanship. Some of them, praise be, are already in the retail establishments of the industry, and the proprietors would do well to get in more of them before the next season sends them into the bankruptcy courts

“Strays” from the Laboratory

The New A. C. Tube

UNCERTAINTY regarding the constants of the new a.c. tubes reigns supreme, as a glance at the table on this page will show. While it has been impossible to secure all makes of tubes designed to operate from raw a.c., those measured in the Laboratory are representative at least, and should give the reader something to think about. Whether or not he is to throw away his batteries and present set of tubes is for him to decide, but if the tubes are good and his battery still possesses its appropriate lead plates and sulphuric acid, he need be in no hurry to make changes.

The a.c. tube has not sprung up overnight. It has been the dream of engineers for a long time and, in the case of the McCullough tube, has been in actual production for several years. It is difficult to understand why there should be any general concern about the situation now that it is possible to choose between a.c. tubes that operate on 1 volt and consume 2 amperes and those that require a voltage of 15 at 0.35 amperes, but there is always something akin to hysteria in the radio business when anyone makes a suggestion that is more or less new.

The a.c. tubes are of two kinds, those that have filaments in the usual sense, and those that have heaters which operate from a.c. and which, in turn, heat a cathode which supplies the electron stream which the radio set actually makes use of. The first a.c. tube in this country was the McCullough tube, which is a heater type requiring a voltage of 3 and a heater current of one ampere. Others tested in the Laboratory in recent weeks are made by Marathon (Northern Manufacturing Company), Sovereign (of Chicago), and of course the Cunningham. It has been impossible up to the time this is written to get R. C. A. a. c. tubes into the Laboratory. The data given here on the C-326 and C-327 (taken from early tubes sent to the Laboratory) will probably not be far from the final design which, according to the Cunningham Company, has not as yet been reached.

The heater type of tube, of which the McCullough is the forerunner, is not new to the industry. The stout filament type, which has been associated with the name of Mr. B. F. Miessner (although others had worked on the tube prior to Mr. Miessner's papers delivered before the Radio Club of America) is newer and works on different principles. It has a true filament, very heavy and rugged, heated by a lot of current at a low voltage. Readers interested in the theory underlying this tube, which is the result of a nice piece of research on Mr. Miessner's part, will do well to read his articles in RADIO BROADCAST for February and March, 1927, and a paper in this issue.

It does not seem possible to use the latter type of tube as a detector of the familiar grid leak and condenser type. For this reason the R. C. A. and Cunningham recommend that the 227 (C-327) or heater type be used as a detector and the rugged filament type for all other positions. There is no reason why the heater tube cannot be used throughout the set; indeed, receivers utilizing the McCullough tube have been used this way for some time. The rugged filament type may be used with a C-battery detector.

A cursory perusal of the data given here shows that the average constants of these new tubes are better than the average d.c. tube designed for the same purpose. For example, the table gives the average plate impedance and amplification factor of the familiar 201-A (C 301-A) type. It is possible with either the heater or rugged filament type to build much better tubes than this table indicates is now being done. Such tubes have been designed to have characteristics as near to those of the d.c. tubes now used as possible. It is futile for a tube manufacturer to build a tube that has half the impedance of present tubes, if only one or two set manufacturers have gumption enough to build a set around them. On the other hand, gradually changing tubes toward those with greater gain and gradually altering the design of radio-frequency transformers to go with them, will ultimately bring about receivers which are more selective and which have greater gain per tube.

Some of these a.c. tubes are noisy while others from the same allotment and with practically the same electrical characteristics are quiet. It seems imperative that a.c. tubes must be highly exhausted. Hum is kept at a minimum by biasing the heater with respect to the cathode, as indicated in Fig. 1. The biasing voltage is not always the same. Some receivers, particularly those with high-quality amplifiers (going down below 60 cycles and using high-quality loud speakers), will hum if a transformer carrying 60-cycle current is anywhere near them. The solution at times is to change the relative positions of the cores of the audio transformers, or chokes, and that of the power transformer. An electrostatic shield, properly grounded, between primary and secondary of a power transformer, is also of considerable aid in stubborn cases of 60-cycle hum.

Some manufacturers of a.c. tubes have been ambitious enough to put out a whole series of a.c. tubes, adding to the general purpose tubes those with high amplification factors, and power tubes. The Van Horne Company lists no less than eight tubes designed for straight a.c. operation or for series filament connection. The Marathon list is made up of general-purpose tubes, high-mu tubes, and power tubes. The Arcturus line includes detector, general purpose and power tubes.

It is unfortunate that all of these tubes require different values of filament, or heater, current and voltage. This puts a big burden on the manufacturers of transformers, and upon those who like to construct their receivers at home. For example, the Cunningham heater tube utilizes 1.75 amperes at 2.5 volts, while the rugged filament type demands a voltage of 1.5 and a current of 1.05 amperes. The Arcturus type, on the other hand, uses a voltage of 15, which can be conveniently supplied by toy transformers stocked by practically every electrical dealer.

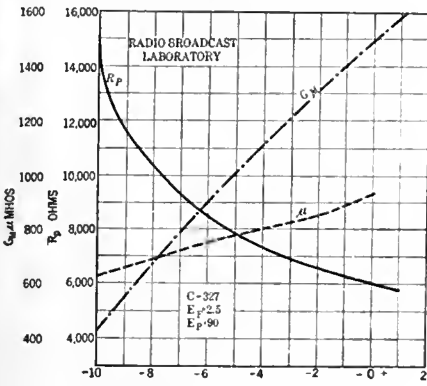
From several engineers who have been responsible for the development of these tubes, comes the suggestion that high values of C bias are desirable from the standpoint of hum, and from others comes the report that at high frequencies, the heater type is subject to some strange vagaries. It seems that the resistance of certain mechanical parts that go into the construction of these tubes decreases at high frequencies, which naturally will cut down the overall gain of a tube. It seems to be true, too, that some trouble is had at times with the vacuum when the oxide coated low-voltage filament is used. Perhaps this explains why some tubes, for no apparent reason, are noisy.

The Arcturus tube is unusual.

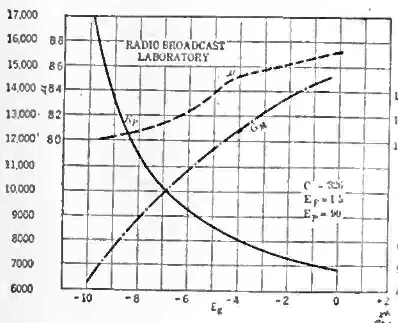
A. C. TUBES

NAME	E_f	I_f	E_p	E_g	I_p	μ	R_p	G_m
Heater Type								
C-327	2.5	1.75	90	−4.5	4.2	8.0	9200	940
McCullough	3.0	1.0	90	−4.5	4.2	8.6	9400	870
Sovereign	3.0	1.5	90	−4.5	4.6	8.5	9100	935
Marathon 608	5.5	1.0	90	−4.5	4.2	7.3	9500	775
Marathon 615	5.5	1.0	90	−1.0	3.2	12.0	19000	635
Marathon 630	5.5	1.0	90	−1.0	1.1	28.0	40000	680
Marathon 605	5.5	1.0	135	−12.5	14.0	4.5	4400	1000
Arcturus	15.0	0.35	90	−4.5	3.1	10.5	12150	870
Filament Type								
C-326	1.5	1.05	90	−4.5	5.0	8.5	8300	1030
Armor A. C. 100	1.0	2.0	90	−4.5	3.8	7.8	11200	690
Van Horne	1.0	2.0	90	−4.5	4.0	9.5	10000	980
CX-301-A (UX 201-A)	5.0	0.25	90	−4.5	2.0	8.0	12000	675

E_f = Filament Volts
I_f = Filament Current
E_p = Plate Volts
E_g = Grid Volts
I_p = Plate Current
μ = Amplification Constant
R_p = Plate Impedance
G_m = Mutual Conductance



IMPORTANT CONSTANTS OF THE C-327 (ABOVE) AND C-326 (BELOW) PLOTTED AGAINST GRID VOLTAGE



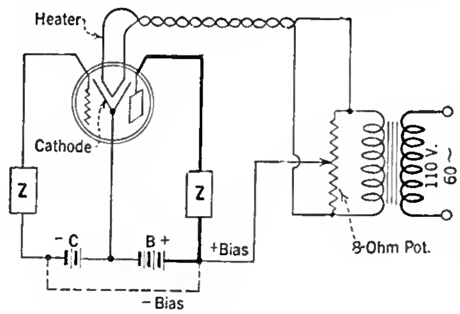
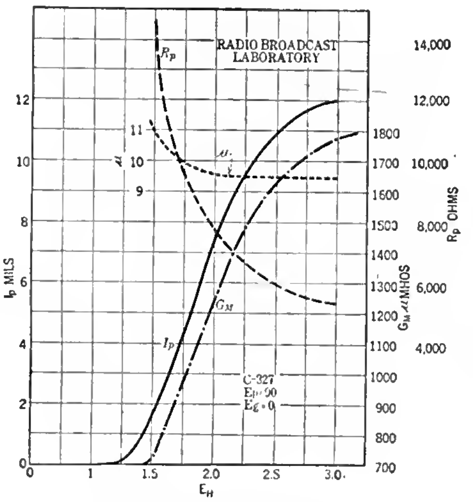
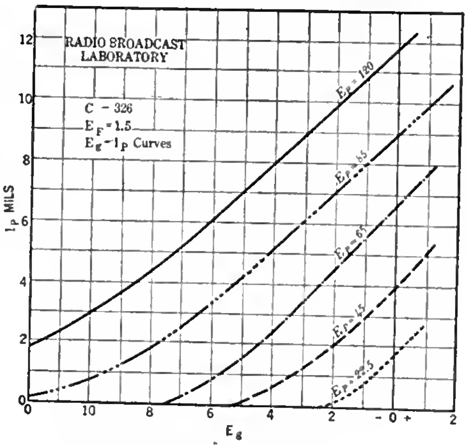


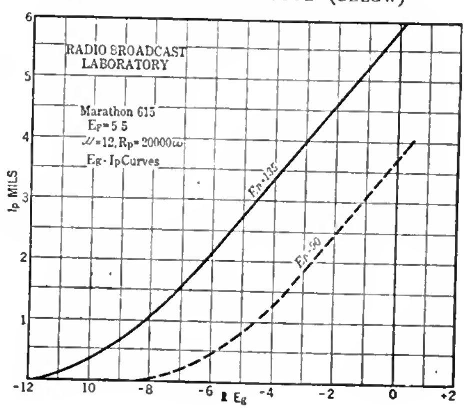
FIG. 1



HOW THE CONSTANTS OF C-327 VARY WITH HEATER VOLTAGE



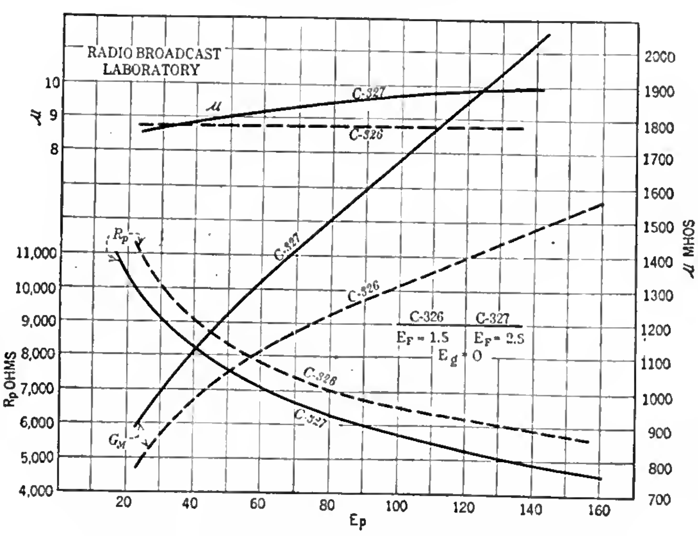
E_g-I_p CURVES FOR C-326 (ABOVE) AND MARATHON HIGH-MU TUBE (BELOW)



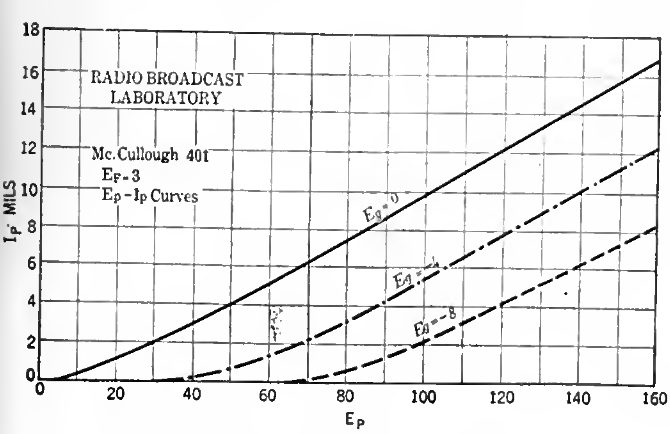
It is a heater type, the heater current being about 0.35 amperes at 15 volts. The heater is a rather heavy carbon filament which at the top is electrically connected to the cathode. This makes it possible to use a standard four-prong base—an obvious advantage which other heater tubes do not possess. The R. C. A. and Cunningham heater tubes require a special five-prong base, while the others, of which the McCullough is the prototype, have two heater terminals at the top of the tube, or at the side, to which are attached the a.c. terminals.

We noted at the Chicago Radio Trade Show that 35 per cent. of the receivers shown were a.c. operated. Not many of these sets used a.c. tubes, but used some other method of eliminating hum when using standard d.c. tubes.

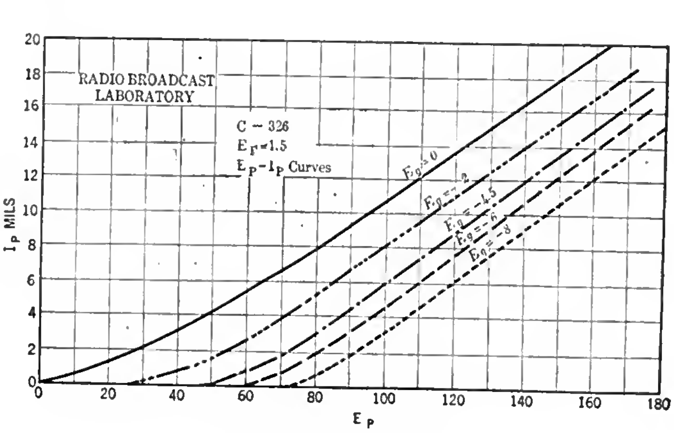
All in all, the a.c. tube is something to watch. It is still in the development stage, and the work of many tube engineers and chemists will be involved before the final answer is ready. The a.c. tube is not destined to supplant the present type of tube we all use in the next six months or in any other period so short. As soon as the Laboratory gets more data on the operation of the new tubes, they will be made available.



CONSTANTS OF C-326 AND C-327 AS RELATED TO PLATE VOLTAGE



E_p-I_p CURVES OF MCCULLOUGH A. C. TUBE



E_p-I_p CURVES FOR C-326

THE LISTENERS' POINT OF VIEW

Conducted by John Wallace

Should We Name Our Broadcasting Stations?

THE following bulletin was recently sent to all station owners by the National Association of Broadcasters:

On many occasions during the past few months, during informal discussions among our members, and occasionally during official hearings, the question of continuing the designation of a station by announcement of its call letters over the air has attracted keen interest.

The use of combinations of letters to designate a radio station originated properly in "point to point" communication some years back, and as a natural outgrowth of this, with the advent of broadcasting stations this type of designation has been continued. It was never specifically designed for *radiophone* broadcasting stations.

It is a well-known fact that due to the phonetic similarity of many letters in the alphabet (for example, B may sound like D, E, P or T) the average owner of a radio receiving set makes many mistakes in identifying the station he has tuned, which in turn causes the credit due that station to be entirely misplaced.

At this point, those who favor abolishing call letters immediately advance the argument that the sole reason for a station existing is to create personality for itself, and immediately draw the analogy between the station and a boat or a yacht. For official records, the Government designates all vessels under a license form, as, for instance, KX-109. However, immediately, regardless of whether it is a pleasure or commercial craft, its owner christens it with an appropriate name which lends personality to the ship, and the license designation of letters and numbers is never given further consideration except in connection with the license to operate.

From this analogy, the proponents of the idea ask, "Why is not an announcement, such as 'The Mayflower, Cincinnati' of more value to the station and easier to identify than the announcement 'This is Station WBDT'?" The first is at once suggestive of a personality and entirely distinguishable while the latter is negative and easily confused.

The opponents of such an idea point out that hundreds of thousands of dollars have been spent, in many instances building up the prestige of a certain combination of letters, which in some cases correspond to the trade slogan of the owner of a station. Undoubtedly such stations would be slow to consider favorably the idea of relinquishing their call letters.

However, the discussions have been so frequent and active by both sides, that it is with the thought of determining what the real consensus of opinion is that your vote is asked on the enclosed ballot.

We tremble. We hold our breath. We pace about apprehensively our pockets loaded with horse shoes. Suppose they decide to do it! What manner of monstrous monikers may we not have to listen to! We think the suggestion a highly indecent and immoral one—like giving small, and notably reckless boys, shining, loaded revolvers to play with. Needless to say the broadcasters will jump at the idea; tacking names on things is their meat. What grand and glorious, resplendent and superlative station names may we not expect. Give a look what the gents did back in the days when they were coining slogans for their stations:

"Kall For Dependable Magnolene"
"Where The Sun Shines Every Day"
"Stephens College Where Friendliness is Broadcast Daily"
"Kant Fool Us Long Horns."
"The Best Little Station"
"The World's Largest Grease Spot"
"Kum To Hot Springs"
"We Sell Goods Cheaper"
"Where Cheer Awaits U"
"Where Harrisburg Broadcasts Gladness"
"One of Indiana's Most Beautiful Little Cities, And The Home Of The First Automobile"
"Watch Mercer Attain Zenith"
"We Are Never Tired"
"Sunshine Center of America"
"Known For Neighborly Folks"
"Keep Folks Quoting The Bible"

Names like the suggested one, "Mayflower," wouldn't be so bad, but there'll never be enough of them for seven hundred stations. Arrived at the second hundred, there will be a terrible struggle to create some appropriate and unduplicated collection of syllables. Moreover we, the poor listeners, will have to do all the dirty work of memorizing the new names, and it was only at the cost of much travail that we got the multitude of call letters finally straight in our mind. Also we shall have to junk our receiving set cabinets and install new ones with three-foot dials whereon to inscribe the new and lengthy apellations.

We submit that letters, or even numbers, are quite as easy to memorize in large quantities as names. Imagine what a boon it would have been if Mr. Pullman had only started off in the dim ages, by christening his sleeping cars with call letters. Have you ever returned from the observation platform at a late hour and attempted to crawl into lower twelve in "Grassmere" or "Graymere," only to discover, amidst much feminine shrieking, that you really belonged in lower twelve in "Grassbeer"?

If names must be used, let us, f'revvens sakes, have some system about it. Let all the stations in Georgia be lovely ladies, and those in Mississippi, flowers; those in New York, drinks and those west of the Rockies, kitchen utensils, and so forth. Thus would we have an entertaining and easily catalogued roll call of such stations as: "Gertrude," "Josie," "Maizie," "Clarabelle"—"Hyacinth," "Petunia," "Erysipelas," "Plastodolphus" — "Old Crow," "Tom and Jerry," "Benedictine," "Kummel"—"Rolling Pin," "Potato Masher," "Egg Beater," etc.

But we quite disagree with the main contention that call letters can have no personality. To us they have always seemed very vivid personalities. What matter the fact that the personalities of the letters, as we interpret them, seldom correspond with the personality of the station mentioned.

WEEI, for instance, is a thin, squeeky sort of a name. It has a long skinny nose which is rather red and which it blows at intervals. It is querulous and complaining and takes its tea rather weak.

KDKA, on the other hand, is a robust, high pressure name. It is six feet two, bulging with muscles and wears red, sweaty underwear. It is

AT WJAX, JACKSONVILLE

Isaac Wessell of the Jacksonville Little Symphony Orchestra—broadcast by WJAX—and his old faithful bass fiddle. The press agent claims that it is over two hundred years old and has been repaired in Budapest, Leipsig, New York, Boston, and other places, and that it has been cracked so often that there is hardly a sound spot on the instrument the dynamic type, bubbling over with energy and talks with explosive loudness. Likes to squeeze little boys' wrists till they squeal.

WEAF is a sanctimonious assembly of letters. It is tall and gaunt and affects loosely flapping black garments. Its cheeks are sunken, its mouth inexpressibly sad, and it wears horn rimmed glasses over a pair of weak watery blue eyes. Delights in eighteen-carat Baptist Camp Meetings.

WJZ is a high sounding and celestial name. It wears purple robes and quite a high crown. Is preceded by two pages blowing trumpets and is followed by a processional of High Priests chanting its praises. Expects the populace to bend its knee before it and occasionally smites one down. Has a large Roman nose.

CNRO is an ugly, snarling name; WOC is bland, honest and open faced, belongs to the Rotary Club; WBBM is a nasty, nagging name, drums on the table with its finger tips while playing bridge; KFOO is boorish and stupid, given to belching at the dinner table and so on, and so forth, through the list. WHAM is breezy—a calliope-like individual. WGY is a deep-voiced soul with a sombrero and an educated voice.

MRS. ANNETTE R. BUSHMAN, PROGRAM DIRECTOR, WEAF

Where Broadcasting Reigns Supreme

THE making known of great national events, while they are actually taking place is, after all, radio's unique contribution, and the one field in which it reigns supreme without competition from phonographs, theaters, churches, or newspapers.

And it is greatly to radio's credit that it does this job so thoroughly and well. As an example of a national broadcast well done, may we be permitted to hearken back as far as last Memorial Day? The official ceremonies at the Arlington National Cemetery, as broadcast by the N. B. C. chain, we listened to from start to finish and found not only interesting but entertaining. The ceremony began with an overture by the United States Marine Band, then a "Call to Order" by Major General John L. Clem. Following a soprano solo, the "Star-Spangled Banner," accompanied by the Marine Band, the original order establishing Memorial Day was read. Then two more musical interludes: the solo "Out of the Night, a Bugle Blew," accompanied by buglers, an enormously effective and dramatic work for such an occasion, and the "Battle Hymn of the Republic" sung by the Imperial Male Quartet. Then the *piece de resistance* President Coolidge's address, which, agree with him or not, was an expert piece of speech construction. The program was concluded with the reading of an original "poem" by Clagett Proctor, which was bad verse and the only stupid moment of the entire ceremony, and a brief address by Commander-in-Chief Means of the United Spanish War Veterans. Each different feature of this varied program, the voices of the speakers, the distant notes of the bugles, the ensemble singing of the quartette, the vocal solos and the massed volume of the Marine Band, was "picked up" in perfect style and broadcast with such clarity that the radio listeners must have heard the program more effectively even than those actually present at Arlington.

The broadcasting of the hullabaloo incidental to Lindbergh's arrival was likewise thoroughly done—perhaps in spots too thoroughly for the interest of this particular listener. For instance at the banquet tendered Lindbergh in New York. We would have been quite content had all the speeches of eulogy been omitted and only that of the flyer broadcast. Never have we heard worse blah sprung at a banquet, and sprung by such eminent leaders, divines and statesmen! The supposedly tongue-tied airplane mechanic gave a valuable, though doubtless unheeded, lesson in public speaking to the much touted, so-called orators who shared his platform. But the nation as a whole was interested in every and any detail of the flyer's reception and credit must be given to the National Broadcasting Company for slipping up on no smallest part. The N. B. C. established a number of new records in covering the event:

Miles of Wire Line Used—14,000.
Number of Engineers Involved—350.
Pick-up Points—Washington, 5; New York, 7.
Number of Stations—50.
Estimated Audience—35,000,000.
Number of "Radio Reporters"—Washington, 4; New York, 6.
Longest Continuous Program Devoted to One Subject—11½ hours.

SUNDAY NIGHTS AT WPG

WPG is offering a series of Sunday night concerts during the summer from the Steel Pier. Operatic arias, duets and concert selections make up the programs which are arranged by Jules Falk. Among the artists scheduled for the series are: Julia Claussen, mezzo-soprano; Marie Sundelius, soprano; John Uppman, baritone; Berta Levina, contralto; Doris Doe, contralto; Arthur Kraft, lyric tenor; Elsa Alsen, soprano; Julian Oliver, tenor; Edwin Swain, baritone; Marie Tiffany, soprano and Paul Althouse, tenor.

NOVELTY THAT IS GENUINE

A COMMENDABLE move on the part of WBAL was the arranging of a program of "first-time" numbers—meaning selections that had never previously been heard over the air. Two of the numbers "Air de Ballet" and "An Irish Tune" were contributed by Gustav Klemm, WBAL's program supervisor who is also a composer. Other selections were "Carioca" and "Batuque," Brazilian tangos by Ernesto Nazareth, "Indian Summer" by Sturkow-Ryder and "Barn Dance" by James Rogers. The recital was given by Sol Sax, pianist, during one of the WBAL Staff Concerts which are on the air Wednesday evenings from 9 to 10 o'clock Eastern Standard Time.

NEW PROGRAM MATERIAL

H. V. KALTENBORN, whose editorial discussions of the outstanding happenings of the week constitute perhaps the best "one man show" of all radio's offerings, is to resume his talks from WOR on October 10. We are informed

THE CRYSTAL STAGE STUDIO OF WOW

Many of the broadcasting stations have made use of this method of accommodating studio visitors without confusion or danger of interference with the program. The stage is insulated from the auditorium by plate glass across the entire stage. Visitors hear the artists via loudspeakers placed behind the grills at the upper left and right that he is at present in the Far East making a study of the Chinese revolution. He is to visit the important centers in South China and North China and will also visit the Philippines to study problems associated with colonial administration and the independence movement. On his return journey he will travel overland through Manchuria and Korea to get first hand information concerning Japanese colonization and penetration and will spend some weeks in Japan before sailing home.

HURRAH FOR THE A. S. C. A. P.

A MOVEMENT has been started (may it get farther than the ten preceding starts!) by the American Society of Composers, Authors and Publishers to prevent the too frequent broadcasting of popular compositions, according to E. C. Mills, representative of the Association. It is contended that experience has proved beyond a doubt that the excessive broadcasting of a composition quickly destroys its market in published and recorded forms.

"It is not at all unusual to hear a number in popular demand broadcast in any particular area from six to a dozen times in an evening," says Mr. Mills. "Long before the public has had opportunity to purchase the rolls and phonograph records, or the music in sheet form, the composition has been 'blasted to death' and the public is weary of even hearing it.

"No composition should be rendered more than once in an evening in the same form. If played by one orchestra it should not be included in the program of another; sung once during an evening, it should not be sung again. From the broadcaster's viewpoint, as well as for the welfare of the composition and its owner, the public appetite should not be surfeited.

"It looks very much as though it were going to be necessary for program directors to exercise the same sort of jurisdiction over their programs as managers of vaudeville theatres do. In the theatres it is the custom to prohibit more than one rendition of the same composition in any program. The rule is that whatever act first rehearses a certain song at the beginning of the engagement shall have the right to use that composition during the appearance at that theatre.

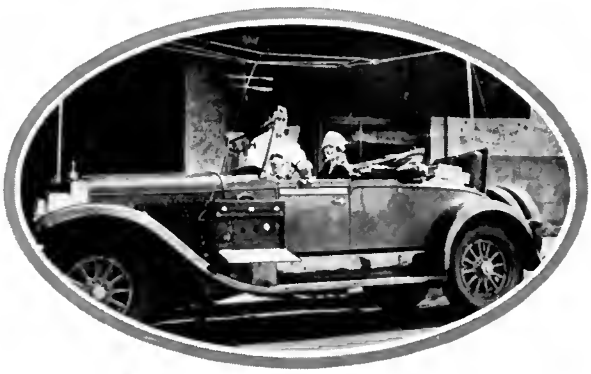
"If it happens that other acts have the same song in their routine, they are required to substitute something else. If this were not done in vaudeville, patrons would in many cases hear the same song two or three times during the course of a show."

GOOD STUFF IN CHIGACO

IF YOU are anywhere near Chicago the best thing available during the daytime in that neck of the woods is the noon musical period furnished by WGN—almost a full two hours of instrumental music of a caliber quite as good as most of the expensive evening programs. From 12:40 to 1:00 P. M. a luncheon concert by the Drake Concert Ensemble and the Blackstone String Quintet; 1 to 2 P.M. Lyon and Healy artist recital; 2 to 2:30 a luncheon concert. And frequently the succeeding half hour, 2:30 to 3 which is turned over to staff soloists, is equally pleasant.

Another Chicago daytime feature that comes as a welcome relief from the unending recipe and household hints lectures is the Overture Hour, WMAQ, 10 to 11 A. M. A varied program, made up according to the expressed wishes of the listeners, is played by the Whitney Trio. We have taken occasion to praise this trio before, while their playing can not yet be called inspired or resplendant with subtle nuances they are at least thoroughly routined and play with a coördination surprisingly good for such a young organization.

THE "COOKIES"
Lucile and Nell Cook, who have been heard in harmony over WEAF, New York, and WEBH, WJJD, Chicago



MARIE HILL OF KTCL, SEATTLE
A Cadillac roadster, equipped with a portable broadcasting set is used by Miss Marie Hill, studio hostess at KTCL in conducting what is known as "Juniata's Shopping Tour," a feature of the daily woman's hour program from this station.

AN ARTISTS' BUREAU AT WLW
WLW, following a practice already in efficient operation at several broadcasting stations, has organized an "Artists' Bureau," an agency for managing the outside bookings of artists appearing regularly on its programs. In the photograph are Emil Heerman, concert master of the Cincinnati Symphony Orchestra, Lydia Dozier, soprano, and Powel Crosley.

THUMB NAIL REVIEWS

WHO—The "Automatic Adjutators," on an advertiser's program, doing some pretty fair harmony singing with fine pianissimo effects. The tenor soloist did as good a job by "Three For Jack" as we have yet heard by radio. It is a surprising fact that songs of the ilk of "Three For Jack" are so seldom heard in radio programs; songs, if you are not familiar with this particular piece, which rely for their effect largely upon the words. Perhaps it is because so few solists can sing them effectively. They require an intelligence astute enough to fully grasp the meaning of, and properly interpret, the verse without at the same time so neglecting the music as to relapse into mere *recitative*. Of course "On the Road to Mandalay" and its sister song are given plenty of airings, but there is a host of other "speaking-songs" that are never heard. They are generally light in mood, sometimes quite funny, and mostly designed for male voices. We offer, gratis, the suggestion that a complete program be arranged of these songs and turned over to a capable singer. We venture to guess that it would be popular.

WLBW—Somebody playing classics on the piano in acceptable style. A premature fading out prevents further record.

WJAY—One of those so called "nut" hours. A reading of original poems by the announcers involved, which was not so hot. Some piano work which was a lot better. And some comics which coaxed an occasional grin. Professor Bumguesser, burlesquing the radio seers, of which we had an epidemic recently, undertook to give answers to the various problems perplexing his listeners, along the lines of: *Q.* ". . . should I have the family wash in the back yard? Signed, "Puzzled Housewife." *A.* "No, the neighbors might fall out the windows." and *Q.* "Should I allow my boss to help me get the mail out or should I stick the stamps on myself?" *A.* "They will be much more effective on the letters."

WGBS—Morry Leaf, the "Eskimo Ukist" and "Bad-Time Story-Man" burlesquing the gwan-to-bed programs and singing some swell original ditties.

WHT—"Al and Pat" on the "Your Hour" (Announcer Pat Barnes and Organ-

AT 3 LO, MELBOURNE, AUSTRALIA

This young woman is not giving a lecture on tooth paste, but has just concluded a recital of "Songs at the Piano." She is Lee White and is, we are told, very popular with Australian audiences

ist Al Carney —we had their names backwards last time we mentioned them—beg pardon!) Between the two of them they put on the complete graduating exercises of a "deestrict school," the unctuous trustee, the quavering voiced teacher, and the smart pupils. We recommend them to you. Humorists of the old, ever-reliable, school.

KFAB—A station operated by an automobile dealer. We sat through a long and tedious direct advertising talk just to see how far they would go with it. They went plenty far enough, a full fifteen minutes was devoted to a long winded discussion on why the car they sold was equipped with cast iron pistons. The main issue seemed to be whether or not wear and tear on the piston was more disadvantageous than wear and tear on the cylinder. Long arguments pro and con were duly considered and the proper and predetermined conclusions reached. Aside from the effrontery in offering such a bald piece of advertising at all, the discussion was of such a technical nature that it could not conceivably have interested anybody less than an automotive engineer. What average motor car buyer gives a whoop, we ask you, whether his car has cast iron pistons or not? And how many other listeners besides ourself—who is paid to do so—lasted out the boring dissertation?

WCFL—"The Two Peppers" delivering some not bad close harmony and some very high-powered self accompanying, and solo work, on the guitar and banjo.

WEBH—The Indiana Male Quartet singing a good novelty song having to do with Whispering Sweet Whispers.

WJZ—A first rate concert now being broadcast every Sunday evening at 9:30 Eastern Daylight Saving Time. A studio orchestra consisting of eighteen instrumental soloists in woodwinds, strings and brass, under the direction of Hugo Mariani. The first program, typical of the ones following, was made up of the lighter and most popular compositions of Goldmark, Strauss, Massenet, Wagner, Schubert, Chaminade, Tschaikowsky, Herbert, and Saint-Saens.

WMCA—Art Gillham, singer of sentimental ballads, par excellence, accompanying himself on the piano.

WOR—A good instrumental ensemble and an unusual one: a trio made up of harp, violin and flute. Called the French Trio and under direction of Mme. Savitskaya.

COMMUNICATIONS

WE QUOTE a couple of paragraphs from a long and interesting letter from G. W. Ferens of New Zealand.

The class of programme transmitted is, in a small way, similar to those broadcast by your well-known stations. You are probably aware that the receiving conditions in New Zealand are considered by experts to be the finest in the world due to our geographical position. For instance, a receiver that is not capable of consistent reception of Australian broadcasts every night of the week over a distance of 1400 to 2000 miles is no good whatsoever in this country. A powerful receiver has no trouble at this time of the year in bringing in Pacific coast Stations and even Chicago. In fact, I have many a time listened to KFON at Long Beach on the loud speaker for two hours and heard it as well as a listener in the Middle West would receive that station. In passing, I would like to mention that KFON is the best American broadcasting station heard in this part of the country.

I trust that you will now understand how acceptable the information in your columns is to readers here, when we can, in many cases actually hear the stations and artists of which we read about. In particular the photographs of the artists and the general description of programs are very interesting and it gives one quite a thrill to hear an artist or an orchestra who, through your columns, one considers an old acquaintance

Ashtabula, Ohio.

Sir:

Re: Sunday Broadcasting, July issue, you have ably covered a subject that has been too long and too much ignored by anyone actively interested in radio programs . . . Church services have a legitimate place in broadcasting but they are not enjoyable to the exclusion of everything else, and neither are the heavy, slow musical features and hymns.

A. K.

D. R. P. COATS

Former program director and announcer at CKY, has taken charge of a new station erected by a manufacturer at Moose Jaw, Saskatchewan, CJRM

Washington, D. C.

Sir:

On the Eveready hour the substitute manager one evening put on the 1812 Overture and then: "After the tumultuous emotions of this great work we will soothe ourselves back to normal by a soprano and tenor duet" and put on the grand seduction scene from Samson et Delilah. What dye mean "normal"?

E. S. S.

Los Angeles, California.

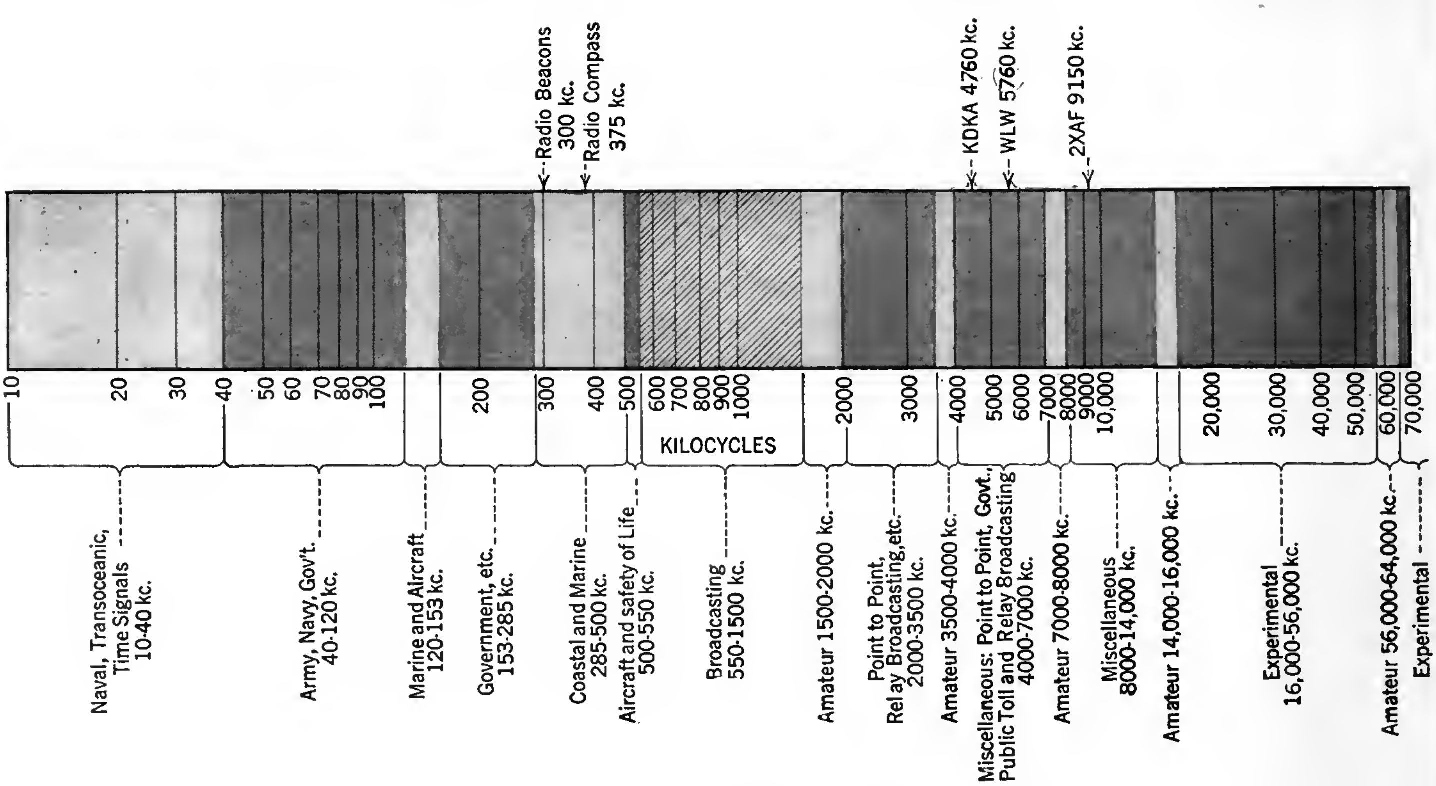
Sir:

The announcer at KFON has just informed his listeners that the orchestra would next play, "Folies Bergères," but, now for the big laugh, he announced it as "Foley's Brassiers," in the approved and generally accepted American pronunciation.

I. W. H.

AT WSM, NASHVILLE

The Andrew Jackson Hotel Trio, Vivian Olson, cellist; Marguerite Shannon, pianist, and Clair Harper, violinist, broadcasting daily through WSM



FROM TEN TO SEVENTY-THOUSAND KILOCYCLES

This diagram shows very clearly how the frequency spectrum between these two widely separated points is divided. and a very good idea of the comparative width of the band set aside for broadcasting may be had

Why Not Try the Short Waves?

In Which the Appetite of the Broadcast Listener Is Whetted—A Receiver for Exploring the Nether Regions of the Wavelength Spectrum, Where a Real Taste of Internationalism Is Possible

By KEITH HENNEY

Director of the Laboratory

OUT of a total number of frequencies available for radio communication amounting to some 60 million, the broadcasting band occupies only one million—a very small band indeed. What goes on in the other bands has been, until recently, a closed book to the vast majority of listeners because of the language used there—the International Morse code. Now, however, there are at least three American broadcasting stations using voice and music to modulate waves in these vast open spaces outside of our familiar broadcasting band, so that adventuring into the other 59 million frequencies is not too devoid of interest.

For many months the General Electric Company has put programs into the ether experimentally on a wavelength of 32.79 (9150 kc.) meters, and the 63-meter (4760 kc.) signals of the Westinghouse station KDKA are already too well known to need introduction. Recently WLW at Cincinnati has been using a band at 52 meters (5750 kc.) for rebroadcasting their regular programs and, according to reports, a 30-meter (9990-kc.) station operated in Eindthoven, Holland, can be heard during the early evening hours in the United States. Also, as this is being written (July) a station near Quebec is testing on approximately 32 meters (9380 kc.) and signing CS.

Here are five landmarks for which anyone equipped with a short-wave set can go seeking. Fortunately, it is possible to build a receiver for the high frequencies in a very simple manner indeed, and with removable coils one can cover the entire range from below about ten meters (30,000 kc.) to something beyond the broadcasting band, thereby opening up a vast expanse of receiving territory unfamiliar to the average listener, and filled with interesting goings-on.

The usual short-wave receiver uses only two tubes since headphone reception is the rule. The first tube is a detector, which may be made to oscillate, or not, as the operator desires, and the second tube is used in a transformer-coupled amplifier. If loud speaker signals are desired it is only necessary to provide an additional stage, preferably equipped with a power tube.

FREQUENCIES AVAILABLE FOR AMATEUR USE

AMATEURS in the United States operate in bands set aside for their use as shown in the table below. Other interesting services carried on the high frequencies are given in the box on page 291:

METERS	KILOCYCLES	WIDTH KC.
0.7477–0.7496	401,000–400,000	1000
4.96 –5.35	64,000–56,000	8000
18.7 –21.4	16,000–14,000	2000
37.5 –42.8	8000–7000	1000
75.0 –85.7	4000–3500	500
150.0 –200.0	2000–1500	500

The illustration forming the heading of this article shows the part of the spectrum that broadcasting utilizes and also gives an idea of the many services which take place in the other parts of this spectrum. Above the broadcasting frequencies come the many-tongued bands filled with amateur transmitters. In the United States, for example, there are several sections in which amateurs may operate, that immediately above our broadcasting section (or below if we think in meters), then another at 3750 kilocycles, or 80 meters, one at 7500 kilocycles or 40 meters, and still others at 15,000 and 60,000 kilocycles, or 20 and 5 meters respectively.

Communications take place on these higher frequency bands that would be considered miraculous on lower frequencies. For example, on February 20th, 1927, the following stations were heard at 2 EJ, one of the stations operated by RADIO BROADCAST Laboratory, on or below the so-called 40-meter (7500-kc.) band:

EST	STATION	LOCATION
3:35 P. M.	NL 4 X	West Indies
	G 5 XY	England
3:50 "	FO A 3B	South Africa
3:55 "	G 5 XY	England
4:00 "	EK 4 UAH	Germany
4:07 "	OA 5 WH	Australia
4:20 "	F 8 IB	France
6:25 "	SB 1 AR	Brazil
6:35 "	NQ 5 AZ	Cuba

Thus, in a space of one hour and a half, it was

Coil No.	Wave-length Range Meters	Kilocycle Range	Secondary, L_2 Total Turns	Secondary, L_2 Length of Winding Inches	Secondary, L_2 Size Wire	Secondary, L_2 Insulation	Tickler, L_3 Total Turns	Tickler, L_3 Size Wire	Tickler, L_3 Insulation
1	15-28	19,990-10,710	3	$\frac{5}{32}$	18	Enamel	2*	26	d.s.c.
2	30-52	9994-5766	8	$\frac{17}{32}$	18	Enamel	4*	26	d.s.c.
3	57½-111	5260-2701	19	$\frac{9}{16}$	18	Enamel	6*	26	d.s.c.
4	119-228	2399-1199	40	1½	22	d.s.c.	15*	26	d.s.c.
5	235-550	1276-545	81	1½*	26	d.s.c.	21*	26	d.s.c.

*Close wound.

Note: Tuning condenser is 100 mmfd. Primary, L_1, consists of 10 turns, wound in a space of 9-32nds inch, of No. 22 cotton-covered wire, and is 2¾ inches in diameter. Secondary is 3 inches in diameter.

possible to listen-in on the whole world. At another time BZ 1 IB, a Brazilian Amateur, was heard talking to GMD, the Dyott Expedition. It would be possible to go on indefinitely with stories of long distances covered and interesting experiences, but the preceding paragraphs should give the uninitiated some idea of what can be expected in the short-wave provinces.

Kits of short-wave coils, condensers, etc., are now available from several manufacturers, and with these, receivers may be constructed. All of these receivers will radiate and can disturb near-by listeners, but with loose coupling to the antenna and an additional audio stage if necessary to make up for the decrease in signal strength, this radiation is reduced to a minimum.

In actual practice, the detector is on the point of oscillating when voice or music is being received, and when code signals are copied the detector is actually oscillating, but is near the point where oscillations are liable to cease. In these conditions the detector is most sensitive.

Attention is called to the two articles by Frank C. Jones, 6 AJF, on non-radiating short-wave receivers. Mr. Jones has made a substantial contribution toward the ideal receiver and the set described by him in RADIO BROADCAST in May, 1927, approaches very closely to a truly non-radiating receiver.

How the Higher Frequencies Are Allocated

An idea of what goes on in the higher frequency bands may be gleaned from the following table, which shows how the various frequencies were divided up by the Fourth National Radio Conference:

Kilocycles	Meters	Service
500-550	600-545	Aircraft and fixed safety of life stations.
550-1500	545-200	Broadcasting only.
1500-2000	200-150	Amateur only.
2000-2250	150-133	Point to point.
2250-2300	133-130	Aircraft only.
2300-2750	130-109	Mobile and Government mobile only.
2750-2850	109-105	Relay Broadcasting only.
2850-3500	105-85.7	Public toll service, Government mobile, and point-to-point communication by electric power supply utilities, and point-to-point and multiple-address message service by press organizations, only.
3500-4000	85.7-75.0	Amateur, Army mobile, naval aircraft, and naval vessels working aircraft, only.
4000-4525	75.0-66.3	Public toll service, mobile, Government point to point, and point-to-point public utilities.
4525-5000	66.3-60.0	Relay broadcasting only.
5000-5500	60.0-54.5	Public toll service only.
5500-5700	54.5-52.6	Relay broadcasting only.
5700-7000	52.6-42.8	Point to point only.
7000-8000	42.8-37.5	Amateur and Army mobile only.
8000-9050	37.5-33.1	Public toll service, mobile, Government point to point, and point-to-point public utilities.
9050-10,000	33.1-30.0	Relay broadcasting only.
10,000-11,000	30.0-27.3	Public toll service only.
11,000-11,400	27.3-26.3	Relay broadcasting only.
11,400-14,000	26.3-21.4	Public service, mobile, and Government point to point.
14,000-16,000	21.4-18.7	Amateur only.
16,000-18,100	18.7-16.6	Public toll service, mobile and Government point to point.
18,100-56,000	16.6-5.35	Experimental.
56,000-64,000	5.35-4.69	Amateur.
64,000-400,000	4.69-0.7496	Experimental.
400,000-401,000	0.7496-0.7477	Amateur.

Each of the coils designed for the short-wave kits differs from the others, Silver-Marshall using a form similar to broadcast coils, Aero Products using spaced windings on slotted forms, REL supplying the familiar basketweave style, and those of Gross or Hammarlund consisting of spaced windings on a celluloid form.

WINDING THE COILS

For the experimenter who likes to make his own, the following description of coils similiar to the Aero inductances will be helpful. The number of turns for the various frequency bands to be covered is given in the table on this page.

An insulating tubing three inches in diameter can be used without introducing much loss. The tickler coil is, in each case, 2¾ inches in diameter and is made self-supporting by using collodion or some other binder. This coil is placed inside the secondary at a position near the grounded end of the coil and need not have a great deal of mechanical strength as it is protected by the secondary. The same primary is used for every coil and should be fastened on a hinge which makes it possible to vary the coupling as desired. This coil is made self supporting, is wound without spacing, and a binder is used to keep it in shape. It is wound with ten turns of No. 22 double silk-covered wire. The primary may be mounted on the sub-panel of the receiver. It will be found, in operation, that the setting of the coupling need not be changed very often and once adjusted properly may be left in a fixed position. Secondary coils Nos. 1, 2, and 3 are wound with No. 18 enameled wire spaced approximately the diameter of the wire. Secondary coil No. 4 is space wound with No. 22 double silk-covered wire, the dimensions of the coil being 1½ inches by three inches. Coil No. 5, which covers the broadcast band, is wound with No. 26 double silk-covered wire and is not spaced. The coils are mounted on flat strips of bakelite, and four connections are brought out from each coil in the form of pins, mounted on the bakelite strips. The pins are designed to fit into corresponding slots in the sub-panel mounting. Three pins are spaced at one end of the bakelite strip with a fourth apart from the others, making it impossible to plug the coils in the wrong way. Almost any type of plug system having four contacts may be used. Suggestions have been made from time to time for using an old base of a vacuum tube and a tube socket for this purpose. If such a device is used care should be exercised to see that too much capacity is not introduced, otherwise the wavelength ranges will be considerably affected.

This covers the mechanical details of the coils. It is not necessary to go into details of the wiring of the receiver shown in Fig. 1 as most of our readers are familiar with this part of set building. It is important, however, especially in short-wave work, to make the grid lead very short and to keep all wires rigidly fixed in their respective positions. The actual order of wiring is not mandatory but it is suggested that the filament wires be completed first.

The circuit used for the several kits on the market is fundamentally the same. That used in the Aero kit is shown in Fig. 1. The Radio Engineering Laboratories kit consists of a complete set of parts, including panel, wire, transformer, coils, etc., and lists at $36. Silver-

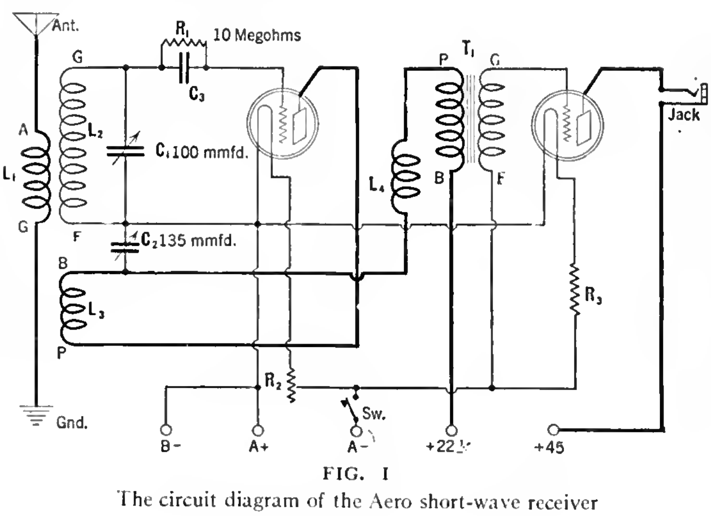
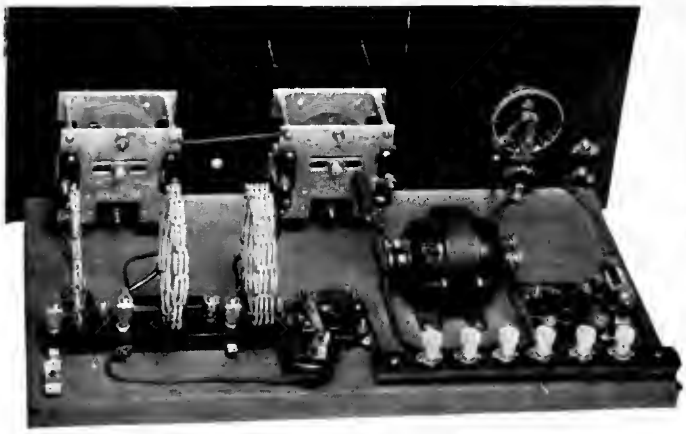


FIG. 1

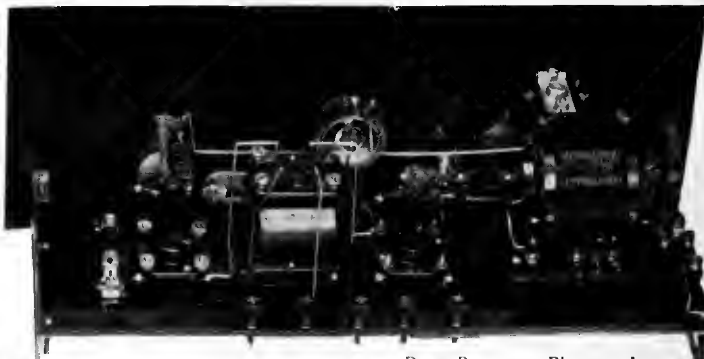
The circuit diagram of the Aero short-wave receiver



RADIO BROADCAST Photograph

MADE IN THE LABORATORY

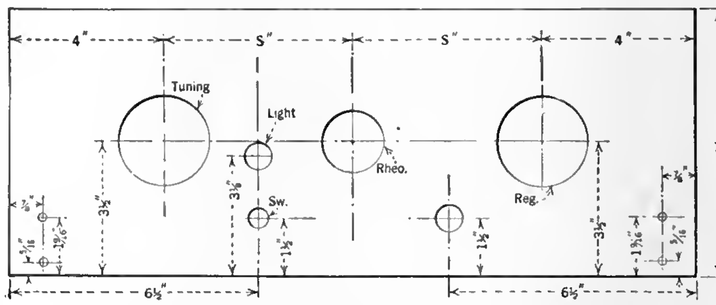
The short-wave receiver here shown employs REL coils, National condensers, X-L binding posts, etc. The circuit is basically the same as that shown in Fig. 1



RADIO BROADCAST Photograph

THE RECEIVER DESCRIBED IN THIS ARTICLE

The parts list and panel layout for this particular receiver are given on this page while the circuit diagram appears as Fig. 1, on page 291



PANEL LAYOUT OF THE SHORT-WAVE RECEIVER

Marshall's kit includes coils, coil socket, and three condensers and lists at $23.00. Other kits of coils are sold by the Aero Products Company as indicated on the list of parts in this article, and that sold by J. Gross which lists at $27.90. Aero also stocks a short-wave drilled and engraved foundation unit listing at $5.75.

THE ANTENNA

THE antenna used with these receivers may be of practically any type, long or short. A long outside antenna will naturally give the better DX results, though the coupling between the primary and secondary coil will have to be reduced or perhaps a series condenser inserted in the lead-in, if it is found that the set refuses to oscillate over a certain band. This is probably due to absorption by the antenna. A little experimenting with the coupling or perhaps changing the antenna length or position will usually remedy this.

Another point which is important in making a set of this character oscillate evenly over the entire band is the grid leak. For best results a high-resistance leak should be used, say of 6–10 megohms. The detector tube should go in and out of oscillation easily when the regeneration condenser is varied. As seen from the circuit diagram the set may be grounded on the negative return (dotted lines) or not, according to which connection gives the better results. A little time spent in becoming familiar with the adjustments of the set will tend to insure better results and at the same time preclude unnecessary disappointments.

The variable condenser used for tuning the set illustrated in Fig. 1 is one of 100 micro-microfarad (0.0001-mfd.) capacity. While this condenser does not quite cover the entire bands it does spread out the available bands and makes tuning much easier. If it is desired to cover every wavelength over the full range a small shunt condenser may be placed across the main condenser and be operated with a switch. A straight frequency-line condenser is used for tuning. The regeneration control condenser may be of any type as this control is not at all critical.

A list of parts for this Aero receiver, shown diagramatically in Fig. 1, made in the Laboratory, and used at 2 GY, is given below, and panel and sub-panel layouts are shown in Figs. 2 and 3.

RADIO BROADCAST Photograph

ANOTHER SHORT-WAVE RECEIVER

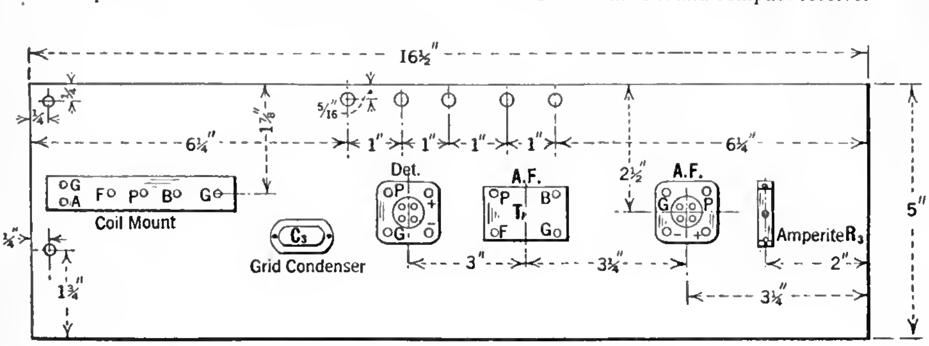
Silver-Marshall parts form the basis of this efficient and compact receiver

LIST OF PARTS

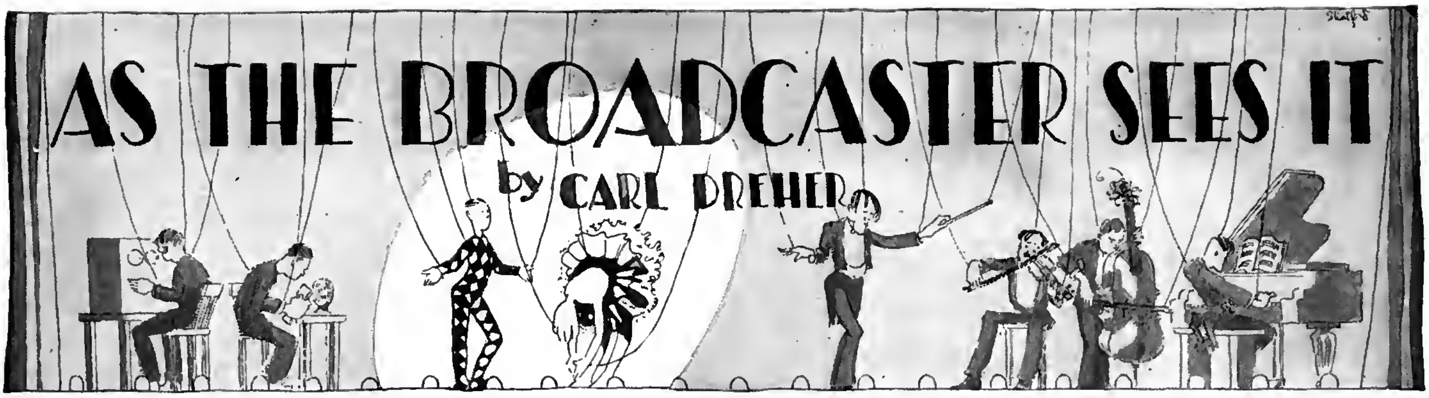
L_1, L_2, L_3—Short-Wave Kit Consisting of Coils Nos. 1, 2, and 3 with Primary and Plug-In Mounting, Aero Products Company (15–111 m.)	$12.50
L_2—Coils Nos. 4 and 5, Aero Products Company (119–550 m.)	8.00
L_4—Silver-Marshall Short-Wave Choke	.60
C_1—Hammarlund Variable Condenser, 100 Mmfd.	4.25
C_2—Precise Variable Condenser, 135 Mmfd.	2.00
C_3—Sangamo 0.0001-Mfd. Grid Condenser with Mounting	.40
R_1—Grid Leak, 10 Megohms	.50
R_2—Frost 20-Ohm Rheostat	.50
R_3—Amperite and Mounting, 1–A	1.10
T_1—Samson 6:1 Audio Transformer	5.00
Two Benjamin Spring Sockets	1.50
Yaxley Single-Circuit Jack	.50
Yaxley Combination Switch and Pilot Light	.75
Two Benjamin Brackets	.70
Five Eby Binding Posts	.75
Two Karas Vernier Dials	7.00
Radion Hard Rubber Panel 7 x 18 x $\frac{3}{16}$ Inches	2.50
Radion Hard Rubber Sub-Panel 5 x $16\frac{1}{2}$ x $\frac{3}{16}$ Inches	1.65
Wire, Screws, Etc.	.50
TOTAL	$50.70

ACCESSORIES NEEDED

2 CX-301-A Type Tubes
1 45-Volt B Battery
Pair of Phones
Antenna and Ground Connections



A SUB-PANEL LAYOUT OF THE RECEIVER

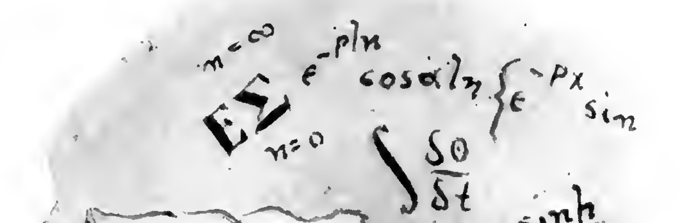


Drawings by Franklyn F. Stratford

Design And Operation Of Broadcasting Stations

17. *Attenuation Pads*

THE instrument known as a "pad" among broadcasters is usually a simple resistive network used to cut down signal level by a definite amount. It may be adjustable, but more frequently various sizes are supplied with the terminals led to jack strips so that a loss of, say, ten, twenty, or forty TU may be introduced at will. A general and sufficiently exhaustive treatment of passive networks in general may be found in Chapters VIII and XI of *Transmission Circuits for Telephonic Communication*, by K. S. Johnson. (D. Van Nostrand Co.) The most thorough work on the subject of artificial lines is no doubt *Artificial Electric Lines*, by A. E. Kennelly, Sc. D. (McGraw-Hill Book Company). Being by Doctor Kennelly, this book leaves little to be said on the subject; the reader must be warned, at the same time, that the mode of approach is through hyperbolic geometry and the calculus, quite in the Heaviside and Steinmetz tradition. Here we shall present only a restricted, elementary, practical treatment of one aspect of the subject, for the benefit of those of the boys who have not gone to M. I. T., but manage to broadcast anyway.



"THE READER MUST BE WARNED"

Fig. 1 shows a typical pad of the "H" form. With the resistances shown this network will introduce a loss of 20 transmission units, while presenting an impedance of 500 ohms in either direction. It might be used in the output of an amplifier terminated in a transformer with a 500-ohm secondary, between this secondary and a line, in order to keep the current in the line within allowable cross-talk limits, or for a similar purpose. Fig. 2 illustrates a line which will lose something a little less than 40 TU, but at a lower impedance—about 246 ohms, forwards and backwards. It will be noticed that the sum of the two side resistances and the shunt member gives the approximate impedance presented by the network, when the resistance of the shunt member is low compared to the rest of the artificial line on the other side and the apparatus tied thereto. This qualification must not be neglected, for, as in the 10-TU pad shown in Fig. 3, the impedance may be 500 ohms in each direction, while the sum of the three members of the network proper is 125 plus 125 plus 375, equalling 625. However, the 375-ohm shunt member is paralleled by 750 ohms (125 plus 125 plus the 500 ohms of the actual line) which brings the resultant down to 250 ohms, and 125 plus 125 plus 250 equals 500.

In Figs. 1, 2, and 3 we have shown H-shaped artificial lines of various sizes, and with the same impedance looking in either direction. This type of line exhibits complete symmetry, the resistance being the same on each side of the pair, and the impedance the same on each side of the cross-member. Except for the consideration of bilateral symmetry, any such H-network may be replaced by a T-network with three members instead of five. For example, take the 10-TU H circuit of Fig. 3. This may be replaced, if perfect symmetry is not required, by the T circuit of Fig. 4. The only change is in the shifting of one 125-ohm resistance to the same side as the other, leaving no series resistance on one side and collecting 250 ohms on the other. The ohmic relations are unaffected. A different effect is secured when the network is unsymmetrical about the cross member. Then the impedance looking backwards and forwards is changed. To illustrate: take the 40-mile pad of Fig. 2, presenting some 240 ohms at both terminals. Assume that it has become necessary to match a 500-ohm circuit on the right. The network might then be modified as shown in Fig. 5. Toward the left the impedance remains sensibly unchanged, but toward the right the impedance is now approx-

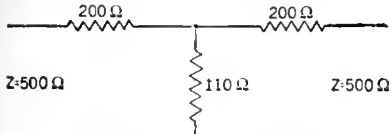


Fig. 1

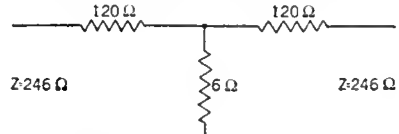


Fig. 2

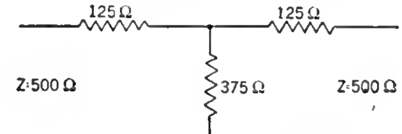


Fig. 3

imately 500 ohms. This network would match a 200-ohm output to a 500-ohm input. At the same time, of course, the attenuation of the pad has been changed. The magnitude of the change may readily be calculated, but instead of taking this network as an example we shall outline in a more general way the simple theory involved. All that is required is an acquaintance with Ohm's Law.

Fig. 6 shows a network of the H-type, with series resistances x_1 and x_2 and shunt resistance y. The impedance on either side of this network is Z. In the calculation we shall also use the quantity r, which represents the resistance of the shunt combination formed by y paralleled by $x_2 + Z + x_2$. E_1 is the voltage across the input of the network, Ey the voltage across the shunt member y, E_2 the output voltage of the device. The current in the left-hand rectangle is i_1, that in the right-hand rectangle is i_2. With these symbols we may carry out a sufficiently accurate calculation.

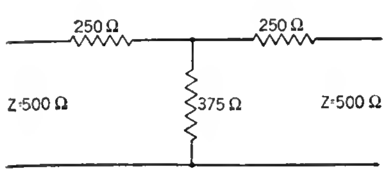


Fig. 4

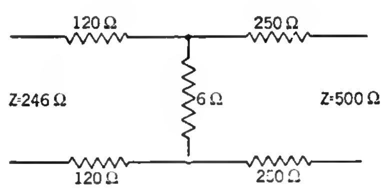


Fig. 5

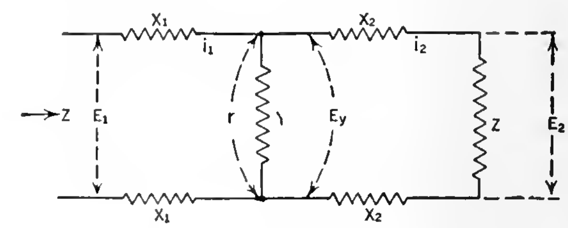


Fig. 6

First we may write

$$E_1 - 2\,x_1\,i_1 = Ey \qquad (1)$$

And $$Ey - 2\,x_2 i_2 = E_2 \qquad (2)$$

Whence $$E_1 - 2\,x_1 i_1 - 2\,x_2 i_2 = E_2 \qquad (3)$$

Or $$E_1 - 2\,x_1 i_1 = E_2 + 2 x_2 i_2 \qquad (4)$$

Also $$i_1 = \frac{E_1}{2\,x_1 + r} \qquad (5)$$

And $$i_2 = \frac{E_2}{Z} \qquad (6)$$

Substituting (5) and (6) in (4), we obtain

$$E_1 - \frac{2\,x_1\,E_1}{2\,x_1 + r} = E_2 + \frac{2\,x_2\,E_2}{Z} \qquad (7)$$

Or $$E_1\left(1 - \frac{2\,x_1}{2\,x_1 + r}\right) = E_2\left(1 + \frac{2\,x_2}{Z}\right) \qquad (8)$$

Simplifying $$\frac{E_1}{E_2} = \frac{(Z + 2x_2)\,(r + 2\,x_1)}{Zr} \qquad (9)$$

The value of r is found readily on the principle that the resultant conductivity (the reciprocal of resistance) of paths in parallel equals the sum of the individual conductivities:

$$\frac{1}{r} = \frac{1}{y} + \frac{1}{2\,x_2 + Z} \qquad (10)$$

Clearing of fractions

$$y\,(2\,x_2 + Z) = r\,(2\,x_2 + Z) + r\,(y)$$

Whence $$r = \frac{y\,(2\,x_2 + Z)}{2\,x_2 + Z + y} \qquad (11)$$

By definition, the TU loss of the network is given by

$$L = 20 \log_{10} \frac{E_1}{E_2}$$

(See this department in RADIO BROADCAST for September and October, 1926, for a discussion of the meaning of the telephonic "Transmission Unit.")

Hence, from (9) above

$$L = 20 \log_{10} \frac{(Z + 2\,x_2)\,(r + 2\,x_1)}{Z\,r} \qquad (12)$$

From (11) and (12) we may calculate the loss introduced by any H-network where the impedance is unchanged from input to output. In the usual practical case, where in addition $x_1 = x_2 = x$, (12) becomes

$$L = 20 \log_{10} \frac{(Z + 2\,x)\,(r + 2\,x)}{Z\,r} \qquad (13)$$

And $$r = \frac{y\,(2x + Z)}{2\,x + Z + y} \qquad (14)$$

We may now apply the last two formulas to the artificial line of Fig. 3, which was stated to be of 10-TU size. Substituting $x = 125$, $y = 375$, and $Z = 500$ in (14), we find

$$r = \frac{(375)\,(250 + 500)}{250 + 500 + 375} = \frac{(375)\,(750)}{1125} = 250$$

This value ($r = 250$) being substituted in (13) with the other numerical data, we have

$$L = 20 \log_{10} \frac{(500 + 250)\,(250 + 250)}{(500)\,(250)}$$
$$= 20 \log_{10} 3$$
$$= 20\,(0.477)$$
$$= 9.54 \text{ TU}$$

This answer is sufficiently close to the actual attenuation of the pad for all practical purposes, and the formulæ derived in the discussion above may be used in calculating the constants of other networks of the same type. The simplest procedure is usually to draw up a network for the required purpose on the basis of previous experience, make a calculation of the TU drop corresponding thereto, modify the constants as indicated by the result of the calculation, and by successive changes and calculations to approach the desired value. With a little experience a very few operations will be found sufficient.

Broadcasters In Church

A WHILE ago my distinguished colleague, O. B. Hanson, who presides over the engineering destinies of the National Broadcasting Company, a prominent architect of New York, and I, were engaged in argument concerning the merits and demerits of various commercial sound-absorbing materials. Harassed by the fireproofing zealots of the Building Department, who care little about the yearning of a broadcaster for acoustically flat studios, we sat sweating amid sample slabs of expensive special plasters and nondescript compounds, which we glared at through magnifying glasses, scratched with pencils, and chewed with our teeth. Finally, having exhausted our learning without reaching a conclusion, we leaped into a taxicab and sped to a point on First Avenue where, we had been informed, there stood a church whose domed ceiling had been treated with one of the materials in which we were interested, so that we might see and hear the virtues of this substance for ourselves.

Leaving my companions to pay the taxi driver, I approached the door of the edifice, which, I noted, was of the Catholic denomination. The door was open, and, removing my hat, I stepped into a sort of lobby, in which votive lights were burning. It was only at this point that I realized the incongruity of our errand with the primary purpose of the building. We had come neither for prayer, meditation, nor the confession of our sins, but to test the acoustics of an auditorium, a deed in itself neither good nor bad, but certainly not of a religious character. While I was casting about for the proper etiquette under the circumstances, my two friends, having settled the inevitable dispute as to who should have the privilege of paying for the ride, joined me, and together we entered, through a second door, the main body of the church. It was quite light, in contrast to the gloom of many church auditoriums, and empty, save for us and one fair penitent who knelt before the altar at the far end.

I need not tell my readers that it is the inviolate custom of all good broadcasters in the technical end of the business, on entering a hall of any kind, to clap their hands, whistle, yell, sing, and stamp on the floor in a learned manner, in order to test the acoustics of the enclosed space. The eyes of Mr. Hanson and myself rolled upward toward the groined ceiling of the church, and both of us felt the impulse to clap our hands, at least, but we stood as still as the statues of the saints confronting us on every side. We twitched and opened our mouths, but no sounds came forth. Such an inhibition is astounding in men who have been broadcasting as long as we have. The architect seemed to suffer less. Architects are concerned with the building of houses, rather than with the noises generated in them after completion.

"Now that we are here," I whispered, hunching my shoulders fearfully at the lady kneeling with her back to us, "how shall we proceed? What noise can we make without damning ourselves, if it has not been done already? What shall we do?"

"Don't you know any monsignors or high church dignitaries who might furnish us with a dispensation to make a racket in this church?" mumbled Mr. Hanson, wiping the perspiration from his brow with his hat.

"I do not move in those circles," I answered regretfully. "Once, at a reception on Pearl Street, I was introduced to a rabbi, but I left him to talk to a pretty girl. How about you?"

"I am an Episcopalian," confessed Mr. Hanson, in a tragic whisper.

"Cough!" the architectural gentlemen suddenly ejaculated, voicelessly. I flashed him a grateful look, and emitted several genteel but loud reverberations from the region of my diaphragm. Emboldened by the echoes, Mr. Hanson snapped his fingers under his coat, skilfully varying the pitch. I continued to cough and whoop. After about half a minute the lady at the altar crossed herself and rose, perhaps to send for an ambulance. If so, she has certainly increased her chances of ascending to heaven, because she neglected her own salvation to aid a fellow being. But it was equally possible that she was going to call the sacristan, so the three of us turned and fled. We slowed down on the next block and my colleague Hanson addressed me.

"I have spent a bad ten minutes," he said. "I'm never going into a church with you again. Knowing your record, I was afraid you would start to yell and howl as you do up at Carnegie Hall in order to impress the ushers, with the result that we would have been thrown out on our ears into First Avenue and clubbed by all the cops in the parish. Our social reputation would have been ruined if we had had to go to jail with you. Finally, I must say that you cough in a disgusting manner."

But I was unable to answer. I was still coughing.

That SOS Question Once More

THE behavior, actual and ideal, of broadcasters when an sos call is on the air, constitutes a question of perennial interest which has been discussed a number of times in this department, and will no doubt bob up again at intervals. Mr. Ray Newby of San Jose, California, wrote us about it some time ago, and his view is worth noting. Mr. Newby says:

I wish to take exception to the suggested complete shutdown of broadcasting stations in the vicinity of distressed vessels, and to take sides with the critic mentioned, who was in favor of a station coming on the air at intervals during sos shutdowns with its call letters and the reason for its silence.

The article in contradiction to this practice was well taken, but there are two sides to all questions. As an ex-ship operator, broadcast, etc., allow me to present mine.

With present-day commercial receivers there is no possibility of a broadcast station interfering with ship traffic carried on at 600 meters and above, and as to the 300-meter wave for ships, I think this is automatically eliminated.

Now for the main reason: Did it ever occur to you that the ship operators also listen to broadcast programs? Well, that is the case, even though the Chief Operator says that one ear must be on the stand-by wave (600 meters) at all times while the vessel is at sea. Now, if an operator's favorite broadcast station reminded him at intervals that there was an sos on the air, no doubt he would get both ears working where they were supposed to be, and possibly be of some assistance to the sos'er.

I claim from experience that this is entirely possible, and it is also probable that some one-operator oil boat, or perhaps a private yacht, might be within a stone's throw of the ship in trouble.

Mr. Newby takes a practical view of the matter, and what he says is pertinent enough. It is unfortunately true that some marine operators, standing their watches at sea, neglect their immeasurably important duty in order to listen to jazz on the higher kilocycle channels. I can understand why they do it, and I might be tempted myself if I were standing midnight-to-eight watches again—but that stunt is going to put one of the boys into jail yet. Mr. Newby's argument recognizes, and in some slight measure tolerates, this practice. I doubt whether it is wise to condone what amounts to criminal negligence, even to this degree. The great majority of ship radio operators are wholly reliable; they would as soon think of leaving their marine listening channels to hear some entertainment as they would push ahead of women and children into the life boats on a sinking vessel. The relatively few men who neglect their stand-by function on 600 meters are controlled to some extent, also, by the necessity of making a log entry every fifteen minutes.

. The point regardin gthe one-operator boats and private yachts not required to stand a regular radio watch, seems to me well-taken. In the case of yachts carrying only a broadcast receiver it would seem, however, that little good would be accomplished even if it became known, through a broadcast station's announcement, that an sos was abroad. In the absence of a telegraph operator the people on the yachts would have no idea where the ship in distress was to be found. The chance of succor from this quarter is hardly great enough to justify permitting powerful broadcast stations on the higher wavelengths to make lengthy announcements giving the location of the vessel in trouble, when these communications might interfere with the radio telegraph stations in direct charge of the situation. Furthermore, in actual practice stations below 360 meters, or well inland, generally do not shut down at all for sos calls, leaving only a fraction of the broadcast stations for possible utility in these situations.

My view has been right along that a careful study should be made of the possibility of interference by broadcast stations with distress signals, that those entertainment transmitters which may conceivably interfere should shut down and not let out another note beyond a bare sos sign-off formula till the clear signal is given by the radio telegraph station in charge, and that where there is no possibility of interference, broadcasting should be permitted to continue without interruption.

With more general high power broadcasting, however, another consideration arises. A powerful radio telegraph coastal station may have about five kilowatts in the antenna. A few of the broadcasters, existing and projected, possess ten times that energy. When an sos is heard, these stentorian voices become silent. Yet it is conceivable that under conditions of heavy static and a distress call far out at sea those fifty kilowatts might come in handy. It might be practicable to arrange some of the very high powered broadcasting stations so that they could be controlled telegraphically, in case of need, from the nearest Naval District Communication Office, the wavelength being shifted, by an automatic wave-changer, to 600 meters. The main item of expense would be the telegraph line. If the handling of sos signals were facilitated in even a small percentage of cases, it would be money well spent.

Blame It on Radio

UNDER this caption we have repeatedly reprinted denunciations of radio broadcasting, which has been blamed for every thing but prohibition and the World War, and would be blamed for those little annoyances as well if they had not antedated it. One of the most persistent of these eruptions of scapegoat psychology is the notion that broadcasting, or wireless communication in general, is responsible for heavy rainfall and floods. Only recently a noted French statesman is reported to have issued a discourse on this subject, suggesting solemnly that the excessive amount of broadcasting in Europe caused the Seine to overflow its banks. A domestic specimen follows below:

SUGGESTS RADIO INTERFERENCE CAUSED SOUTHERN FLOODS

Special to the New York Times

WASHINGTON, May 7.—The Federal Radio Commission has received a letter from a man in Hurricane, W. Va., suggesting that radio interference may be responsible for the present floods. He wrote:

"In view of the excessive downpour of rain and the havoc wrought by floods and the inability of dirt farmers to plow or plant lately, might it not be possible that 'high-wattage' from the many broadcasting stations is so magnetizing the ether, similar to lightning descending to earth, producing magnetic disturbances and rain?

"There surely is some cause. If broadcasting were suspended for ten days or two weeks in America we might find the culprit or nolle the indictment."

Toward the close of the World War there was a summer during which a great deal of rain fell. There resulted great suffering among summer hotel proprietors and the managers of carnivals, fairs, medicine shows, and the like. The organ of the latter, the *Billboard*, printed an advertisement, or remarked in one of its departments—I don't remember which—that the unusual amount of rainfall must be caused by the firing of the heavy guns in France. The bankrupt concessionaires were advised to go into the umbrella business. Exactly how the detonation of the guns, which could not even be heard a few hundred miles away—and it takes doggone few dynes per square centimeter to make an audible sound, and a dyne, withal, is a pitiably small force, such as might be exerted by a section of a human hair less than an inch long—just how that sort of disturbance was to cause rain to fall . . . but why labor the point? Schiller said all there was to be said when he declared, "Against stupidity the gods themselves fight in vain." And if there is any field in which superstition is rampant, it is the perennial topic of the weather, in its relation to the other phenomena of the universe. After all, radio only gets a little tar from that stick. Ignorant people have always feared the "powers of the air."

As for the suggestion of the gentleman from Hurricane, W. Va., I announce myself in favor of it, although not for the reason he mentions. I could use a two weeks' vacation very nicely almost any time.

Correction On The Gamma Rays

MR. S. WHITTEN of Berkeley, California, justly takes us to task in the following letter:

Please refer to the center column of Page 107 of your June, 1927 issue, in which the wavelength of the gamma rays of radium is given as about 200 Angstroms.

A few years ago some bright gentlemen got a lot of credit for measuring X-rays as *long* as 15 Angstroms, and Millikan measured ultra-violet rays as short as 400 Angstroms. So I'm afraid someone misinformed you and dropped you in a dark and lonesome part of the spectrum. Therapeutic X-rays are around one Angstrom and gamma rays are one-tenth to one-twentieth as long. (See Page 96 of the *Bell Technical Journal*, January, 1927, for a fine discussion).

I like your department and wouldn't be as rude as this, but we radio bugs are "powerful ignorant" about some things and I hate to see it spread.

I'm glad to see that Mr. Stratford uses log-log slide rules in his pictures. Few of us can use them any other way.

The article in the *Bell System Technical Journal* to which Mr. Whitten refers is by Dr. Karl K. Darrow, on "Contemporary Advances in Physics—XII. Radioactivity," and, curiously enough, it was lying on my desk when I perpetrated the lamentable bull now dragged into the light. Doctor Darrow remarks:

The gamma-rays are spread out into a spectrum, and sometimes lines are discernible in the spectrum; but the line of shortest wavelength thus far measured (so far as I know) is at 0.052 Angstrom units or 52 X-units, and there are certainly many others at much shorter wavelengths which the crystal spectroscope does not diffract far enough outward to be located.

As for Mr. Franklyn Stratford, whose name has adventitiously entered the discussion, let it be known that by vocation he is an engineer, engaged, furthermore, in the active practice of the telephone and telegraph arts. The sketches with which he has amused the readers and the author of "As the Broadcaster Sees It" for, now, over two years, are merely one of his relaxations from TU calculations and struggles with quadruplex balances.

The Causes of Poor Tone Quality

How to Systematize the Search for and Remedy the Causes of Distortion in Radio Receivers

By EDGAR H. FELIX

THE radio listener may, with the aid of modern amplifiers and reproducers, secure tonal quality which is little short of perfect. Advances made this last twelvemonth have lifted radio reception from near-mediocrity to such a standard that it is possible to reproduce music difficult to distinguish from the original. The full force of this statement, however, cannot be realized unless one has opportunity, over a period of hours, to compare a last year's receiver with the best kind of modern equipment. For this purpose, switches must be installed so that one may change from an inferior amplifier system to a modern one without the loss of an instant. After such a test, there are few listeners who would be content with anything less than the best reception attainable.

In general, distortion arises either from improper operation and adjustment of the receiving set and its associated equipment, or from imperfect design of parts in the set itself. When improper operation or adjustment is the cause the trouble may lie almost anywhere in the radio receiver. Given a high-grade amplifier system and a loud speaker adequate to handle the output of the receiver, distortion may yet exist because of failure to work within the power or voltage limitations of one or more parts of the receiver. The most frequent cause of curable distortion is overloading of vacuum tubes.

Any judgment formed must be based only upon the reproduction of high-grade broadcasting stations. Not more than ten per cent. of the broadcasting stations on the air exercise sufficient care in the placing of their artists before the microphone, in the adjustment of the input amplifier, and in determining the percentage of modulation, to be classed as being fit to listen to by the owner of a really high-grade receiving set capable of true reproduction.

Overloading may arise in almost any part of the radio receiver. Briefly, it is manifested by blurred, ringing, or harsh effects, particularly noticeable on loud signals. A receiver so overloaded but otherwise satisfactory, gives high-grade reproduction when tuned to nearby stations which deliver a strong signal providing the volume is so adjusted that the music is only quietly and softly heard. Under those conditions, a good receiver gives adequate amplification of low, middle, and high registers, meeting all the requirements constituting good quality. Yet, when volume is increased, displeasing distortion may occur. Oftentimes, this kind of overloading may be corrected by adjustments.

DISTORTION ARISING IN THE R. F. AMPLIFIER

THE first point of distortion which we will consider is that occurring in the radio-frequency amplifier. Distortion in this part of the receiver is not always due to too powerful a signal but frequently to the influence of regeneration. It may be present, therefore, even though the signal itself is weak. Appreciable regeneration in the radio-frequency amplifier is fatal to good quality because it cuts off the high frequencies and causes the lower frequencies to be drummy and ringing.

No matter what the circuit used, good quality cannot be expected if the radio-frequency amplification is mainly regenerative. With the most modern receivers, sensitiveness and volume may be controlled by a means of varying the gain in the radio-frequency amplifier. With such receivers, it is not difficult to determine if distortion is due to overworking of the radio-frequency amplifier.

Tune to the most powerful nearby station, and then weaken the signal to *moderate* volume, at the same time observe the quality carefully. Now tune-in a station at a moderate distance which is delivering considerably less energy than the first station. For instance, if the first station is a 500-watter, twenty-five miles distant, pick a second station of equal power forty of fifty miles away. Then, by adjustment of the radio-frequency amplifier control, bring the volume of the second station up to the same point of moderate volume as the first. Provided the quality of transmission of both stations is equal, there will be a marked falling off of quality with the more distant station because of the regenerative influence. An additional stage of radio-frequency amplification, or limiting reception to only nearby stations, is the cure for this condition.

READERS of RADIO BROADCAST *have made so many requests for specific information as to A and B power devices, tubes, single-control sets, and the various other subjects treated in this series of practical articles on how to select and judge the quality and performance of manufactured products, that we have arranged to make it more convenient to take advantage of the information which we can make available.*

If you are interested in learning of manufactured products, embodying the features of high-grade tone quality, mentioned in this article, and the one which preceded it, address the Service Department, RADIO BROADCAST, Garden City, New York, *and the necessary information will be sent to you. Preferably use one of the two forms below in wording your letter or postal:*

(1.) I desire to convert my .... receiver into one giving the best tone quality. Please send me information as to suitable apparatus which will accomplish this purpose.

(2.) I desire information as to manufactured receiving sets which give the high-grade tone quality described in the series of articles on that subject in the July, August, and September issues of RADIO BROADCAST.—THE EDITOR.

It must not be assumed that absence of a regeneration control implies that no regeneration occurs in the receiver. If stations, particularly distant ones, fall into tune with a hiss and give good quality only when tuned-in exactly, but distort badly if de-tuned slightly, the regenerative effect is likely to be present. The result is that the "highs" are lost and the "lows" are drummy and throaty.

One source of regeneration, both in the audio and radio amplifier, arises from inadequate bypassing and failure to keep the radio and audio signals out of the plate potential leads. This may be caused by magnetic coupling between transformers or by conductive coupling in the power supply leads. The latter difficulty is obviated by the use of choke coils in the plate supply leads and adequate bypass condensers to shunt the radio- and audio-frequency currents. This precaution of adequate choking and by-passing is usually neglected in home-built receivers.

The high-grade manufactured receiver of 1927 employs three and four stages of fully shielded radio-frequency amplification. Its range is likely to be little more than that of the home constructor's receiver with one stage of radio frequency and a regenerative detector. It may deliver but little more signal to the detector than does the delicate receiver of the home constructor. The principal advantage of the four-stage r. f. receiver is not greater efficiency, but the fact that every element in it has a capacity far in excess of that which it is called upon to exert. Under all conditions it operates far below the overloading point. Similarly, a small four-cylinder automobile covers the ground just as rapidly and carries just as many passengers as a powerful straight-eight. The latter's reserve power, however, gives a smooth, gliding power, impossible with the small, four-cylinder car. Reserve capacity, in the case of a radio receiver, means a realistic tone with all the necessary volume variations between soft and loud to portray the varying feeling of musical compositions.

OVERCOMING DETECTOR OVERLOADING

THERE is a different form of overloading possible with high-gain radio-frequency amplifiers when too powerful a signal is offered to the detector tube. For example, home-made super-heterodyne receivers, equipped with a volume control only in the audio system (particularly if fed by an outside antenna) may overload the detector because too powerful a voltage is delivered to the grid of this tube. When the radio-frequency system is equipped with a volume control, usually through a filament rheostat in the first stage, no trouble is encountered from this source because it is possible to keep the volume below the point where the detector or audio stages overload. In absence of this well nigh essential control, reduce the signal input by considerably shortening the antenna. If a long antenna is considered necessary for distance work, install both a long and a short one, employing the latter for enjoying nearby stations.

Two stages of radio-frequency amplification, so neutralized that there is no regenerative amplification, require a fair sized antenna to produce a good signal, even from nearby stations. Three tuned stages of radio-frequency amplification work satisfactorily with a small, indoor antenna, while four stages pick up sufficient signal to work from a loop.

The use of a C-battery detector in preference to a grid leak and condenser, somewhat increases the handling capacity of the detector tube and reduces the danger of overloading, due to excessive radio-frequency energy. The best results are attained if the audio amplifier system is sufficiently good to give normal loud speaker volume when the detector signal, as heard in the phones connected in the detector circuit, is so weak as to be practically inaudible. Under those conditions, reception from a good station is characterized not only by absence of noticeable distortion but by great variations in volume following those existing in the original music.

When, however, the signal heard in the detector circuit with a pair of phones is comfortably loud, it is quite likely that at least the second stage of audio-frequency will be overloaded, unless a tube capable of handling considerable power and with correct plate and grid voltages is used.

The recommended C-battery voltages must invariably be used if overloading is not to be experienced even in the first stage, a precaution frequently neglected.

The same principle applies to power tubes. Generally speaking, the higher the amplification factor, the smaller the variation in grid voltage which may be impressed upon it without overloading. For example, the 112 (cx-312) type gives higher amplification than the 171 (cx-371) both of which, incidentally, may employ the same plate voltage. If powerful signals from nearby stations overload a 112 (cx-312) tube, the substitution of a 171, using proper grid biasing voltage, will very probably overcome overloading.

The output stage, to give a comfortably loud signal in a good sized living room, must employ a 371, a 310 tube, or perhaps, two 112 tubes in parallel. The 120 tube is of sufficient power to give satisfactory music only in a small room, unless used in connection with an amplifier which neglects the lower tones. When such semi-power tubes, rather than power tubes, are used, it is simply a matter of operating the set at low volume to attain good quality.

It is not often realized that the improvement of the audio-frequency system of a receiver by the substitution, for example, of three stages of resistance coupling for two poor transformers, or by the use of the highest grade of transformers now available in preference to a pair of low or medium priced transformers, means that the power handling capacity of the audio system, tubes and reproducer, may be easily exceeded. If, by this process of renovation, the lowest frequency amplified is brought from 200 down to 125 cycles, the voltage swings in the audio system may increase fivefold as a result. The hum from a poor-filtered power supply is now easily audible. The output tube and the reproducer, which might have been satisfactory under the old conditions, may overload considerably when better transformers are installed. By substituting, for the 120, a 371 or 310 output tube, satisfactory reproduction of low tones is secured. It must be said here that no receiver employing a 201-A type tube as the second audio amplifier is capable of quality reproduction. It is bound to overload and distort.

Quality of reproduction requires that every link in the chain—radio-frequency amplifier, detector, audio-frequency transformers, tubes in the audio stages, and reproducer—be adequate to do its work. Improvement of any one part of the receiver may simply uncover other weaknesses.

REPRODUCER PROBLEMS

A POOR loud speaker usually fails to reproduce a wide scale of frequencies, missing either "lows" or "highs." When a 171 or a 210 (Cunningham 371 or 310) tube is used, an output transformer, or choke and condenser, should be employed so that the direct-current component of the plate current does not pass through the loud speaker winding. This is absolutely essential. The coupling device must be carefully engineered. Listeners still using the old diaphragm type of speaker with the short narrow necked horn need not expect good reproduction because such a horn cannot release the lower tones properly. Cones of small diameter give good reproduction of the high tones but are incapable of setting up the lows. Again we must realize that distortion in the radio-frequency amplifier, or that overloading the detector, audio stages, or loud speaker, is fatal to true reproduction and is best cured by strengthening the weak link or maintaining the receiver at gentle volume.

One of the most difficult causes of distortion for the receiving set owner to analyze for himself is the kind which creeps upon him gradually. When the receiving set is first installed, it may give amazingly good reproduction but quality may fall off so gradually that this deterioration does not attract the attention of the listener. This often occurs because the voltage of the power supply falls or amplifier tubes lose their emission or A batteries run down. With socket B power supply, gradual deterioration of the rectifier tube may bring this trouble. B batteries used too long bring about the same result. Amplifier tubes themselves are often used unconsciously long after their emission has fallen below the point where they carry the low tones without distortion.

RESONANCE PEAKS AND THEIR CONTROL

DISTORTION is sometimes of the resonant variety, that is, confined to a particular frequency rather than spread over a wide range. This is particularly true of horn type loud speakers or poor transformer-coupled audio amplifiers. When the loud speaker is on top of the cabinet, it frequently causes the cabinet to be vibrated mechanically and that, in turn, causes the tube elements themselves to vibrate, producing distortion due to mechanical resonance of tubes, etc. If the loud speaker is moved twenty feet away from the set, the mechanical energy of the sound wave imparted to the tubes is reduced to a minute fraction.

Microphonic tubes usually have a characteristic ringing sound fairly familiar to the listener, and moving the loud speaker some distance from the set often prevents a continuous "sing" produced by mechanical resonance. Sometimes this cure is inconvenient to apply and less troublesome means may be successful. First try changing the tubes about in different sockets, giving particular attention to the detector tube. Tap each tube lightly and see which one causes the most ringing noise. Frequently the microphonic tube may be identified in this way. Exchange that tube with each of the other stages until the trouble is minimized. With dry cell tubes, it often pays to wrap a cloth around the detector tube or, better yet, to use one of the weighted arrangements or vibration dampers made for the purpose.

A convenient expedient is to hang the reproducer from the moulding so that it is mechanically free and clear of wooden floors and furniture. Plaster walls do not transmit the frequencies to which cabinets resonate nearly as readily as do tables and floors.

Super-sensitive detector tubes often introduce the resonance type of distortion and this effect may frequently be minimized by burning the filament rather brilliantly.

Those who read the article in last month's RADIO BROADCAST on quality of reproduction should have no difficulty in detecting the absence of either "highs' or "lows." Whatever the kind of amplifier the home constructor likes, transformer, resistance, impedance, or combinations thereof, it is entirely possible to secure relatively perfect reproduction. A loss of a broad band of frequencies, if no regenerative or resonant effects are present, almost invariably points to an incapable reproducer or the use of coupling devices which give a filtering effect.

The experimenter who takes pride in the manipulation of a delicate, efficient, and sensitive receiving set is most likely to neglect tonal reproduction. Experiment is usually concerned with problems of efficiency—getting the greatest distance, the best possible selectivity, or the highest gain with the minimum number of tubes. The attainment of these objectives is in opposition to securing true tonal quality. More than half of those answering a recent questionnaire maintain two or more sets, one for experimental and long-distance purposes and a receiver for local high-grade reception which meets, or attempts to meet, the modern standards of good tone quality.

RADIO BROADCAST Photograph

CONCOMITANTS OF GOOD QUALITY

The use of power tubes, together with good reproducers, is essential if good quality signals of adequate volume are desired. The photograph shows a baffleboard "Peerless" cone and a Western Electric cone, together with a 171 type power tube

New Receiver Offerings for the Fall

What the Radio Industry Has in Store for the Set Builder—Advance Information about the Hammarlund-Roberts, LC 28, Silver-Marshall Line, Infradyne, Aero Products Kit, Loftin-White, Strobodyne, and Others

By THE LABORATORY STAFF

DRUM tuning controls, complete shielding, and high-gain radio-frequency amplifiers will be the predominant trend in kit receivers available to home constructors this fall. All of the new kits also provide for the use of power tubes in the output stage so that good quality can be obtained, and in many cases it is possible to operate the receiver either from batteries or from alternating current, using, in the latter case, a.c. tubes or special rectifier tubes with the filaments of the tubes in the receiver connected in series. Many modern kit receivers are the equal in every respect of much more expensive manufactured sets in the same class, and because of the many kits to be available this coming season, the home constructor will have a wide choice of different types and will doubtless find some one kit which meets his own needs particularly well.

One of the most popular kit receivers of 1927 was the Hammarlund-Roberts "Hi-Q," so it is interesting to note that a new Hi-Q receiver has been developed for the fall. This new "Hi-Q" receiver will contain three stages of tuned radio-frequency amplification, using automatic coupling variation between the primaries and secondaries of the radio-frequency transformers. All of the radio-frequency stages will be carefully neutralized by the Roberts method and the receiver will be completely shielded by the use of a Van Doorn metal sub-panel and heavy aluminum interstage shields. The set has been designed so that most of the wiring may be done beneath the sub-panel, and the final appearance of the receiver is thereby improved. The tuning of this new "Hi-Q" receiver is accomplished by a unique drum control which has not the slightest amount of backlash and which is illuminated by means of a small flashlight bulb placed above the indicator. The drum is actually in two sections, each section controlling two of the variable condensers. Radio-frequency choke coils and bypass condensers are used in each radio-frequency stage and likewise in the plate circuit of the detector tube, so as to prevent coupling in the power supply. The audio amplifier will consist of a two stage transformer-coupled unit with an output filter in the plate circuit of the power tube.

The LC28, which will be featured by *Popular Radio* during the fall, will contain three completely shielded radio-frequency stages so designed that they cannot oscillate. The receiver will be tuned by two drum controls one controlling the antenna circuit and the other controlling a gang condenser which tunes the other two stages. The radio-frequency amplifier and detector have been designed as a single unit which will be described in *Popular Radio* in a preliminary article. Later articles will then tell how to use this high-gain radio-frequency amplifier with several different audio amplifying systems. The set will be engineered so that it can be operated from batteries or from a.c., using alternating current tubes in the latter case. An unusual feature about the receiver is that it is laid out in such a manner that very short leads are possible and the complete wiring can be done with slightly less than five feet of wire. Also, the receiver will be so designed that it will give satisfactory operation using no outside antenna but merely a very short indoor antenna, or the ground system may also be used as part of the antenna system.

The Silver-Marshall Company will place before home constructors three kits, including an improved design of the shielded six, which proved so popular last year. The receiver will be tuned by means of a new type drum control and will be designed to operate on either a.c. or d.c. Silver-Marshall will also market in kit form a four-tube receiver designed for a.c. or d.c. operation. The third Silver-Marshall unit presents essentials for a super-heterodyne, a description of which appears elsewhere in this issue of RADIO BROADCAST.

Many improvements are evident in the new 1928 model of the Infradyne receiver which was featured by *Radio* during the season of 1927. The new model will be tuned by two large drum dials and there will be two supplementary controls, one for adjusting the volume and the other for adjusting the sensitivity. A special filament switch is used and wired so that in one position all the filaments are turned off and when in the center position the filaments of the radio-frequency, audio-frequency and detector tubes are lighted while the tubes in the special Infradyne amplifier are automatically cut out. When the filament switch is in the third position all the tubes are lighted and the complete receiver is in operation. A single turn of this switch therefore makes available a five-tube single-control tuned radio-frequency receiver for those who desire extreme simplicity, or a ten-tube Infradyne offering high sensitivity and selectivity. The audio amplifier will be a two-stage transformer coupled affair with an output transformer. The receiver is so designed that very little wiring need be done above the sub-panel.

Aero Products, Incorporated, have done considerable work on a new seven-tube receiver to be put out in kit form and which will contain three stages of tuned radio-frequency and three stages of resistance-coupled audio-frequency amplification. This receiver will be somewhat unique in that no shielding will be used, the new Aero coils having been designed so that they are rather long in comparison with their diameter, this causing their magnetic fields to be quite closely confined; as a result, it is possible to make up a high-gain radio-frequency amplifier without the use of shielding. The set will measure about 22 inches long and it is understood that it will be engineered for a.c. operation.

The Loftin-White receiver, after enjoying a popular year in 1927, will be slightly redesigned and placed among the kits available in the fall. Very few details regarding the receiver are available but it is understood that the receiver will very likely be an a.c. model with single control and shielding.

Super-heterodyne fans will find much interest in the new Strobodyne, an eight-tube set using a new type of frequency changer which causes the circuit to function very much like a super-regenerative receiver. In practical operation it will be found possible to receive a station at only one point on the dial, a feature in which this receiver is different from many other super-heterodynes, in which stations can always be picked up at two adjacent points. The new Strobodyne will contain one stage of radio-frequency and three stages of intermediate-frequency amplification and a two-stage transformer-coupled audio amplifier with a choke condenser combination in the output of the power tube. The tuning will be controlled by two main dials but there will also be several supplementary controls consisting of one potentiometer, three rheostats, and a volume control. The radio frequency stage and first detector stage will be operated by a single dial and the oscillator will be operated by the other main dial. The receiver will be carefully shielded with three individual stage shields.

Incidentally, we might mention here that an article is at present being prepared by the laboratory staff describing the various super-heterodyne kits now being sold. This article will shortly appear and should prove very interesting because it will be crammed full of valuable dope on many super-heterodyne receivers.

The Arthur H. Lynch Company has designed a unique unit which should prove to be unusually popular because of its adaptability to many different circuits. Briefly, the unit which they have developed consists of five tube sockets mounted on a bakelite panel measuring about 6" x 12". Four of the sockets are arranged along the rear part of this small sub-panel and one socket is placed in the center toward the front. There is on the sub-panel, besides the sockets, three resistance-coupled amplifier stages which are wired into the circuit when the assembly is purchased. We therefore have a unit consisting of a complete resistance-coupled amplifier, a socket for a detector tube, and a fifth socket in the front part of the panel for a radio-frequency tube. The home-constructor may then use any r. f. and detector circuit which he prefers and will find space on either side of the r. f. tube socket for the placement of the necessary coils and condensers. The unit may be used as part of a receiver with a 14" or 18" front panel.

Besides the kits which we have mentioned above, there will be several others on which no detailed information was available at the time this article was written. The Karas Electric Company is working on two kits which will incorporate the "equamatic" system, featuring automatic coupling variation. The Bruno Radio Corporation and the Grimes Radio Engineering Company are also designing new kit receivers for the fall but no information concerning their characteristics is available. It is also likely that a new Browning-Drake receiver will be designed. The Radio Receptor Company, Incorporated will continue to sell the kit which they manufactured last year, which consists of three stages of tuned radio-frequency amplification, a stage of reflexed audio, and two straight audio stages.

Suppressing Radio Interference

Practical Hints on How Radio Interference May be Minimized With Actual Data on How It Has Been Accomplished in Numerous Cases

By A. T. LAWTON

RADIO BROADCAST published some of the first articles which appeared in the technical press dealing with the reduction of man-made or "artificial" interference. These were written by A. F. Van Dyck of the Radio Corporation of America and appeared in this magazine for April, May, and July, 1924. This article, the first of a pretentious series, includes some of the material covered by Mr. Van Dyck, and also a large amount of additional definite information of immeasurable practical value to the man faced by an interference problem in his own locality. Every conceivable source of interference is noted in these articles. The treatment is intensely practical, for Mr. Lawton has crystallized here the results of his work for two and one half years in more than 132 cities.

—THE EDITOR

NOTWITHSTANDING the fact that we have really good broadcasting stations and radio receivers of high quality, a surprising number of broadcast listeners are deprived of normal reception because of local outside interference. This interference may take the form of harsh nondescript noises, so-called "static," crashing, buzzing, clicking noises, etc., which either mutilate the program or blot it out altogether.

Almost any piece of electrical apparatus is a potential source of disturbance to the radio receiver. Wherever an electric spark is formed, waves of high-frequency electrical energy are sent out. They are identical (though untuned and uncontrolled) with those emitted from the broadcasting station. Consequently, they are picked up by the radio installation and amplified in the same manner as radio music or speech. There are two different methods of suppressing the interference due to sparking electrical apparatus. One is to eliminate the spark by discarding the apparatus or by placing it in a condition so the spark will not occur. The other is to confine the electrical waves set up by the apparatus to a very small area and thus prevent interference to reception of radio programs. The following paragraphs, and other articles of this series which will appear in RADIO BROADCAST from time to time, will give definite data on the various causes of interference and, in most cases, the solution of the problem. These data were collected over a period of two and one-half years, during which a 6000-mile patrol with a radio-equipped car was made, taking in the combined interference of more than one hundred and thirty-two towns and cities.

OIL BURNING FURNACES

THE problem of interference from the oil-burning furnace is a most important one today and will be discussed first. Certain types of oil-burning furnaces will interfere with reception one block or more distant. At close range they will probably put the set out of business for whatever period the electrical ignition system is functioning.

We say "certain types" of burners because there are many types on the market, and no two seem to act alike, especially when suppressive measures are being considered. Any oil-burning furnace which has its ignition system covered in several enclosures of metal and has all its associated wiring run in conduits, will cause a minimum of interference. This is a condition obtaining only occasionally; the majority of furnaces cause a lot of radio noise.

The fact that the ignition of some furnaces operates only for ten seconds each time the furnace starts does not help matters. Eight such installations were recently investigated in less than one block on the same street. Being of the thermostat control type, they started up and stopped at frequent and irregular intervals. The combined interference made reception in the whole district unsatisfactory. Three other furnaces in the same town were fitted with continuous type ignition system, *i. e.*, the spark coil operated for fifteen minutes or more at a time and did not shut off automatically after lighting the gas. This type is a bad offender.

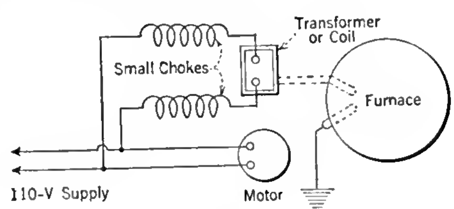


FIG. 2

In considering methods of interference elimination it should be noted that two types of ignition coil are in general use. The first, an ordinary spark coil with vibrating contact, and the second, a straight 100 to 1 ratio transformer giving 11,000 volts on the secondary and operating directly off the 110-volt supply. The former creates much more disturbance than the latter.

While interference from the motor on the oil burner is possible, in most cases the major disturbance is confined to the high-tension spark. For this reason it is usual, when installing apparatus to eliminate the radio interference, to concentrate on the spark coil, or transformer circuit, rather than on the main 110-volt supply lines.

The first and most promising method is to bridge the transformer primary with two 2-mfd. condensers connected in series, with the mid-point grounded. The interference from five furnaces has been entirely eliminated by this arrangement, shown diagramatically in Fig. 1. Thermostats, control wires, etc., have been omitted in this diagram for the sake of simplicity. The following points should be noted:

(1) Connection of the condensers is made as close to the coil as possible.
(2) Keep the ground wire short; if it is abnormally long, elimination of the interference is not complete.
(3) Two 500-volt condensers are used (costing about $2.00 each). We are dealing with a 110-volt circuit but the surge causing radio noise may be many times this voltage—sufficient to puncture a low voltage condenser.
(4) The capacity of the condensers should be at least 2 microfarads each. One-half or one-microfarad condensers are not usually effective.
(5) Ground connection to the furnace itself may prove more effective than direct connection to, say, a water pipe.

Another method is shown in Fig. 2, where small choke coils are substituted for condensers. The current in the coil primary circuit varies from one ampere to two and one-quarter amperes according to the type of manufacture, and in winding the choke coils, wire of sufficient size to carry this current without heating must be used. For intermittent service, No. 18 d.c.c. wire may be employed; for the continuous electrical ignition type it might be as well to use No. 16 d.c.c. since, in a narrow coil wound ten or twelve layers deep, the radiating surface is small.

Approximately one hundred and thirty turns are required on a wooden bobbin of the measurements given in Fig. 3. No particular effort need be made to have this winding done neatly in regular layer fashion, as jumble winding is usually just as effective as straight winding.

Taken by itself, while not usually as effective as the condenser method, the choke coil method becomes an important factor in obstinate cases. Several furnaces failed to respond to either of the foregoing arrangements but all interference caused by them was successfully obliterated by a combination of the two, as shown in Fig. 4.

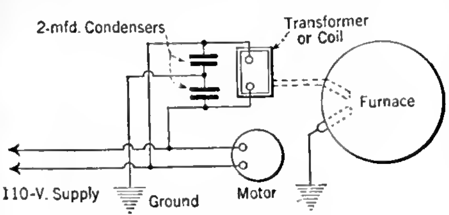
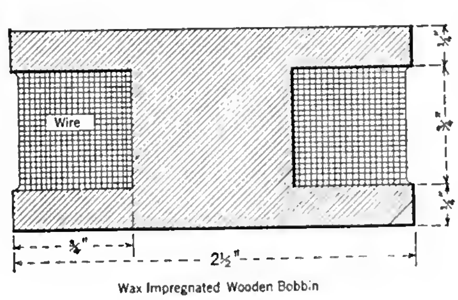


FIG. 1



Wax Impregnated Wooden Bobbin

FIG. 3

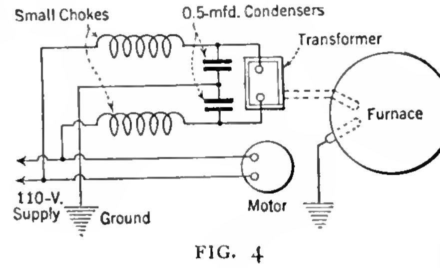


FIG. 4

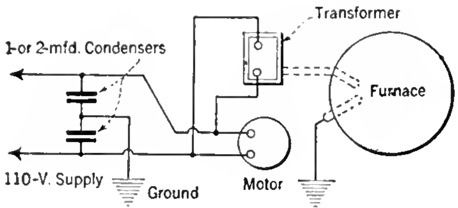


FIG. 5

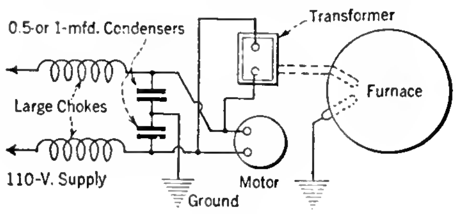
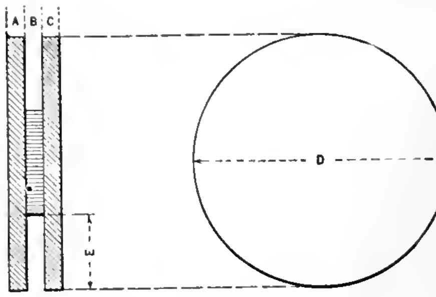


FIG. 6



110 Turns No. 12 D C C Wire on Wax Impregnated Hardwood Bobbin Winding Grove ½" wide, 2⅛" deep; A, B, C, ½" each; E, 2⅛"; D, 7⅛".

FIG. 7

It will be noted that 0.5-mfd. condensers are used instead of the two-microfarad capacity type. Care should be taken to see that the condensers are attached to those leads of the choke coils which are connected to the spark coil or transformer. Attaching them to the opposite, or supply line, end, is of practically no value.

One might imagine that this "surge trap," incorporating as it does, the merits of two methods, would be an all-round more efficient eliminator. As a matter of fact it is not necessarily so. Certain furnaces which respond to the choke coil method again become noisy when condensers are attached, and the only sure check is to try each method individually.

We now come to those cases where interference is caused by the furnace motor as well as by the ignition spark. In this instance, we apply the above methods to the main supply lines with condenser and choke values altered.

Fig. 5 shows an arrangement which has proved successful on several furnaces fitted with the straight transformer coil. This circuit is electrically the same as that given in Fig. 1, the difference being that the condensers are connected close up to the motor instead of near to the transformer. This condenser method did not work in every case, however, as two furnace installations were found in which the addition of the condensers only increased the trouble.

Choke coils wired as shown in Fig. 6 and of the specifications shown in Fig. 7, entirely eliminated the interference from these two offenders; adding condensers brought all the trouble back again, so these latter were dispensed with.

Fig. 8 shows a method which may be applied to the main supply lines, No. 12 wire chokes being used. This method has been found necessary in certain cases.

Practically all furnace motors operating on 110-volt circuits draw a current of 5 amperes. Allowing 2 amperes for spark coil consumption we have a total current of 7 amperes to handle. On first consideration No. 12 wire may seem unnecessarily large but when the necessary reduction in current-carrying capacity is made for layer depth in winding and proper heat radiation it will be seen that only normal precautions are taken to ensure a reasonable factor of safety.

Tests carried out with single-layer coils, *i. e.*, 100 turns of wire wound in a single layer along a tube 3½ inches in diameter, were not conclusive. Complications rendered the findings void and the dimensions of the completed surge trap were such as to make its use objectionable.

The data on bank wound coils, as applied to furnaces, are also incomplete though some tests have been carried out with satisfactory results. For intermittent current under 8 amperes, however, little can be gained by substituting banked coils for jumble winding unless it can be determined that, in the former, a smaller quantity of wire can be used with equal results.

PLACING THE COILS CORRECTLY

BEFORE going any further we should stress a point, the importance of which is often overlooked. Let us suppose that you have eliminated the trouble by one of the choke coil methods, say Fig. 6. In this case you have deliberately or unconsciously made the right connections and placed the proper coil faces together. For the sake of compactness it is usual to install these chokes one on top of the other in a standard metal outlet box, and by simply turning one coil over we may bring back the interference sixty per cent. or more although the connections remain unchanged.

Contradictory results in actual practice indicate that so far as furnace installations are concerned no specific method of connection will suit all cases, so if interference elimination is not complete on first trial, then lay the two flat coils face to face and turn the top one over. If this does not produce the desired result reverse the leads of one coil only and repeat the turning test.

You are not so likely to run into this trouble if the inside lead of one coil and the outside lead of the other be connected to the furnace and the two free ends to the 110-volt supply line, but if two inside leads are connected to the furnace and the two outside leads to the line, or vice versa, and both coils are wound in the same direction, then the "turning" test may be necessary.

The reason for this little complication, which, by the way, has caused some investigators to abandon their experiments on the brink of success, is that in one setting the flux of one coil "helps" that of the other, but when the top coil is turned over, both are, as electrical men say, "bucking" or opposing. Just whether they should "help" or "buck" is a question more likely to be settled by the individual furnace than by any other authority. Different installations give different results, but in all cases one or other of the settings proves effective.

Paradoxical as it may seem, all this care and attention to coil positions, etc., proved unnecessary in three instances; the furnace interference in these three cases was reduced to zero when coils were installed in the lines, regardless of the manner of connection or relation of one coil to the other. This is quite in keeping, however, with the whims and vagaries of radio interference.

Perhaps we should condition the statement made a little while ago that "in all cases, one or other of the settings proves effective." This is literally true so far as the ignition systems under discussion are concerned, but in the course of extended patrol one occasionally meets the old belt driven magneto type ignition. Some day it may yield, but so far, all efforts to eliminate its interference have failed. The best method we can suggest now is to take it out and substitute a transformer with surge traps.

High tension leads on modern type furnaces are comparatively short and do not need any particular attention, but on older types, where the lead to the spark plug is two or three feet long, it may be necessary to run a metal pipe, of say, one inch diameter, over this to shield it, first of all running a piece of rubber hose over the high tension lead. The latter precaution is taken not altogether for the sake of insulation but to increase the distance from the wire itself to the metal shield so that there is less probability of foundering the spark energy. In most cases grounding this shield increases its efficiency as an eliminator.

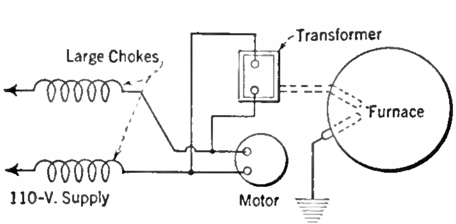


FIG. 8

Oil burning furnaces, as a rule, are hooked up to the electric supply lines by an ordinary cable and bayonet plug-receptacle fitting. If for any reason the circuit is opened here in the course of making tests the plug and receptacle should be carefully marked so that the plug is inserted the same way in the receptacle each time it is replaced.

Remembering that one side of this line is grounded and "dead" and the other side very much alive, you will appreciate the desirability of guarding against the introduction of unnecessary complications. As a test, however, there is no objection to reversing this plug during experimental work to find out if, in conjunction with the surge traps, a reversal of the supply leads has any beneficial effect.

The first thing to do when setting out to clear up some determined source of interference is to talk the matter over with some man in the electrical business, preferably one conversant with radio, and get an estimate of the cost of making up the necessary filter coils. If you do not care to stand the whole expense personally, interview the furnace owner and ascertain if he is willing to meet you half way. In a good many instances you will find that the owner, once he is made aware of the disturbance unconsciously created, will gladly shoulder the whole or part of the expense.

A more equable apportionment of the costs, however, is desirable; we must remember that the neighbor is just as much entitled to run his furnace as we are to run our radio receivers. In a recent instance, twelve radio fans in the immediate vicinity of an offending furnace were approached on the question of furnishing the necessary interference elimination apparatus and all but two agreed to a division of costs. The installation came to six dollars; for sixty cents each they rid themselves of an aggravating interference that spoiled winter evening reception for a previous three years.

ELECTRO-MEDICAL THERAPEUTIC APPARATUS

BROADCAST listeners living in the vicinity of a hospital are quite familiar with the class of interference generated by high-tension electromedical treatment machines. Even the humble violet ray for home treatments can spoil reception over a radius which will include a large number of residences.

Larger machines, as used by medical men, can be distinctly heard a distance of eight city blocks, and in the near vicinity radio interference is extremely heavy. When this is multiplied by the number of machines in every city, it becomes obvious that the total interference from this source alone is serious.

Details and particulars of the various types in common use would serve no useful purpose. Ninety per cent. reduction of interference caused by one of the small machines was obtained by inserting 100-turn banked choke coils of No. 16 d.c.c. wire in each line near the machine, and bridging the circuit with condensers. This large percentage of reduction was not evident in the same building, only forty per cent. reduction being noted here, but in the neighboring residences, only a short distance away, practically all the noise had disappeared. A second machine, closely resembling this one but of greater power, failed to respond sufficiently to this treatment to warrant the expense of installing a surge trap.

So far as the larger apparatus is concerned we have experimented with every known surge trap connected at the machine, where preventative measures usually are most effective, and without exception, all proved useless.

The reason is obvious. If, while walking in a room where one of these machines is being operated, you place your hand near a radiator or lamp fixture or any piece of metal, grounded or ungrounded, sparks will pass from your body to the metal, and vice versa. The whole atmosphere is charged with electricity as also is the water piping, gas piping, metal fixtures, etc. And by the same token the electric lighting wires are charged, all the more because they are directly connected to the offending apparatus, and interfering surges set up are carried out over the distribution system.

It is hardly possible to clear up this interference to the satisfaction of broadcast listeners in the immediate vicinity, say within 100 feet, but it can be stopped from radiating very far beyond, an actual case on record proving this conclusively.

The necessary choke coils in this case are connected, not at the machine, but in the residence main supply lines, preferably at the meter. No condensers are used. Condensers in any combination, in the particular case referred to, brought all the interference back after it had been cleared up with choke coils alone.

Coils for the purpose should be bank wound, three layers deep, and should consist of 150 turns of d.c.c. copper wire on a $3\frac{1}{2}$-inch tube of insulating material. See Fig. 9.

It must be remembered that these coils are required to handle the house load, not merely the current drawn by the therapeutic machine, and the size of wire used will be governed by this. It will probably be No. 8 or 10, B. & S. gauge.

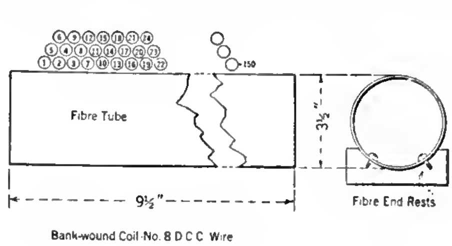


FIG. 9

Allowance is not made for electric cooking ranges or fireplace coils as these are usually on a separate circuit. If their associated wiring runs close by the lighting mains, however, it is desirable to separate them or else introduce additional heavy coils.

This interference reaches near-by listeners in two ways; first, by radiation from the surges set up in the city distribution wires, and second, by direct radiation from the source.

Preventive measures already described take care of the first channel; direct radiation can only be reduced by shielding the offending apparatus with a metal screen. More interference comes from the high-tension flexible cables than from the coil or vibrator itself, so thath sielding of the vibrator proper has no beneficial effect.

We find too that any amount of metal screening in close proximity to the equipment interferes with free use of its various parts by the operator, and the only satisfactory way to get around this problem of direct radiation is to shield the entire room with a metal screen, an expensive arrangement but one which is more or less common in up-to-date hospitals where X-ray machines are in daily use.

X-RAY EQUIPMENT

THERE is a marked difference between the sound characteristics of X-ray interference and that propagated by the apparatus just discussed. High-frequency treatment machines give rise to an indefinite "mushy" noise—more or less of a blanketing interference—while that from the X-ray is more in the nature of a hard buzzing.

Where a rotary synchronous rectifier is used you can safely count on the installation setting up violent interference. In fact, it constitutes a good, healthy wireless transmitter and interferes, to a greater or lesser extent, all over a small town. In addition to the spark disturbance several cases are on record where the motor driving this rectifier caused enough trouble to bother reception within a radius of 300 feet.

From theory, we should say that choke coils inserted in the main supply at the house meter would reduce the total radiation though it is questionable if complete elimination can be secured. Preventive measures taken on the machine itself gave unsatisfactory results.

So far as our experience goes, we have never yet gotten any trouble from the X-ray tube itself. Also, two complete installations were checked while operating on full power without any interference being noted. These installations used tube rectifiers instead of rotary synchronous rectifiers.

Possibly old or defective tube rectifiers might give rise to some trouble but no definite case appears on record and the substitution of tubes for the rotary rectifier seems to be the best solution of this problem.

Since the change over from rotary synchronous to tube rectification involves considerable expense, it is our policy to place the situation frankly—and courteously—before the medical men using such equipment, and with very few exceptions all have agreed to refrain from using the apparatus during the evening broadcast hours, or at least, limit its operation to urgent cases which cannot be left over.

DENTAL MOTORS

THERE is every probability of your getting fairly loud radio interference if your radio set is being operated in the vicinity of a dental office.

The motor commonly used is of the universal type, which may be operated off direct or alternating current. It runs so smoothly and silently that sometimes with the naked ear it is difficult to tell whether the machine is running or not, while at the same time radio sets for four or five houses either side of its location experience a high pitched buzzing interference.

Fig. 10 shows three methods of clearing up this trouble; No. 1 does not always prove effective; No. 3 is only required in obstinate cases; and No. 2 will usually do the trick.

A little removable plate at the base of the engine stand gives access to the motor supply leads, and makes a convenient point at which to cut in with surge traps. Water piping runs up the centre of this column also, facilitating good ground connections.

Remember that the coil in (b) Fig. 10, must be inserted in the live side of the line, not the grounded side. The live side is easily found with an ordinary incandescent lamp and socket. One lamp lead is attached to a water pipe or other convenient ground and the free lead touched on the two motor mains in turn; the lamp lights only when touched on the live wire.

Little consideration need be given the second motor usually found in dental offices; we refer to the lathe or "working" motor. Its interference as a rule is negligible and its periods of operation are short.

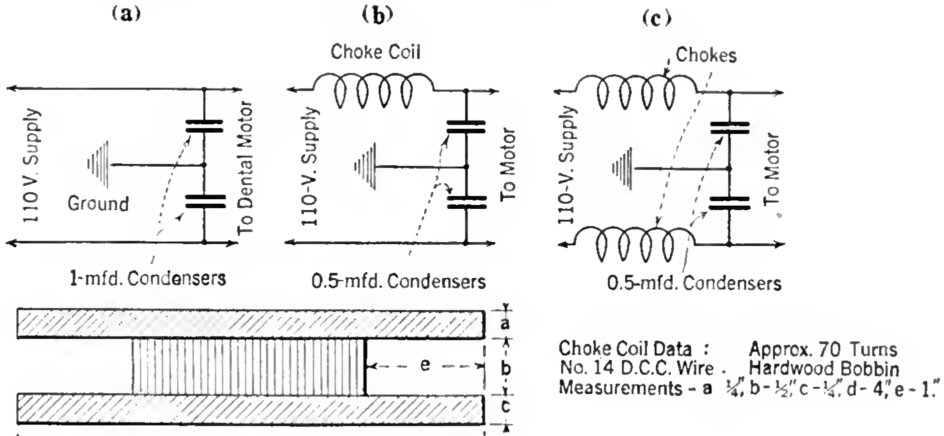


FIG. 10

The Three-Element A. C. Vacuum Tube

A Paper Delivered Before the Radio Club of America Which Discusses the Theory Underlying A. C. Operation of Vacuum Tubes

By BENJAMIN F. MIESSNER

Chief Engineer, Garod Corporation

IN A RECENT paper delivered before the Radio Club of America by the author, and printed in the February and March, 1927, issues of RADIO BROADCAST, it was shown that two principal causes for hum are present within tubes of the ordinary types when their filaments are heated with alternating current. One of these is due to the fluctuations of filament temperature with fluctuations of the energizing current, and the other is due to the effect of the positive leg of the filament acting as a plate electrode of periodically varying potential. It was further pointed out and demonstrated that at least one of the commercially available standard receiving tubes, when subjected to the proper operating conditions, would function normally as an amplifier without the introduction of an objectionable amount of disturbing hum. A commercial broadcast receiver, the Garod Model EA, which has a. c. excitation of all filaments except the detector (this latter has a 199 type tube heated by the combined plate current of all tubes), was demonstrated. Control of the two types of hum resulted in the neutralization of one by the other within the tube itself. Numerous curves were shown, which indicate the relation of the hum amplitude to the operating voltages on most of the standard types of receiving tubes. It was also pointed out in the latter paper that the author's experiments with special tubes had demonstrated the possibility of accentuating the desirable characteristics of standard tubes by a tube of new design, which could be used not only in the amplifier stages, but in the detector stage as well, which requires hum elimination of an extremely high order because of the large amount of amplification behind it in the receiver.

The purpose of the present paper is to amplify some points in the previous discussion, which time did not then permit, and more particularly to describe the a. c. tube, which was discussed briefly and which is now being made available through commercial channels, for use as a detector as well as a radio or audio amplifier.

In the author's researches on a. c. filament excitation, it was found that there are three distinct cases, requiring separate analysis and discussion, depending upon the use of the tube so operated. In audio-frequency amplifiers, with which the hum measurements of the first paper were principally concerned, we have one set of conditions. Another set of conditions obtains when the tube is used as a radio-frequency amplifier; and a third, and considerably more complicated set of conditions, are presented when the tube is used as a detector. Here both the radio and audio effects are present in the same tube, and some very interesting actions have been observed.

HUM IN AUDIO-FREQUENCY AMPLIFIER TUBES

AS BEFORE stated, the previous paper dealt principally with the hum in audio-frequency amplifier circuits. It was shown that the temperature type of hum resulted from the changes in temperature of the filament due to the variable heating current flowing through it. It was shown further, that the degree of the temperature variation is due to what was termed "thermal inertia" of the filament, this "thermal inertia" being dependent upon the ratio of heat storage capacity of the filament, to its heat dissipating ability. The heat storage capacity depends upon the volume or cubical contents of the filament as well as upon its heat absorbing ability, which is called specific heat. This storage capacity may be likened to the electrical storage capacity of a condenser wherein the area of its electrodes compares with the volume of the filament, and its dielectric constant compares with the specific heat of the filament. The capacity in either case is proportional to the product of the two factors. It was shown that the amount of this temperature hum was greatest with thin low-heat capacity filaments, such as those used in the 199 type of tube, and smallest in the heaviest filaments, such as those used in the 112 type of tube. It was shown further, that the amount of temperature variation depended not alone upon the ratio of surface or radiating area to the mass of the filament, but also upon the actual operating temperature of the filament itself. The radiation losses for heat are proportional approximately to the fourth power of the temperature, and inasmuch as these radiation losses are the chief ones to be reckoned with as lowering the filament temperature during periods of small or no current, it is seen that very low temperatures greatly facilitate temperature stability.

The temperature stability of such a filament, with a pulsating heat input occasioned by its alternating heating current, and with a heat output or load consisting chiefly of radiation losses, and partly of conduction losses, depends, as above stated, upon the ratio of its heat storage capacity to its heat dissipating ability. The former has already been defined, and the latter depends upon the operating temperature and the radiating or surface area, neglecting the conduction losses through lead wires. Obviously our problem, in securing high stability, is to obtain a high ratio of storage capacity to dissipating ability.

One method of accomplishing this is to use a filament of round cross-section. This form is to be preferred because the ratio of volume, or storage capacity, to surface, or dissipating ability, is greatest. The strip form of filament so common in the oxide-coated types, decreases this ratio, and is therefore to be avoided, unless increased area is necessary for other reasons.

Another method of increasing this ratio is to use a filament of large diameter. Since the volume is proportional to the second power of the radius, while the surface area is proportional to its first power only, it is seen that the ratio of volume to area of the filament increases rapidly with increasing diameter, and as large a diameter as possible, consistent with other considerations, is to be desired.

A third method, as before noted, consists in reducing the operating temperature to as low a value as possible consistent with other considerations so that the heat dissipation rate of the filament is low. Remembering that the radiation losses are proportional to the fourth power of the temperature, it will be seen that merely cutting the operating temperature in half, as by going from a thoriated tungsten to an oxide platinum filament, may permit of a very great decrease in radiation losses and a correspondingly greater temperature stability.

The temperature stability of an a. c. energized filament may be understood better perhaps by comparing it with the voltage stability across a condenser fed from a rectifier and feeding a load resistance. In both cases we have a pulsating input and a more or less steady output of energy. If the output load is small, the energy level of temperature or voltage remains steady. If the load be large, there will be a large decrease in energy level during periods of little or no input, and consequent great instability.

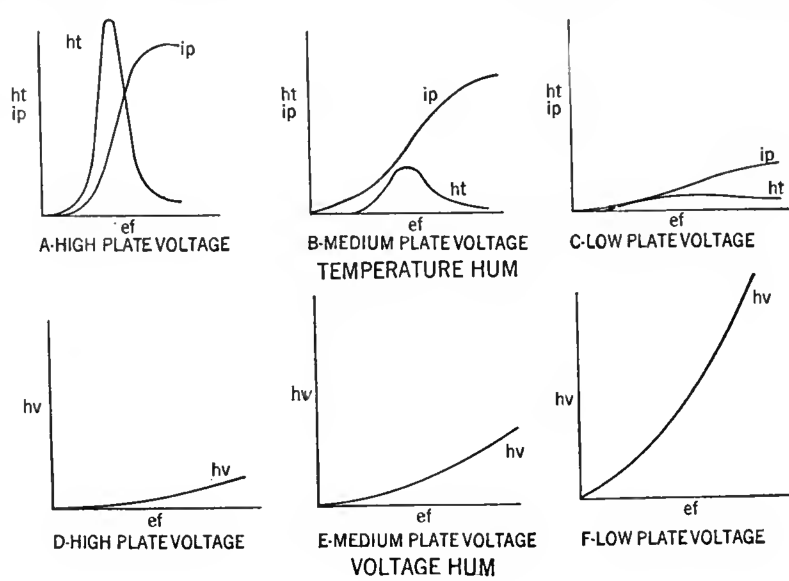


FIG. 1

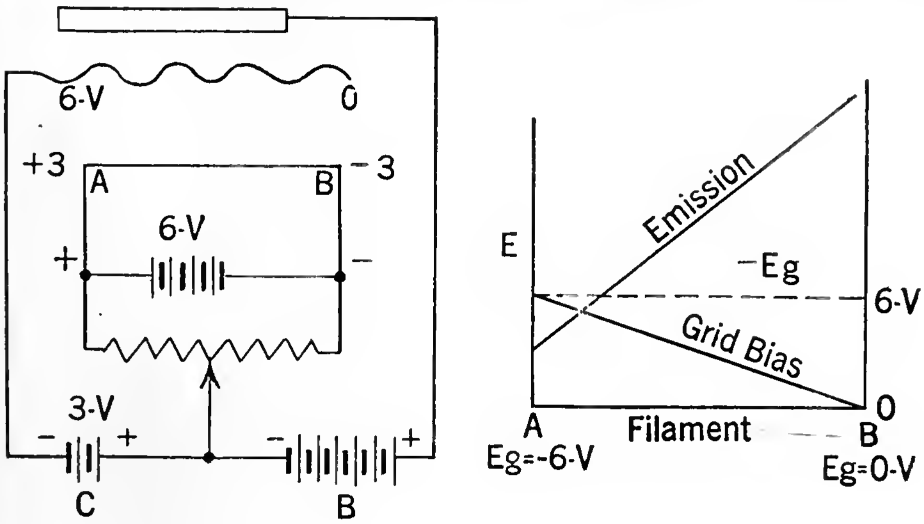


FIG. 2

To summarize then, the method of securing high temperature stability is to use a filament of round cross section, large diameter low temperature, and high specific heat.

The curves presented in the former paper show that the temperature type of hum is at its maximum value at the point of greatest steepness of the filament-voltage plate-current curve of any given tube. That is to say, if a static plate-current curve be plotted with variable filament voltages, the greatest amount of plate current variation will be obtained for a given amount of filament voltage variation at the steepest point in such a curve, and it follows that under dynamic conditions, where the filament current is constantly changing at a high rate, such as by the action of a 60-cycle impressed voltage, the greatest amount of temperature fluctuation would be obtained at a filament voltage corresponding to the steepest point of the plate current curve.

The curves show also that at high plate voltages, where the plate current curve is steepest, the temperature type of hum is greatest, and at low plate voltages, where the plate current curve is comparatively flat, the temperature hum is low or has entirely disappeared. This is shown by the typical curves of Fig. 1.

In curve "A," for a plate voltage that is high compared to the filament voltage, a high temperature peak is produced, due to the steep plate current curve. In "B," where the plate voltage is reduced and the plate current curve is thereby flattened, the temperature peak is much reduced. In "C," where the plate voltage is low and the plate current curve is relatively very flat, the temperature hum has almost completely disappeared. In "D" is shown the low-voltage type of hum produced when the plate voltage is high compared with the filament voltage. In "E," where the plate voltage is reduced, the hum has considerably increased, while in "F," where the plate voltage is very low, the voltage hum has become very high.

These curves represent the general relationship between the two types of hum and the plate voltage with a tube of any given type. With a fixed plate voltage and differing filament voltages the same general results will be obtained, as the *ratio* of plate to filament voltage is the factor determining the degree of the voltage type hum. This is explained by the fact that there are within the tube two electrodes of positive potential and competing with each other for the emission of the filament. With an a. c. filament voltage of, say, five volts, and a d. c. plate voltage, say, 135 volts, the plate electrode, by reason of its over-powering attraction for the electrons, attracts to itself most of the emission, while the positive filament end with its small voltage gets only a small part of the emission. When, however, the plate voltage is reduced to a low value, such as twenty-five volts, the five-volt potential of the filament becomes relatively important and it now takes a much greater proportion of the emission than it did under the high-voltage plate condition.

It should be remembered here that the attraction of the plate electrode is considerably modified by the presence of the intervening negatively charged grid, and that no such intervening grid is present between the positive side of the filament and the negative side, and this further contributes to the effectiveness of the positive filament end as a contender with the plate for the electron emission.

As a result of these various studies, the previous paper pointed out that the temperature type of hum could be reduced by increasing the ratio of mass to radiating surface of the filament and by lowering the temperature, and that the voltage hum could be decreased by reducing the filament voltage to a low value and by separating the filament ends as far as possible, that is, by use of a filament of the straight type. Another method is to so construct the grid of the tube, that it surrounds the two filament sides in a V-type filament and thereby shields the emitting negative side from the attracting positive side, by virtue of its relatively high negative bias.

The latter paper also discussed the variation of emission from the two sides of the filament and explained that the negative leg was considered to be responsible for the chief part of the emission, at least during those portions of the applied a. c. cycle where the voltage was high. In addition to the reasons given for this non-uniform emission, there is another simple explanation which leaves no doubt on this point. This has been proposed by the author's assistant, Mr. Charles T. Jacobs.

Consider a filament excited by a six-volt battery; its associated grid and plate circuits are returned to the mid-point of a potentiometer connected across the battery and filament, as shown in Fig. 2. The grid is biased negatively by a three-volt battery. An examination of this circuit discloses that the negative bias with respect to the negative end of the filament is zero, while the bias with respect to the positive end of the filament is six volts. It is seen that in the case of the negative end of the filament, the C-battery voltage is exactly neutralized by the oppositely poled voltage of one half the A battery. However, for the positive end, one half the A battery voltage is added to the negative bias, producing an overall bias between the grid and the most positive end of the filament of six volts. At the mid-point of the filament, the A voltage neither adds nor subtracts, so that the voltage of the grid with respect to this point is that of the C battery, or negative 3 volts. We can conceive, therefore, that the emission of the positive end of the filament compared to that of the negative end must be very small, because of the much greater negative bias on the grid with respect to the positive end, and that the emission will vary uniformly from one end to the other. The conditions here may be understood by reference to the graphs showing the distribution of emission over the filament as shown in this diagram. If "A" is the positive end of the filament, three volts positive with respect to the mid-point, and "B" is the negative end of the filament, three volts negative with respect to the mid-point, then the potential difference between the grid and "B" is zero volts. The accompanying graph shows in general the distribution of emission over the filament from "A" to "B," being lowest at "A" and highest at "B."

If now the polarity be reversed, as shown in Fig. 3, we see that the distribution of emission is

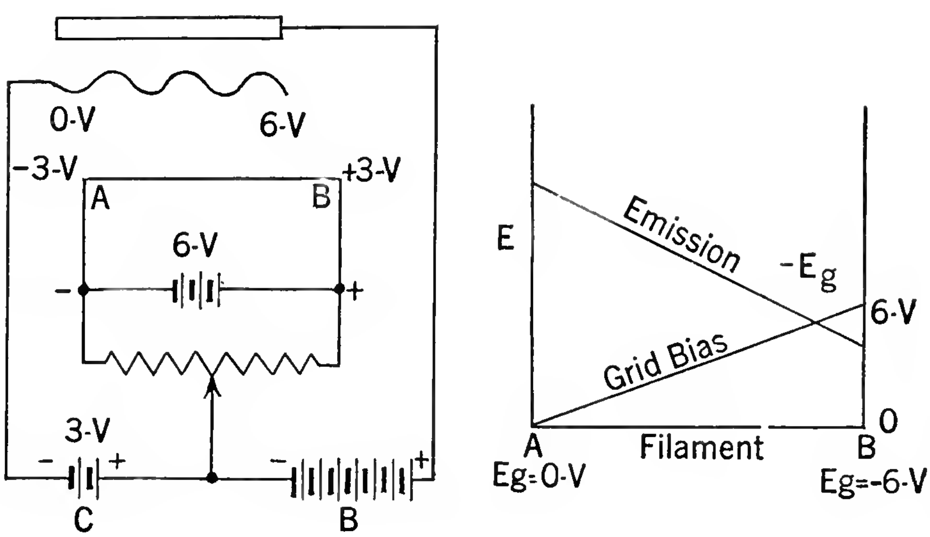


FIG. 3

the same but reversed with respect to the filament ends. In the third case, shown in Fig. 4, wherein the filament supply voltage passes through the zero point, shown by the omission of the battery, the whole filament will be at a uniform potential difference with respect to the grid, and equal to the voltage of the C battery or three volts. The emission of the filament in this case will have an amplitude equal to the mean value of the amplitude over the filament as a whole, as shown in either Fig. 2 or Fig. 3.

If now, we exchange for the six-volt battery a source of alternating current, such as a transformer secondary, having a peak voltage of six and, for sake of simplicity, a sinusoidal wave-form of 60 cycles frequency, we have a continuously changing condition wherein at some instances we have one or the opposite set of polarities on the filament with varying voltage, and at other instances, we have no voltage whatsoever, that is, when the applied voltage passes through the zero point in its cycle. The action under these circumstances is considerably more complex than in the steady state given by the battery, and can best be expressed by graphs showing the separate effects, their phase relations, and the net result of all of them.

In Fig. 5, this a.c. filament excitation substituted for the A battery is shown, together with graphs indicating the nature of the emission variation to the plate with respect to the two filament ends. With a peak filament voltage of six, a mid-point grid return, and a C bias of 3 volts, as indicated, both ends of the filament, "A"-"B," will vary from zero to six volts with respect to the grid, during a cycle of the filament voltage. Graph No. 1 shows the filament voltage; graph No. 2, shows the variation in emission from "A;" and graph No. 3, shows the corresponding variation from "B." Graph No. 4, which is a straight line, represents the sum of "A" and "B," and shows the total plate current under this condition to be constant, neglecting the slight effect of the B return and any slight departure from symmetry in the geometry of the the filament, grid, and plate at the two ends of the filament. Returning now to Fig. 4, we can make this quite clear. If the emission and grid bias lines be given an oscillatory rotating motion in opposite directions, each about its point of mean amplitude, it is obvious that the total emission is always constant

If, now, the grid and plate return be made at some point off the central point of the potentiometer, it can be shown that the emission will no longer undulate symmetrically about the center point and therefore remain constant, so that the two effects will be unbalanced, and a 60-cycle variation of plate current will result. In Fig. 6, the dynamic conditions with a.c. on the filament and the potentiometer slider displaced somewhat from the center, are shown. Here again Graph No. 1 represents the exciting voltage across the ends of the filament; No. 2, the emission from one end of the filament; No. 3, the emission from the other end of the filament; and No. 4, the sum of curves Nos. 2 and 3, which is a 60-cycle variation. It will be explained later how this 60-cycle grid voltage can be made to counteract a 60-cycle ripple in the plate voltage.

These curves and this analysis are, of course, based upon the assumption that the tube is operating as a proper amplifier, with the normal negative grid bias coinciding approximately with the center of the straight line portion of the grid-voltage plate-current curve of the tube. The action in the case of a detector acting as a plate rectifier is different from that of the amplifier as above explained, and will be discussed at length later in this paper, the latter half of which will appear soon in Radio Broadcast.

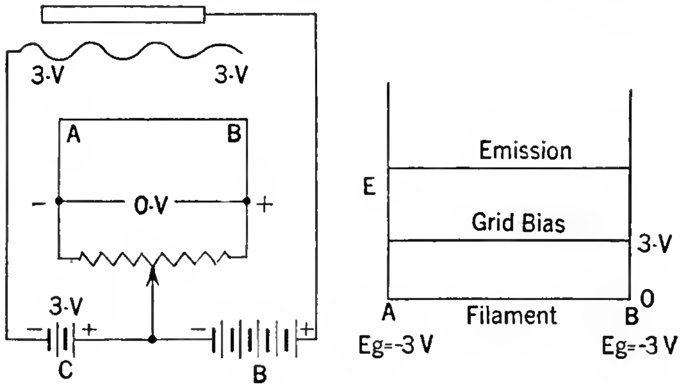


FIG. 4

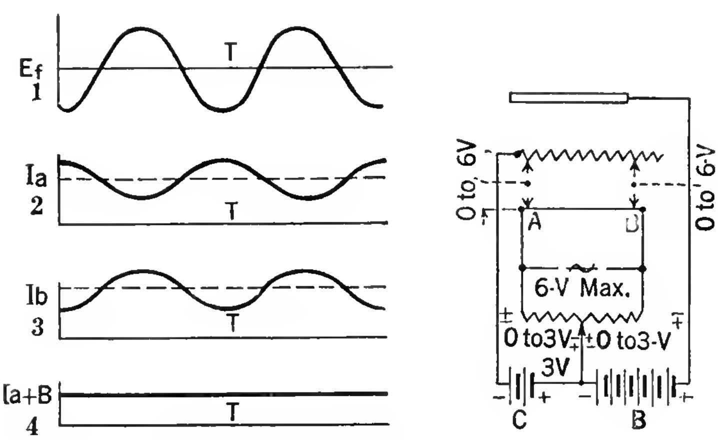


FIG. 5

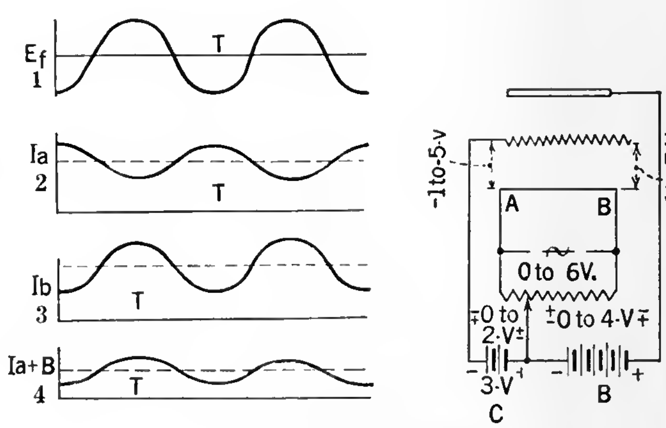


FIG. 6

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New!

THORDARSON POWER TRANSFORMERS

130 M. A. FULL WAVE RECTIFIER

Here is a power unit that will satisfy the ever increasing demand for improved quality of reception. A split secondary 550 volts either side of center, makes possible full wave rectification, using two 216-B or two 281 tubes. Current capacity, 130 milliamperes. The low voltage secondary, 7½ volts, will supply two UX-210 power tubes, enabling the use of push-pull amplification in last audio stage.

The Double Choke Unit 2099 is designed for this power unit. Contains two individual chokes of 30 henries, 130 milli-amperes capacity each.

T-2098 Transformer, 4½" x 5¼" x 5¾"
List Price, $20.00

T-2099, Choke Unit 3¼" x 4⅞" x 5⅝" high
List Price $14.00

POWER PUSH-PULL TRANSFORMER and CHOKE

Quality reproduction that cannot be obtained with straight audio amplification, is made possible through the Thordarson power push-pull combination. This arrangement is designed for use with power tubes only and has sufficient capacity for all tubes up to and including the UX-210. Makes an ideal power amplifier when used with power supply unit T-2098.

Input transformer couples stage of straight audio to stage of push-pull. Output choke is center-tapped with 30 henries on either side of center tap. Dimensions of both transformer and choke, 2½" x 2½" x 3" high.

Input Transformer T-2408
List Price, $8.00

Output Choke T-2420
List Price $8.00

A. C. TUBE FILAMENT SUPPLY

The new R. C. A. and Cunningham A. C. filament tubes will be very popular with the home constructor this season. The Thordarson Transformer T-2445 is designed especially for these tubes. Three separate filament windings are provided.

Sec. No. 1, 1½ volts, will supply six UX-226 amplifier tubes.

Sec. No. 2, 2½ volts, will supply two UX-227 detector tubes.

Sec. No. 3, 5 volts, will supply two 5 volt power tubes.

In addition to the above, this transformer is equipped with a receptacle for the B-supply input plug. Supplied with six-foot cord and separable plug for attachment to the light circuit. Transformer in compound filled, crackle-finished case. Dimensions — 2¾" x 5¾" x 4¾".

A. C. Tube Supply, T-2445
List Price, $10.00

Realistic tone quality, that elusive but much talked of characteristic of radio reception—can be obtained only through the use of apparatus of the finest materials and workmanship. For years Thordarson transformers have been the choice of many discriminating manufacturers of quality receiving sets. Follow the lead of the leaders. If you enjoy good music *specify Thordarson transformers*

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Transformer Specialists Since 1895
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500 W. Huron St., Chicago, Ill.
Gentlemen:
Please send me your booklets describing your new power supply transformers.

Name ....

Address ....

City .... *State* ....

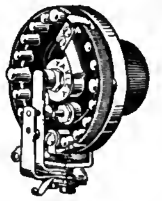
(3562-J)

Modernize Your Radio

YAXLEY APPROVED RADIO PRODUCTS

Improvements will bring you a new standard of convenience and comfort in radio entertainment.

Switching Rheostat



Serves as a filament switch and rheostat in one. Construction same as famous Air-Cooled Rheostat—gives correct voltage range and carrying capacity; feeds current slowly and evenly through use of large number of turns of special non-rusting, resistance wire. Resistance unit suspended in air to permit ventilation.

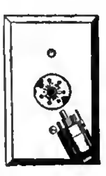
Furnished in sizes from 2 to 100 ohms $1.75

Pup Jacks

Easy to mount on front, sub or rear panels. The ideal Jack for Loud Speaker connections and for use as binding post, for connecting Battery Leads, Ground, Antenna, etc. Mount in $\frac{5}{16}''$ panel hole.

Per Pair....................25c

Convenience Outlets



To give you greater joy with your radio, with less muss and fuss with its accessories, these Radio Convenience Outlets permit the wiring of the home so that batteries are out of sight, a loud speaker can be placed in any room, and the aerial and ground can be tapped like your regular electric convenience outlets. Do away with unsightly lead-in wires and set connections. Avoid damage to the building and acid stains on floors or furnishings. Outlet plates made single or in gangs. Fit any standard switch box or may be attached directly to plaster laths or studding.

No. 135-Radio Convenience Outlet for Loud Speaker and Head Phones.......$1.00
No. 136-Radio Convenience Outlet for Aerial and Ground....................$1.00
No. 137-Radio Convenience Outlet with Plug for Battery Connections..........$2.50

Yaxley also makes Air-Cooled Rheostats, Automatic Power Controls, Cable Connector Devices, Potentiometers, Jacks, Jack Switches, Special Switches, Phone Plugs, Midget Jacks and Plugs, Pilot and Panel Lights, Pilot Light Switches, Name Plates, etc.

Write for new illustrated and descriptive price sheet

At your dealer's. If he cannot supply you, send his name with your order to

YAXLEY MFG. CO.
Dept. B—9 So. Clinton Street
CHICAGO, ILL.

The *Radio Broadcast* LABORATORY INFORMATION SHEETS

THE RADIO BROADCAST Laboratory Information Sheets are a regular feature of this magazine and have appeared since our June, 1926, issue. They cover a wide range of information of value to the experimenter and to the technical radio man. It is not our purpose always to include new information but to present concise and accurate facts in the most convenient form. The sheets are arranged so that they may be cut from the magazine and preserved for constant reference, and we suggest that each sheet be cut out with a razor blade and pasted on 4" x 6" filing cards, or in a notebook. The cards should be arranged in numerical order. An index appears twice a year dealing with the sheets published during that year. The first index appeared on sheets Nos. 47 and 48, in November, 1926. Last month an index to all sheets appearing since that time was printed.

The June, October, November, and December, 1926, issues are out of print. A complete set of Sheets, Nos. 1 to 88, can be secured from the Circulation Department, Doubleday, Page & Company, Garden City, New York, for $1.00. Some readers have asked what provision is made to rectify possible errors in these Sheets. In the unfortunate event that any such errors do appear, a new Laboratory Sheet with the old number will appear.

—THE EDITOR.

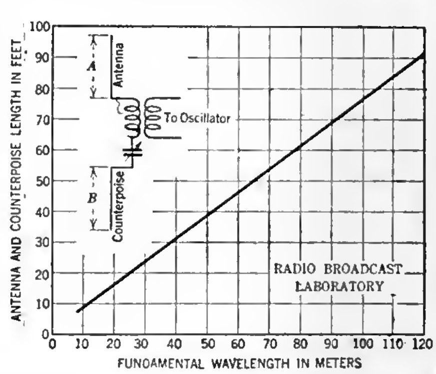
No. 121 RADIO BROADCAST Laboratory Information Sheet September, 1927

The Hertz Antenna

CHA ACTERISTICS

ONE of the commonest antenna systems used by amateurs for transmitting purposes is the Hertz system. This antenna, in its simplest form, consists of two straight wires located diametrically opposite each other as indicated in the drawing on the accompanying curve. The length of the two wires bears a definite relation to the fundamental wavelength at which the antenna system will tune and this relation is indicted by the curve, which is reprinted from *QST* of May, 1926. The relation between the length of the antenna system and the fundamental wavelength is a constant; the length L is equal to the wavelength divided by a constant, 1.3.

It is possible to obtain radiation on any wavelength by using different lengths of antenna and counterpoise. Suppose we wish to transmit on 40 meters (7500 kc.) and the antenna system is to be operated on the fundamental wavelength. Then from the curve the length of the antenna "A" would be 31 feet and the length of the counterpose "B" would also be 31 feet. It would also be possible to transmit on 40 meters using the third harmonic of the antenna, in which case the antenna would be of such a size as to have a fundamental wavelength equal to 40 times 3 or 120 meters. If supplied with energy at a frequency corresponding to 40 meters, however, the antenna would radiate energy at this frequency very efficiently even though its natural wavelength is 120. If such a system of transmission were to be used, the length of the antenna and the counterpoise would each be 93 feet.



No. 122 RADIO BROADCAST Laboratory Information Sheet September, 1927

Testing Radio Receivers

FEATURES TO CONSIDER

IT IS obviously of distinct advantage to test radio receivers in accordance with some standardized test procedure so that the results obtained from different receivers can be readily compared. If such a method is used the manufacturer will be able to have before him information which will tell him definitely just how his product compares with those of other manufacturers and also the buyer of a receiver will have certain definite data upon which to base his decision in buying a receiver. Considerable information on methods of testing radio receiving sets is given in the Technologic Paper of the Bureau of Standards, No. 256. In this paper it is suggested that the following tests be made on a receiver:

(A) Frequency range.

(B) Vibration test, which determines how well the set has been constructed mechanically and whether it will be able to withstand the ordinary shocks obtained in transportation.

(C) Sensitivity.

(D) Selectivity.

These tests are especially effective in indicating how well the set has been engineered from an electrical standpoint. A test should also be made of fidelity, to determine how well the receiver is capable of reproducing voice and music.

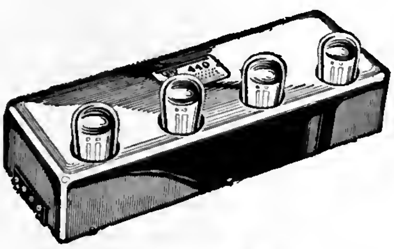
From the standpoint of the average user these tests are not conclusive because he is interested in other things besides the electrical efficiency of the receiver or its fidelity of reproduction. In a laboratory test one receiver might show up much better than another in regard to sensitivity and selectivity but the good results might only be obtained with very accurate adjustments. Obviously, a single-control receiver lacking somewhat in sensitivity and selectivity in comparison with another receiver might actually give somewhat better results when operated by an ordinary buyer with little knowledge of the circuit. As is stated in the paper mentioned above, it is really very difficult to judge the performance of any particular receiving set on the basis of any one trial of its operation, largely due to the widely different types of receivers and conditions under which they are best operated. The skill of the operator very largely determines the degree of satisfaction that will be obtained from any given receiver. In practice it will very likely be found best to just make available to the prospective purchaser some figures of merit indicating the sensitivity, selectivity, and fidelity and then to let him determine for himself whether the receiver in his hands gives satisfactory results.

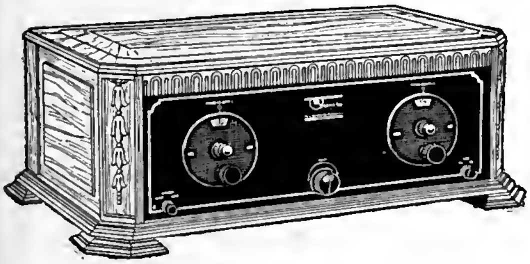
Many letters are received from readers requesting comparisons between different receivers but to give conclusive information of this sort is impossible. The choice of the receiver which one finally purchases after trying out many sets is governed by many factors on which no laboratory measurements can be made.

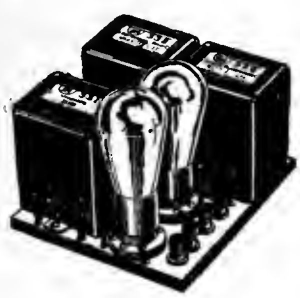
SM

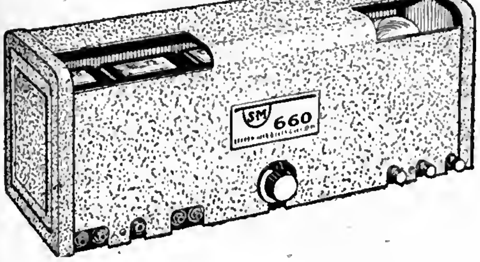
S-M IS READY—

For A. C. Tubes or Any New Developments!









THE 440 time signal amplifier is a fully assembled three stage, 112 K. C., long wave amplifier-detector catacomb. It consists of three air-core low-resistance tuned R. F. stages and detector, with all necessary by-pass condensers, etc., mounted in a copper and brass catacomb, providing individual stage and over-all shielding.

Each 440 amplifier is accurately matched in the S-M laboratories to exactly 112 K. C., and every amplifier is guaranteed to within one-half of one percent. The selectivity of the 440 is tremendous—it may be made 10 K. C., or even 5 K. C., at will, while the sensitivity is guaranteed greater than that of any amplifier that might be built of individual parts. Price $35.00.

The fall season finds S-M 220 audio and 221 output transformers still the acknowledged leaders in the high-quality transformer field. And they are accorded the sincerest form of flattery—imitation—for this year other manufacturers, profiting by their phenomenal success copy the 220 characteristics, introduced by S-M a year ago—5000 cycle cut-off, rising low frequency characteristics, and plenty of iron and copper to make a good job.

But S-M audio transformers stand supreme as the finest available—the only types ever backed by a guarantee of BETTER reproduction or your money back. That's the S-M guarantee—and the return average is less than one in every 4000 sold—3999 satisfied customers out of every 4000. 220 Audio Transformer, price $8.00. 221 Output Transformer, $7.50.

The S-M Unipacs, introduced this June, have taken the country by storm. Everywhere, builders are realizing what true distortionless reproduction really is—for the larger Unipacs (power amplifiers and ABC power supplies) can deliver from 5 to 300 times more—and purer signals—than any standard receiver amplifier, which they replace. Prices range from $62.00 to $93.25 for wired and unwired models.

The new 1927 model Improved Shielded six has all the points that made the original the most popular high-priced TRF kit ever offered. The new "Six" has greatly improved selectivity—so great that will allow 10 to 20 K.C. separation of local and distance stations. The volume has been increased. The tone quality of the new 630 is just as fine as last year's model—GUARANTEED UNCONDITIONALLY to be equal or superior to any other set, regardless of price.

The new 630 can be built for battery, eliminator, or complete A. C operation. The A. C. model is absolutely batteryless, and uses the 652A, ABC power supply. (Any 1926 Shielded six can easily be brought up to date, or adapted for complete A. C. operation.) No matter what developments come, the 630 will always be one of the finest of sets, amply satisfying the most discriminating of fans. Price $95.00.

The S-M 652A unit is the famous 652 "Reservoir B" supply, developed into a complete ABC power supply. Thus, with a 652A kit at $36.50, plus as many A. C. tubes as your set needs, you make it entirely A. C. operated, with all batteries eliminated. Or any new set you are building can dispense with batteries if you use the 652A. Or if you want to change over your present B eliminator, new S-M ABC power transformers are available.

We can't tell you the whole story of new S-M developments, so if you'll just fill in the coupon, and mail it with 10c to cover postage, we'll send you free more up-to-the-minute advance radio information than you could buy in a text book.

Silver-Marshall, Inc.

838 West Jackson Blvd. Chicago, U. S. A.

SILVER-MARSHALL, Inc.
838 West Jackson Blvd., Chicago, U. S. A.

Please send me information on new S-M developments, for which I enclose 10c.

Name..............................

Address..............................

ASK . . ANY . . RADIO . . ENGINEER

The Crowning Adventure of Burgess Radio Batteries

They Flew Over the North Pole with Byrd

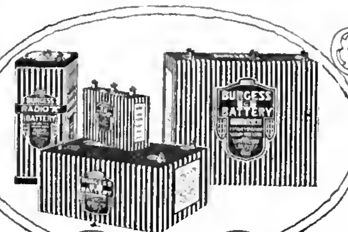
ON May 9, history was made . . . American history . . . World history . . . undying history.

Lieut. Commander Byrd, in his fearless 1500-mile flight across the top of the world, adds another thrilling triumph to the long, proud list of American achievements.

Radio went along, for radio has become vital to the lives and success of explorers and adventurers. Burgess Batteries went along, sharing the fate—sharing the hardships and the glory of Commander Byrd, the Detroit Artic Expedition, and Capt. Donald MacMillan.

It is eminently significant that in these glorious triumphs of American courage and American equipment where the test of men and their tools was the test of the survival of the fittest, that the standard products of the Burgess Battery Company were selected, used and "carried on" under extreme and unprecedented conditions.

BURGESS BATTERY COMPANY
GENERAL SALES OFFICES: CHICAGO
Canadian Factories and Offices:
Niagara Falls and Winnipeg



BURGESS
RADIO BATTERIES

No. 123 — RADIO BROADCAST Laboratory Information Sheet — September, 1927

Characteristics of 171 Type Tube

STATIC AND DYNAMIC

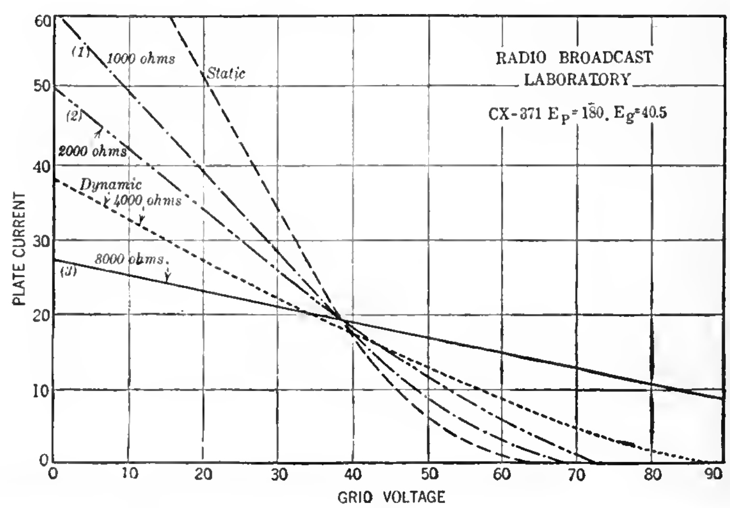
ON LABORATORY Sheet No. 124 are given several curves for the 171 tube. It will be noted that one curve is marked static and another dynamic. The dynamic characteristic is, as its name implies, a curve indicating how the tube will function under actual operating conditions. The static characteristic curve, although valuable in giving an idea of the general characteristics of a tube, gives no indication at all of the tube's actual performance. Under actual operating conditions a tube always operates with a certain load in its plate circuit and consequently a curve taken to indicate the tube's performance should be made with some load in the plate circuit. The curve marked "dynamic" was taken when the tube had 4000 ohms resistance in its plate circuit. The difference between the static and the dynamic curves is considerable.

The curves were taken with 180 volts on the plate and 40.5 volts on the grid. In order that an amplifier may give good quality, its plate-current grid-voltage characteristic must be straight from zero grid voltage to twice the d. c. voltage on the grid. The static characteristic, although straight from 40.5 volts to zero volts, is very curved at voltages greater than 40.5. It might be judged from this curve that the tube's performance would be very poor. However, if a dynamic characteristic is taken, we find that the characteristic remains straight from zero grid voltage down to about 85 volts and consequently the tube would actually give good results.

The other curves on Sheet No. 124 are dynamic characteristics taken with different resistances in the plate circuit. Curve No. 1 was made with 1000 ohms resistance, No. 2 with 2000 ohms, and No. 3 with 8000 ohms. It will be noticed that as the resistances increase the straight portion of the curve becomes greater and greater. The curves all cross at about 40 volts because this grid voltage represents the initial d. c. potential placed on the grid and the curves are made by increasing and decreasing the grid voltage about this average value. It is necessary in taking the curves to adjust the plate voltage each time so that with the different resistances the same plate current is obtained at 40.5 volts on the grid.

No. 124 — RADIO BROADCAST Laboratory Information Sheet — September, 1927

Curves of the 171 Type Tube



No. 125 — RADIO BROADCAST Laboratory Information Sheet — September, 1927

The Morse Code

A	·—
B	—···
C	—·—·
D	—··
E	·
F	··—·
G	——·
H	····
I	··
J	·———
K	—·—
L	·—··
M	——
N	—·
O	———
P	·——·
Q	——·—
R	·—·
S	···
T	—
U	··—
V	···—
W	·——
X	—··—
Y	—·——
Z	——··

Ä (German)	·—·—
Á or Å Spanish-Scandinavian	·——·—
CH (German-Spanish)	————
(É French)	··—··
(Ñ Spanish)	——·——
Ö (German)	———·
Ü (German)	··——
1	·————
2	··———
3	···——
4	····—
5	·····
6	—····
7	——···
8	———··
9	————·
0	—————

Period	·· ·· ··
Semicolon	—·—·—·
Comma	·—·—·—
Colon	———···
Interrogation	··——··
Exclamation Point	——··——
Apostrophe	·————·
Hyphen	—····—
Bar indicating fraction	—··—·
Parenthesis	—·——·—
Inverted Commas	·—··—·
Underline	··——·—
Double dash	—···—
Distress Call	···———···
Attention call to precede every transmission	—·—·—
General inquiry call	—·—· ——·—
From (de)	—·· ·
Invitation to transmit (go ahead)	—·—
Warning-high power	——··——
Question (please repeat after ______) interrupting long messages	··——··
Wait	·—···
Break (double dash)	—···—
Understand	···—·
Error	········
Received (O.K.)	·—·
Position report (to precede all position messages)	—·—··
End of message (cross)	·—·—·
Transmission finished (end of work)	···—·—

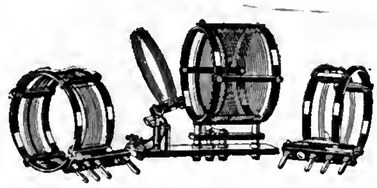
For the Best in Short Wave Reception

Build the

AERO SHORT WAVE RECEIVER

Described in this issue of Radio Broadcast

This kit is the basis of the Aero Short Wave Receiver, described in this issue.



AERO LOW WAVE TUNER KIT
Code No. L. W. T. 125........Price $12.50

Experts and amateurs everywhere have found that this Aero Kit improves any circuit.

Everyone interested in short wave reception should read about the Aero Short Wave Receiver described elsewhere in this issue of Radio Broadcast. This superlative set insures the very best in short wave reception.

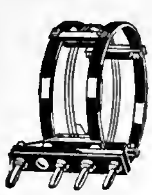
Always the prime favorite of experts and amateurs insistent upon extraordinary short wave performance, the Aero Short Wave Receiver for this season has been made even better than ever. Greater volume, finer selectivity, better tone quality and flexibility to a degree never before thought possible have been embodied in the new Aero Low Wave Tuner Kit, around which this Aero Short Wave Receiver is built, so that the set has a gapless range (when used with INT. coils No. 0, 4, and 5) of 13 to 725 meters!

The performance of this Aero Receiver is so flawless, so satisfactory in every way, that it has been selected as standard equipment by the University of Michigan's Expedition to Greenland (1926-1927-1928) and by the MacMillan Arctic Expedition. No greater proof of its efficiency could be offered than by its selection for these important tasks.

The Aero Low Wave Tuner Kit, illustrated above, is completely interchangeable. The kit itself includes three coils and base mounting, covering U. S. bands 20, 30 and 80 meters. You can increase or decrease the range by securing the Aero Interchangeable Coils described below. All coils fit the same base and use the same condensers.

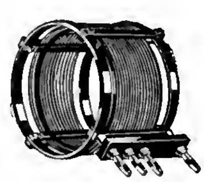
New AERO INTERCHANGEABLE COILS

INT. NO. 0



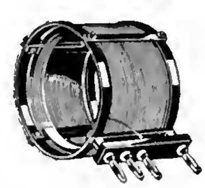
Range 13 to 29.4 meters. This is the most efficient inductance for this low band. Code number INT. No. 0. Price $4.00

INT. NO. 4



Range 125 to 250 meters. Fits same base supplied with low wave tuner kit. Code number INT. No. 4. Price $4.00

INT. NO. 5



Normal range 235 to 550 meters. However, by using .0001 Sangamo fixed condenser across the rotor and stator of the .00014 variable condenser, the maximum wave band of this coil is increased to 725 meters. This gives you coverage of the following bands: Airplane to Airplane, Land to Airplane, Ship to Shore (Great Lakes), Ship to Shore (Atlantic and Pacific oceans), Code number INT. No. 5
Price $4.00

NEW AERO CHOKE COILS

The new Aero Choke 60 has a uniform choking action over a wide range of wave lengths. It eliminates so-called "holes" in the tuning range and is exceptionally efficient in every respect.
Price $1.50

The Aero Choke 248 is an unusually efficient transmitter choke. It presents a high impedance over the usual amateur wave lengths and handles transmitters up to 100 watts.
Price $1.50

We Can Furnish Foundation Unit for this Set

We have made arrangements to furnish complete foundation units for the Aero Short Wave Receiver, completely drilled and engraved on Westinghouse Micarta, at a price of $5.75 each. This fully finished panel greatly simplifies the construction of the Aero Short Wave Receiver and is a great convenience for the home set builder. A detailed blueprint and wiring diagram for this circuit is included with every foundation unit.

Plan for DX Records NOW

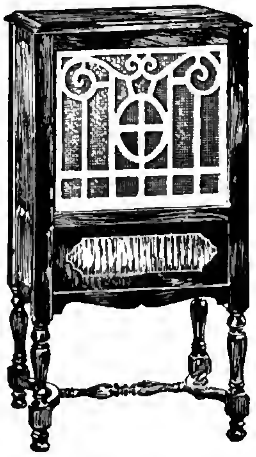
Order any of these Aero Coils direct from us if your dealer doesn't happen to have them. Be sure to specify code numbers when ordering

AERO PRODUCTS, Inc., 1772 Wilson Ave., Chicago

Dept. 109

It will pay you to investigate the new Aero Amateur Transmitter Coils and improved Aero Universal Coil, designed for broadcast band usage. These coils are supplied in complete kits for the improved Aero-Dyne Six, the Aero Seven, the Aero Four and other popular circuits. Write for interesting descriptive literature on these and other new Aero products.

LOBOY MODEL
$160 (without tubes)



MAGNAVOX

Power Cone Speaker
(Dynamic)

Now—a speaker to match the finest set

Improved quality of reception is the keynote of the new sets and tubes. Magnavox matches the finest with its new power speaker. Built on electro-dynamic principles under patents controlled exclusively and made famous by Magnavox.

All the music in ALL its natural beauty is possible only with this type speaker. Even extreme upper and lower register fundamental notes can come through with complete fidelity. Volume ranges from pianissimo to fortissimo without the slighest distortion.

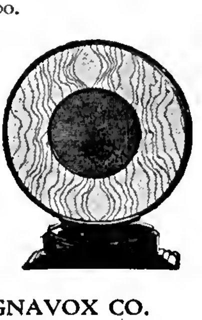
Uses one 216B and one 210 type tube. For connection with alternating house current, doing away with B batteries and B eliminators. Works directly from light socket.

Magnavox Electro-dynamic speaker unit only, type R4, for 6 volts ½ ampere field winding $45.00.

Type R5, unit only, for use in Electric phonograph 100 volt 40 milliampere field winding $45.00.

Type R50, unit only, as used in **Loboy** Speaker complete with amplifier and eliminator $110.00.

Warwick Model Cone
Permanent magnet type handles power tube volume without distortion $27.50.
Type M7 Self contained, complete permanent magnet cone, unit only, 8¼" diameter $12.50.
If you don't know a Magnavox dealer, write us.



THE MAGNAVOX CO.
Oakland, California
1315 So. Michigan Ave. Chicago

No. 126 RADIO BROADCAST Laboratory Information Sheet September, 1927

Condenser Reactance

HOW IT IS CALCULATED

If A condenser is connected in series with an a. c. ammeter to a source of alternating current, a certain amount of current will flow in the circuit, depending upon the size of the condenser and the frequency of the current. If the voltage of the source is divided by the current, the quotient will be the "reactance" of the condenser in ohms. For example, if the frequency of the current being supplied by the source of potential was 60 cycles and the voltage was 110 volts and the size of the condenser was 1 mfd. we would find that 0.412 amperes of current would flow through the circuit. Then 110 volts divided by 0.412 gives 2666, which is the reactance in ohms at 60 cycles of a 1 mfd. condenser. The reactance of a condenser depends upon its size and upon the frequency of the current. It can be calculated by means of the following formula:

$$\text{Reactance} = \frac{10^6}{6.28\ FC}$$

Where F is the frequency in cycles per second and C is the capacity of the condenser in microfarads.

In many calculations it is necessary to know the reactance of a particular condenser at some frequency, and for this reason, on Laboratory Sheet No. 127, is given a table of condenser reactances for capacities between 0.001 and 10 mfd. at frequencies from 60 to 1,000,000 cycles. From the formula given herewith it is evident that the reactance of a condenser is inversely proportional to the capacity of the condenser and inversely proportional to the frequency. Doubling the size of the condenser therefore gives half the reactance, and doubling the frequency of the current also halves the reactance of the condenser. Remembering these two facts it is a simple matter to calculate mentally the reactance of almost any capacity not given in the table on Laboratory Sheet No. 127. For example, a 3-mfd. condenser at 100 cycles has ⅓ of the reactance of a 1 mfd. condenser at 100 cycles. Since the reactance of the latter size at 100 cycles is 1600, then the reactance of a 3-mfd. condenser must be 1600 divided by 3, or 533⅓ ohms. A 0.001-mfd. condenser at 1,000,000 cycles has a reactance of 160 ohms. A 0.0001-mfd. condenser at this frequency therefore has a reactance of 1600 ohms and a 0.01-mfd. condenser likewise has a reactance of 16 ohms.

No. 127 RADIO BROADCAST Laboratory Information Sheet September, 1927

Condenser Reactance

Condenser Capacity in Mfds.	Reactance in Ohms at Various Frequencies							
	60	100	250	500	1000	10,000	100,000	1,000,000
0.001	2666000	1600000	640000	320000	160000	16000	1600	160
0.005	533200	320000	128000	64000	32000	3200	320	32
0.01	266600	160000	64000	32000	16000	1600	160	16
0.1	26660	16000	6400	3200	1600	160	16	1.6
0.5	5332	3200	1280	640	320	32	3.2	.32
1.0	2666	1600	640	320	160	16	1.6	0.16
2.0	1333	800	320	160	80	8	0.8	0.08
4.0	666	400	160	80	40	4	0.4	0.04
8.0	333	200	80	40	20	2	0.2	0.02
10.0	267	160	64	32	16	1.6	0.16	0.016

This table shows how the reactance of various capacities varies with different frequencies. The reactance of a condenser varies inversely with its capacity and with the frequency. See Laboratory Sheet No. 126

No. 128 RADIO BROADCAST Laboratory Information Sheet September, 1927

B Power Units

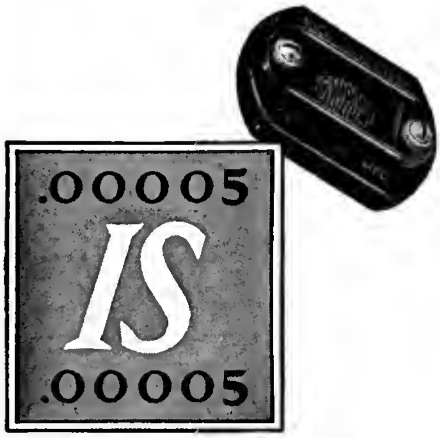
DESIRABLE CHARACTERISTICS

A B-POWER unit is essentially a device to supply plate voltage to a radio receiver but such a unit has several characteristics besides the ability to supply proper voltages that are important in determining how satisfactorily it will operate. Modern batteries for the plate supply of a receiver can hardly be improved on. Their voltage is constant, they are perfectly quiet in operation, and leave little to be desired as a source of plate potential. The expense of operating a multi-tube receiver using power tubes from batteries is considerable, however, but a B power unit, properly designed, affords an excellent source of high plate potential at moderate cost.

What are the desirable characteristics of such a unit? It must first of all be capable of supplying the proper voltages to a receiver. Either insufficient or excessive voltage will adversely affect the operation of a receiver in many cases and it is therefore essential that some care be taken to make certain that the voltages being supplied are correct.

The power unit must deliver those voltages with a minimum of a. c. hum. Low hum output is only obtained with a properly designed transformer and filter system. The various filter chokes should be shielded so that magnetic coupling between them will not be possible and it is also necessary that some means be used to electrostatically shield the high-voltage secondary windings from the primary winding to prevent any line noise from the power mains getting into the filter system, and making the output of the unit noisy. This shielding between the primary and secondary may be accomplished by means of a grounded copper shield between the primary and secondary windings or the shielding may be accomplished quite effectively by placing the filament winding, supplying the power tube, between the primary and high-voltage windings. The filament winding, being at ground potential, therefore acts as a very effective shield. A noisy plate supply unit generally indicates the lack of proper magnetic shielding, or improper filtering.

A third desirable characteristic of a power unit is good regulation, which determines how much the output voltage will change with changes in the amount of current being supplied by the unit. A particular plate supply device might give exactly 90 volts at the 90-volt tap with a load of 10 mA. If, however, the regulation was poor and your receiver only required 4 mA. from the 90-volt tap, the actual voltage at this tap might rise as high as 130 volts; if the unit had good regulation the voltage would not be more than 98 at a load of 4 mA. Power units with poor regulation frequently cause receivers to "motor boat" or distort the signal in some other way, and good regulation, *i. e.*, small variation of output voltage with output load, is therefore a very desirable characteristic.



Permanently when Sangamo Mica Condensers are used.

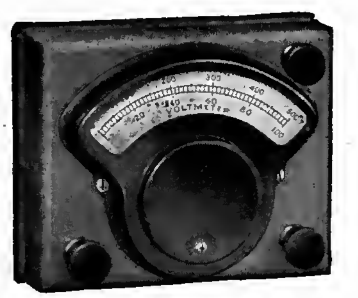
Condenser accuracy is not only measured by factory tests of value—it is determined by permanence after heat of soldering, work box knocks, and a year or more of service under all atmospheric conditions!

Sangamo condensers are accurately rated (within 10 per cent of marked value) and of greater importance—they stay accurate. A solid sheathing of pressure-molded bakelite makes that certain.

SANGAMO ELECTRIC COMPANY
Springfield, Illinois

SANGAMO
MICA CONDENSERS

Hoyt B ELIMINATOR VOLTMETER



A new sensitive voltmeter, for regular dealers' service work as well as for laboratory and precision measurements. Resistance 1,000 ohms per volt. Provided with two scales—0-100 volts and 0-500 volts, covering the entire range of ordinary B-Eliminator and Power-Amplifier work.

PRICES

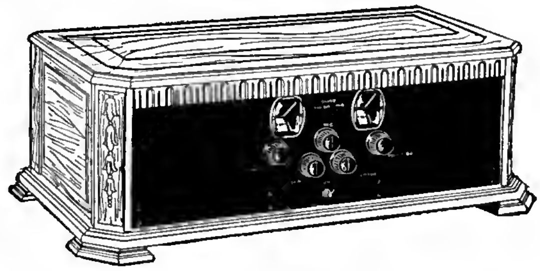
HOYT Standard B-Eliminator Voltmeter, 0-100 and 0-500 volts, $28.00.

Supplied on special order with additional scale, either: 0-10 volts or 0-100 ma. at $32.50.

Send for price list B-9

BURTON-ROGERS CO.
Sole Selling Agents
Boston Massachusetts

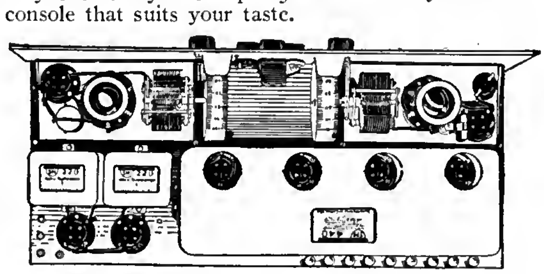
The Improved
SHIELDED LABORATORY
Receiver



FROM the Setbuilders Supply Co. you can get all parts for the new Laboratory Receiver, each and every item most carefully inspected and checked, and with a guarantee that your set, assembled from these parts, will give you results you've never had before *on any set.* You can also buy tubes, batteries, cabinets and loud speakers specially approved and tested for the Laboratory Super by McMurdo Silver and Ernest R. Pfaff.

It goes without saying that you want to own the Laboratory Receiver, just as you want the *best* of anything. And the Laboratory Receiver *is* the best, for it has features that you won't find in the most expensive factory set you could buy. Take its selectivity for instance—it will tune in out of town stations through local interference that paralyzes ordinary sets. It's so sensitive it brings in these same stations with tremendous punch—when other sets don't even get through.

Then, its appearance is in the three to five hundred dollar class, though you're not handicapped by a factory cabinet—you can put *your* set in any cabinet or console that suits your taste.



Tested and Guarateed Parts Exactly as Specified for the Laboratory Receiver

I Van Doorn panel and chassis, pierced, with hardware	$8.50
1 Carter .00015 condenser with leak clips	.50
1 Carter M-200 potentiometer	.75
2 Carter No. 105, ½ mfd. condensers @ .90	1.80
1 Carter 3 ohm rheostat	.50
1 Carter battery Switch	.50
4 Carter No. 10 tipjacks @ .10	.40
1 Polymet 2 megohm leak	.25
2 S-M 220 audio transformers @ 8.00	16.00
4 S-M 511 tube sockets @ .50	2.00
2 S-M 805 vernier drum dials @ 3.00	6.00
1 S-M 275 RF choke	.90
1 S-M 342 condenser	1.50
1 S-M 440 time signal amplified, 112 K.C.	35.00
2 S-M 515 coil sockets @ 1.00	2.00
2 S-M 111A coils @ 2.50	5.00
9 X-L binding posts @ .15	1.35
2 S-M 320 .00035 condensers @ 3.25	6.50
	$89.45

GUARANTEE

The Setbuilders Supply Company unconditionally guarantees the performance of any receiver built from the parts listed above to be superior to that of any other eight-tube receiver.

FACTS

Sensitivity: The Laboratory Receiver, in direct comparative tests, will bring in with loud speaker volume stations barely audible upon seven and eight tube shielded neutrodynes. Compared to other super-heterodynes, it will give greater volume, and generally bring in more stations, than any other eight or nine tube sets.

Selectivity: Located in Chicago, the Laboratory Receiver will allow reception of out-of-town stations within 7 to 10 kilocycles of powerful locals. In comparative tests, it will give greater selectivity than any eight or nine tube super that can be built from standard parts. In fact, the set is so selective that it will take a week's careful combing of the broadcast band to log all stations within range!

Range: On short waves below 200 meters, the range is unlimited—5,000 to 12,000 miles reception is not at all unusual. In the 200 to 550 meter broadcast band, the range is 1,000 to 10,000 miles, but is guaranteed equal to or greater than that of any other receiver. Between 500 and 3,000 meters, the range is guaranteed greater than that of any other receiver.

Volume: It can only be stated that the volume of the Laboratory Receiver is equal to that of any standard receiver, and is guaranteed equal or greater than that of any eight to ten tube set.

Wavelength Range: 30 to 3,000 meters with standard interchangeable plug-in coil.

Amplification: The first detector and oscillator give a voltage amplification of 25; the long wave and second detector 10,000 (10 x 10 x 10 x 10 for four tubes); and the audio amplifier, 400 (20 x 20 for two stages). The over-all amplification is thus seen to be 100,000,000—about 80 times that of average eight tube superheterodynes; about twice that of the best eight tube neutrodynes, and 20 times that of average seven tube shielded neutrodynes. The one hundred million amplification figure for the Laboratory Receiver is without extremely critical adjustment—critically adjusted for a very weak station, it will go up to a billion times or more!

This Brings All the Details!

Please send me all data on the Laboratory Receiver for which I enclose 10c.

SETBUILDERS SUPPLY CO.
502-E South Peoria St., Chicago, U. S. A.

TRIMM Headsets For Short-Wave Receivers

Dr. Donald B. MacMillan

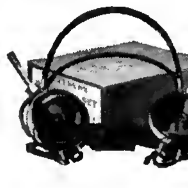
used Trimm Headsets in his last three expeditions to the Arctic regions in the ship Bowdoin. Here, isolated from the rest of the world, with no chance to make repairs, Dr. MacMillan depended on Trimm 'phones, maintaining unprecedented communication over tremendous distances.

Short-Wave Radio

is growing in interest. The new conquests, the big promise of the future are definitely tied up with these experiments. At least three American stations are broadcasting short-wave voice and music. The most progressive of the amateurs are constructing short-wave sets. And their experiences are writing a chapter of modern miracles.

Trimm Head 'Phones

are the choice of the leading amateurs and expert radio men. The Trimm Professional leads the line.



Trimm Professional Headsets at $5.50

The Trimm Dependable at $4.00 is the best low-priced headset on the market. At a price but little higher than that of a cheap, inefficient headset, you may buy this real quality instrument.

At all Radio Dealers or write to us direct

TRIMM RADIO MANUFACTURING COMPANY
847 W. Harrison St. CHICAGO U.S.A.

Manufacturers' Booklets

A Varied List of Books Pertaining to Radio and Allied Subjects Obtainable Free With the Accompanying Coupon

READERS may obtain any of the booklets listed below by using the coupon printed on page 322 Order by number only.

1. FILAMENT CONTROL—Problems of filament supply, voltage regulation, and effect on various circuits. RADIALL COMPANY.

2. HARD RUBBER PANELS—Characteristics and properties of hard rubber as used in radio, with suggestions on how to "work" it. B. F. GOODRICH RUBBER COMPANY.

3. TRANSFORMERS—A booklet giving data on input and output transformers. PACENT ELECTRIC COMPANY.

4. RESISTANCE-COUPLED AMPLIFIERS—A general discussion of resistance coupling with curves and circuit diagrams. COLE RADIO MANUFACTURING COMPANY.

5. CARBORUNDUM IN RADIO—A book giving pertinent data on the crystal as used for detection, with hook-ups, and a section giving information on the use of resistors. THE CARBORUNDUM COMPANY.

6. B-ELIMINATOR CONSTRUCTION—Constructional data on how to build. AMERICAN ELECTRIC COMPANY.

7. TRANSFORMER AND CHOKE-COUPLED AMPLIFICATION—Circuit diagrams and discussion. ALL-AMERICAN RADIO CORPORATION.

8. RESISTANCE UNITS—A data sheet of resistance units and their application. WARD-LEONARD ELECTRIC COMPANY.

9. VOLUME CONTROL—A leaflet showing circuits for distortionless control of volume. CENTRAL RADIO LABORATORIES.

10. VARIABLE RESISTANCE—As used in various circuits. CENTRAL RADIO LABORATORIES.

11. RESISTANCE COUPLING—Resistors and their application to audio amplification, with circuit diagrams. DEJUR PRODUCTS COMPANY.

12. DISTORTION AND WHAT CAUSES IT—Hook-ups of resistance-coupled amplifiers with standard circuits. ALLEN-BRADLEY COMPANY.

15. B-ELIMINATOR AND POWER AMPLIFIER—Instructions for assembly and operation using Raytheon tube. GENERAL RADIO COMPANY.

15a. B-ELIMINATOR AND POWER AMPLIFIER—Instructions for assembly and operation using an R. C. A. rectifier. GENERAL RADIO COMPANY.

16. VARIABLE CONDENSERS—A description of the functions and characteristics of variable condensers with curves and specifications for their application to complete receivers. ALLEN D. CARDWELL MANUFACTURING COMPANY.

17. BAKELITE—A description of various uses of bakelite in radio, its manufacture, and its properties. BAKELITE CORPORATION.

19. POWER SUPPLY—A discussion on power supply with particular reference to lamp-socket operation. Theory and constructional data for building power supply devices. ACME APPARATUS COMPANY.

20. AUDIO AMPLIFICATION—A booklet containing data on audio amplification together with hints for the constructor. ALL AMERICAN RADIO CORPORATION.

21. HIGH-FREQUENCY DRIVER AND SHORT-WAVE WAVEMETER—Constructional data and application. BURGESS BATTERY COMPANY.

46. AUDIO-FREQUENCY CHOKES—A pamphlet showing positions in the circuit where audio-frequency chokes may be used. SAMSON ELECTRIC COMPANY.

47. RADIO-FREQUENCY CHOKES—Circuit diagrams illustrating the use of chokes to keep out radio-frequency currents from definite points. SAMSON ELECTRIC COMPANY.

48. TRANSFORMER AND IMPEDANCE DATA—Tables giving the mechanical and electrical characteristics of transformers and impedances, together with a short description of their use in the circuit. SAMSON ELECTRIC COMPANY.

49. BYPASS CONDENSERS—A description of the manufacture of bypass and filter condensers. LESLIE F. MUTER COMPANY.

50. AUDIO MANUAL—Fifty questions which are often asked regarding audio amplification, and their answers. AMERTRAN SALES COMPANY, INCORPORATED.

51. SHORT-WAVE RECEIVER—Constructional data on a receiver which, by the substitution of various coils, may be made to tune from a frequency of 16,660 kc. (18 meters) to 1999 kc. (150 meters). SILVER-MARSHALL, INCORPORATED.

52. AUDIO QUALITY—A booklet dealing with audio-frequency amplification of various kinds and the application to well-known circuits. SILVER-MARSHALL, INCORPORATED.

56. VARIABLE CONDENSERS—A bulletin giving an analysis of various condensers together with their characteristics. GENERAL RADIO COMPANY.

57. FILTER DATA—Facts about the filtering of direct current supplied by means of motor-generator outfits used with transmitters. ELECTRIC SPECIALTY COMPANY.

59. RESISTANCE COUPLING—A booklet giving some general information on the subject of radio and the application of resistors to a circuit. DAVEN RADIO CORPORATION.

60. RESISTORS—A pamphlet giving some technical data on resistors which are capable of dissipating considerable energy; also data on the ordinary resistors used in resistance-coupled amplification. THE CRESCENT RADIO SUPPLY COMPANY.

62. RADIO-FREQUENCY AMPLIFICATION—Constructional details of a five-tube receiver using a special design of radio-frequency transformer. CAMFIELD RADIO MFG. COMPANY.

63. FIVE-TUBE RECEIVER—Constructional data on building a receiver. AERO PRODUCTS, INCORPORATED.

64. AMPLIFICATION WITHOUT DISTORTION—Data and curves illustrating the use of various methods of amplification. ACME APPARATUS COMPANY.

66. SUPER-HETERODYNE—Constructional details of a seven-tube set. G. C. EVANS COMPANY.

70. IMPROVING THE AUDIO AMPLIFIER—Data on the characteristics of audio transformers, with a circuit diagram showing where chokes, resistors, and condensers can be used. AMERICAN TRANSFORMER COMPANY.

72. PLATE SUPPLY SYSTEM—A wiring diagram and layout plan for a plate supply system to be used with a power amplifier. Complete directions for wiring are given. AMERTRAN SALES COMPANY.

80. FIVE-TUBE RECEIVER—Data are given for the construction of a five-tube tuned radio-frequency receiver. Complete instructions, list of parts, circuit diagram, and template are given. ALL-AMERICAN RADIO CORPORATION.

81. BETTER TUNING—A booklet giving much general information on the subject of radio reception with specific illustrations. Primarily for the non-technical home constructor. BREMER-TULLY MANUFACTURING COMPANY.

82. SIX-TUBE RECEIVER—A booklet containing photographs, instructions, and diagrams for building a six-tube shielded receiver. SILVER-MARSHALL, INCORPORATED.

83. SOCKET POWER DEVICE—A list of parts, diagrams, and templates for the construction and assembly of socket power devices. JEFFERSON ELECTRIC MANUFACTURING COMPANY.

84. FIVE-TUBE EQUAMATIC—Panel layout, circuit diagrams, and instructions for building a five-tube receiver, together with data on the operation of tuned radio-frequency transformers of special design. KARAS ELECTRIC COMPANY.

85. FILTER—Data on a high-capacity electrolytic condenser used in filter circuits in connection with A socket power supply units, are given in a pamphlet. THE ABOX COMPANY.

86. SHORT-WAVE RECEIVER—A booklet containing data on a short-wave receiver as constructed for experimental purposes. THE ALLEN D. CARDWELL MANUFACTURING CORPORATION.

88. SUPER-HETERODYNE CONSTRUCTION—A booklet giving full instructions, together with a blue print and necessary data, for building an eight-tube receiver. THE GEORGE W. WALKER COMPANY.

89. SHORT-WAVE TRANSMITTER—Data and blue prints are given on the construction of a short-wave transmitter, together with operating instructions, methods of keying, and other pertinent data. RADIO ENGINEERING LABORATORIES.

90. IMPEDANCE AMPLIFICATION—The theory and practice of a special type of dual-impedance audio amplification are given. ALDEN MANUFACTURING COMPANY.

93. B-SOCKET POWER—A booklet giving constructional details of a socket-power device using either the BH or 313 type rectifier. NATIONAL COMPANY, INCORPORATED.

94 POWER AMPLIFIER—Constructional data and wiring diagrams of a power amplifier combined with a B-supply unit are given. NATIONAL COMPANY, INCORPORATED.

100. A, B, AND C SOCKET-POWER SUPPLY—A booklet giving data on the construction and operation of a socket-power supply using the new high-current rectifier tube. THE Q. R. S. MUSIC COMPANY.

101. USING CHOKES—A folder with circuit diagrams of the more popular circuits showing where choke coils may be placed to produce better results. SAMSON ELECTRIC COMPANY.

ACCESSORIES

22. A PRIMER OF ELECTRICITY—Fundamentals of electricity with special reference to the application of dry cells to radio and other uses. Constructional data on buzzers, automatic switches, alarms, etc. NATIONAL CARBON COMPANY.

23. AUTOMATIC RELAY CONNECTIONS—A data sheet showing how a relay may be used to control A and B circuits. YAXLEY MANUFACTURING COMPANY.

25. ELECTROLYTIC RECTIFIER—Technical data on a new type of rectifier with operating curves. KODEL RADIO CORPORATION.

26. DRY CELLS FOR TRANSMITTERS—Actual tests given, well illustrated with curves showing exactly what may be expected of this type of B power. BURGESS BATTERY COMPANY.

27. DRY-CELL BATTERY CAPACITIES FOR RADIO TRANSMITTERS—Characteristic curves and data on discharge tests. BURGESS BATTERY COMPANY.

28. B BATTERY LIFE—Battery life curves with general curves on tube characteristics. BURGESS BATTERY COMPANY.

29. HOW TO MAKE YOUR SET WORK BETTER—A non-technical discussion of general radio subjects with hints on how reception may be bettered by using the right tubes. UNITED RADIO AND ELECTRIC CORPORATION.

30. TUBE CHARACTERISTICS—A data sheet giving constants of tubes. C. E. MANUFACTURING COMPANY.

31. FUNCTIONS OF THE LOUD SPEAKER—A short, non-technical general article on loud speakers. AMPLION CORPORATION OF AMERICA.

32. METERS FOR RADIO—A catalogue of meters used in radio, with connecting diagrams. BURTON-ROGERS COMPANY.

33. SWITCHBOARD AND PORTABLE METERS—A booklet giving dimensions, specifications, and shunts used with various meters. BURTON-ROGERS COMPANY.

34. COST OF B BATTERIES—An interesting discussion of the relative merits of various sources of B supply. HARTFORD BATTERY MANUFACTURING COMPANY.

35. STORAGE BATTERY OPERATION—An illustrated booklet on the care and operation of the storage battery. GENERAL LEAD BATTERIES COMPANY.

36. CHARGING A AND B BATTERIES—Various ways of connecting up batteries for charging purposes. WESTINGHOUSE UNION BATTERY COMPANY.

37. CHOOSING THE RIGHT RADIO BATTERY—Advice on what dry cell battery to use; their application to radio, with wiring diagrams. NATIONAL CARBON COMPANY.

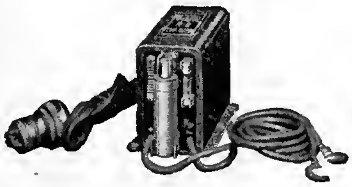
53. TUBE REACTIVATOR—Information on the care of vacuum tubes, with notes on how and when they should be reactivated. THE STERLING MANUFACTURING COMPANY.

54. ARRESTERS—Mechanical details and principles of the vacuum type of arrester. NATIONAL ELECTRIC SPECIALTY COMPANY.

55. CAPACITY CONNECTOR—Description of a new device for connecting up the various parts of a receiving set, and at the same time providing bypass condensers between the leads. KURZ-KASCH COMPANY.

(Continued on page 322)

NATIONAL
RADIO CHARGERS



2½ ampere Charger. Employs one Raytheon "A" Rectifier. Complete with cord and plug, rubber-covered battery leads and terminals.

Price $11.50

NATIONAL Radio Chargers use the new RAYTHEON "A" dry rectifier cartridge. They are light, compact and use very little electric current. Made to recognized NATIONAL standards.

NATIONAL Duo Range Chargers, 2½ or 5 amperes. Complete with fuses, tell-tale lamp, cord, black rubber-covered leads and battery clips and two Raytheon "A's"

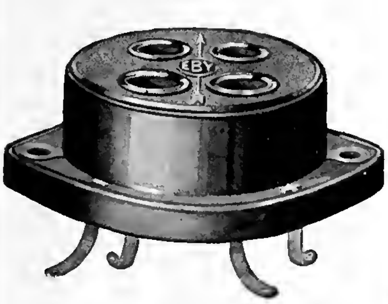
Price $19.00

NATIONAL
RADIO PRODUCTS

Send for Pamphlet B-9

NATIONAL CO., Inc., Malden, Mass.
W. A. Ready, *President*

New!



and *Much* Better!

The prongs are completely enclosed and *can't* spread. No more socket trouble to shoot!

After all, a socket's only job is to provide a perfect contact. The Eby three point wiping spring contact is the most scientifically perfect type known.

Easy to mount above or below Bakelite, Wood, or Metal.

Specified in Hammarlund Roberts Hi-Q6 and other popular circuits.

List Price 40c

THE H. H. EBY MFG. CO.
INCORPORATED
4710 Stenton Ave.
Phila., Pa.

Makers of Eby Binding Posts

TIME
to think about your set!

AUTUMN is coming—World's Series games, Davis Cup matches, football, even a heavyweight championship to be decided.

But will your set be ready? Most sets lose their vitality through summer idleness, taking on a general fatigue which affects batteries, tubes, and circuits alike. Your set is probably no exception.

It may have a "swinging open-circuit," improper voltage "balance" between B and C batteries, or some other electrical defect. Can you locate these troubles and correct them?

Your set deserves an electrical inspection with

WESTON
Model 519
Radio Set Tester
1000 ohms per volt

Consult a Reliable Dealer—One who maintains a service department equipped to make the required tests at your home. Make certain that his service man employs the instrument shown above. You can then be assured that your set will receive a thorough "conditioning"—circuits adjusted, tubes and batteries replaced where necessary—and all with laboratory accuracy.

Then with your set in complete order you should install a small Weston instrument to *maintain* the efficiency of your set.

There are several models available. Your dealer will advise you which one to use for your set. *Ask for Circular J.*

WESTON ELECTRICAL INSTRUMENT CORPORATION

179 Weston Avenue, Newark, N. J.

STANDARD THE WORLD OVER
WESTON
Pioneers since 1888

"RADIO BROADCAST'S" DIRECTORY OF MANUFACTURED RECEIVERS

¶ A coupon will be found on page 328. All readers who desire additional information on the receivers listed below need only insert the proper numbers in the coupon, mail it to the Service Department of RADIO BROADCAST, and full details will be sent.

KEY TO TUBE ABBREVIATIONS

99—60-mA. filament (dry cell)
01A—Storage battery 0.25 amps. filament
12—Power tube (Storage battery)
71—Power tube (Storage battery)
16B—Half-wave rectifier tube
Hmu—High-Mu tube for resistance-coupled audio
20—Power tube (dry cell)
10—Power Tube (Storage battery)
00A—Special detector
13—Full-wave rectifier tube
26—Low-voltage high-current a. c. tubes
27—Heater type a. c. tube

DIRECT CURRENT RECEIVERS

NO. 424. COLONIAL 26

Six tubes; 2 t. r. f. (01-A), detector (12), 2 transformer audio (01-A and 71). Balanced t. r. f. One to three dials. Volume control: antenna switch and potentiometer across first audio. Watts required: 120. Console size: 34 x 38 x 18 inches. Headphone connections. The filaments are connected in a series parallel arrangement. Price $250 including power unit.

NO. 425. SUPERPOWER

Five tubes: All 01-A tubes. Multiplex circuit. Two dials. Volume control: resistance in r. f. plate. Watts required: 30. Antenna: loop or outside. Cabinet sizes: table, 27 x 10 x 9 inches; console, 28 x 50 x 21. Prices: table, $135 including power unit; console, $390 including power unit and loud speaker.

A. C. OPERATED RECEIVERS

NO. 508. ALL-AMERICAN 77, 88, AND 99

Six tubes; 3 t. r. f. (26), detector (27), 2 transformer audio (26 and 71). Rice neutralized t. r. f. Single drum tuning. Volume control: potentiometer in r. f. plate. Cabinet sizes: No. 77, 21 x 10 x 8 inches; No. 88 Hiboy, 25 x 38 x 18 inches; No. 99 console, 27½ x 43 x 20 inches. Shielded. Output device. The filaments are supplied by means of three small transformers. The plate supply employs a gas-filled rectifier tube. Volt-meter in a. c. supply line. Prices: No. 77, $150, including power unit; No. 88, $210 including power unit; No. 99, $285 including power unit and loud speaker.

NO. 509. ALL-AMERICAN "DUET"; "SEXTET"

Six tubes; 2 t. r. f. (99), detector (99), 3 transformer audio (99 and 12). Rice neutralized t.r.f. Two dials. Volume control: resistance in r.f. plate. Cabinet sizes: "Duet," 23 x 56 x 16½ inches; "Sextet," 22½ x 13½ x 15½ inches. Shielded. Output device. The 99 filaments are connected in series and supplied with rectified a.c., while 12 is supplied with raw a.c. The plate and filament supply uses gaseous rectifier tubes. Millammeter on power unit. Prices: "Duet," $160 including power unit; "Sextet," $220 including power unit and loud speaker.

NO. 511. ALL-AMERICAN 80, 90, AND 115

Five tubes; 2 t.r.f. (99), detector (99), 2 transformer audio (99 and 12). Rice neutralized t.r.f. Two dials. Volume control: resistance in r.f. plate. Cabinet sizes: No. 80, 23¼ x 12¼ x 15 inches; No. 90, 37½ x 12 x 12½ inches; No. 115 Hiboy, 24 x 41 x 15 inches. Coils individually shielded. Output device. See No. 509 for power supply. Prices: No. 80, $135 including power unit; No. 90, $145 including power unit and compartment; No. 115, $170 including power unit, compartment, and loud speaker.

NO. 510. ALL-AMERICAN 7

Seven tubes; 3 t.r.f. (26), 1 untuned r.f. (26), detector (27), 2 transformer audio (26 and 71). Rice neutralized t.r.f. One drum. Volume control: resistance in r.f. plate. Cabinet sizes: "Sovereign" console, 30½ x 60½ x 19 inches; "Lorraine" Hiboy, 25½ x 53¾ x 17¼ inches; "Forte" cabinet, 25½ x 13½ x 17½ inches. For filament and plate supply: See No. 508. Prices: "Sovereign" $460; "Lorraine" $360; "Forte" $270. All prices include power unit. First two include loud speaker.

NO. 403. ARGUS 250B

Six tubes; 2 t.r.f. (99), 1 untuned r.f. (99), detector (99), 2 transformer audio (99 and 12). Stabilized with grid resistances. Two dials. Volume control: resistance across 1st audio. Watts required: 100. Cabinet size: 35½ x 14½ x 10¾ inches. Output device. The 99 filaments are connected in series and supplied with rectified a.c., while the 12 is run on raw a.c. The power unit requires two 16-B rectifier tubes. Milliammeter included in d.c. supply. Price $250.00 including self-contained power unit. Other models: No. 125, $125.00; console model, $375.00.

NO. 401. AMRAD AC9

Six tubes; 3 t.r.f. (99), detector (99), 2 transformer (99 and 12). Neutrodyne. Two dials. Volume control: resistance across 1st audio. Watts consumed: 50. Cabinet size: 27 x 9 x 11¾ inches. The 99 filaments are connected in series and supplied with rectified a.c., while the 12 is run on raw a.c. The power unit, requiring two 16-B rectifiers, is separate and supplies A, B, and C current. Price $142 including power unit.

NO. 402. AMRAD AC5

Five tubes. Same as No. 401 except one less r.f. stage. Price $125 including power unit.

NO. 484. BOSWORTH, B5

Five tubes; 2 t.r.f. (26), detector (99), 2 transformer audio (special a.c. tubes). T.r.f. circuit. Two dials. Volume control: potentiometer. Cabinet size: 23 x 7 x 8 inches. Output device included. Price $175.

NO. 406. CLEARTONE 110

Five tubes; 2 t.r.f., detector, 2 transformer audio. All tubes a. c. heater type. One or two dials. Volume control: resistance in r. f. plate. Watts consumed: 40. Cabinet size: varies. The plate supply is built in the receiver and requires one rectifier tube. Filament supply through step down transformers. Prices range from $175 to $375 which includes 5 a.c. tubes and one rectifier tube.

NO. 407. COLONIAL 25

Six tubes; 2 t. r. f. (01-A), detector (99), 2 resistance audio (99). 1 transformer audio (10). Balanced t.r.f. circuit. One or three dials. Volume control: Antenna switch and potentiometer on 1st audio. Watts consumed: 100. Console size: 34 x 38 x 18 inches. Output device. All tube filaments are operated on a. c. except the detector which is supplied with rectified a.c. from the plate supply. The rectifier employs two 16-B tubes. Price $250 including built-in plate and filament supply.

NO. 507. CROSLEY 602 BANDBOX

Six tubes; 3 t.r.f. (26), detector (27), 2 transformer audio (26 and 71). Balanced t.r.f. circuit. One dial, Cabinet size: 17¾ x 5¼ x 7⅝ inches. The heaters for the a.c. tubes and the 71 filament are supplied by small transformers available to operate either on 50 or 60 cycles. The plate current is supplied by means of rectifier tube. Price $65 for set alone, power unit $60.

NO. 408. DAY-FAN "DE LUXE"

Six tubes; 3 t.r.f., detector, 2 transformer audio. All 01-A tubes. One dial. Volume control: potentiometer across r.f. tubes. Watts consumed: 300. Console size: 30 x 40 x 20 inches. The filaments are connected in series and supplied with d.c. from a motor-generator set which also supplies B and C current. Output device. Price $350 including power unit.

NO. 409. DAYCRAFT 5

Five tubes; 2 t.r.f., detector, 2 transformer audio. All a. c. heater tubes. Reflexed t.r.f. One dial. Volume control: potentiometers in r.f. plate and 1st audio. Watts consumed: 135. Console size: 34 x 36 x 14 inches. Output device. The heaters are supplied by means of a small transformer. A built-in rectifier supplies B and C voltages. Price $170, less tubes. The following have one more r.f. stage and are not reflexed: Daycraft 6, $195; Dayrole 6, $235; Dayfan 6, $110. All prices less tubes.

NO. 469. FREED-EISEMANN NR11

Six tubes; 3 t.r.f. (01-A), detector (01-A), 2 transformer audio (01-A and 71). Neutrodyne. One dial. Volume control: potentiometer. Watts consumed: 150. Cabinet size: 19⅞ x 10 x 10½ inches. Shielded. Output device. A special power unit is included employing a rectifier tube. Price $225 including NR-411 power unit.

NO. 487. FRESHMAN 7F-AC

Six tubes; 3 t.r.f. (26), detector (27), 2 transformer audio (26 and 71). Equaphase circuit. One dial. Volume control: potentiometer across 1st audio. Console size: 24½ x 41½ x 15 inches. Output device. The filaments and heaters are all supplied by means of small transformers. The plate supply requires one 13 rectifier tube. Price $160 including tubes.

NO. 411. HERBERT LECTRO 120

Five tubes; 2 t.r.f. (99), detector (99), 2 transformer audio (99 and 71). Three dials. Volume control: rheostat in primary of a.c. transformer. Watts required: 45. Cabinet size: 32 x 10 x 12 inches. The 99 filaments are connected in series, supplied with rectified a. c., while the 71 is run on raw a. c. The power unit uses a Q. R. S. rectifier tube. Price $120.

NO. 412. HERBERT LECTRO 200

Six tubes; 2 t.r.f. (99), detector (99), 1 transformer audio (99), 1 push-pull audio (71). One dial. Volume control: rheostat in primary of a. c. transformer. Watts consumed: 60. Cabinet size: 20 x 12 x 12 inches. Filaments connected same as above. Completely shielded. Output device. Price $200.

NO. 410. LARCOFLEX 73

Seven tubes; 4 t.r.f. (O1-A), detector (01-A), 2 transformer audio (01-A and 71). T.r.f. circuit. One dial. Volume control: resistance in r.f. plate. Console size 30 x 42 x 20 inches. Completely shielded. Built-in A, B and C supply. Price $215.

NO. 490. MOHAWK

Six tubes; 2 t.r.f., detector, 2 transformer audio. All tubes a.c heater type except 71 in last stage. One dial. Volume control: rheostat on r.f. Watts consumed: 40. Panel size: 12½ x 8¾ inches. Output device. The heaters for the a.c tubes and the 71 filament are supplied by small transformers. The plate supply is of the built-in type using a rectifier tube. Prices range from $65 to $245

NO. 413. MARTI

Six tubes: 2 t.r.f., detector, 3 resistance audio. All tubes a.c. heater type. Two dials. Volume control: resistance in r.f. plate. Watts consumed: 38. Panel size 7 x 21 inches. The built-in plate supply employs one 16-B rectifier. The filaments are supplied by a small transformer. Prices: table, $235 including tubes and rectifier; console, $275 including tubes and rectifier; console, $325 including tubes, rectifier, and loud speaker.

NO. 416. NASSAU POWER

Six tubes; 2 t. r. f. (99) detector (99), 3 audio (99 and 10). Two dials. Volume control: resistace in r.f. plate circuit. Bridge circuit. Cabinet size: 28 x 45 x 18 inches. The 99 filaments are connected in series and supplied with rectified a. c., while the 10 is supplied with raw a. c. The power unit requires one 16-B tube. Output device. Milliammeter on the front panel indicates filament current.

NO. 417. RADIOLA 28

Eight tubes; 2 detectors (99) 1 oscillator (99), 2 transformer audio (99 and 10), 3 intermediate frequency (99). Super-heterodyne. One dial. Volume control: potentiometer on intermediate stages. Console size: 26½ x 63 x 17 inches. The 99 filaments are connected in series and supplied with rectified a.c., while the 10 tube is supplied with raw a.c. The power unit requires two 216-B's, one 874, and one 876, the latter two being regulator tubes. Loop operated. Shielded. Output device. Price $540 including all tubes and No. 104 loud speaker. Model 28 also sold without the power units and loud speaker.

NO. 418. SUPERPOWER A. C.

Five tubes; "Multiplex" circuit using 01-A tubes. Two dials. Volume control: resistance in r. f. plate. Console size: 28 x 50 x 21 inches. Antenna: loop or outside. The filaments of the 01-A tubes are supplied with rectified a. c. The rectifier employs two tungar tubes. Price $390 including loud speaker and power unit. Cabinet size: 27 x 10 x 9 inches and lists for $180 including power unit.

NO. 420. SIMPLEX B

Six tubes; 3 t.r.f., detector, 2 transformer audio. All tubes a.c. heater type. One dial. Volume control resistance in r.f. plate. Headphone connection. Console size: 34 x 36 x 14 inches. The heaters are supplied by means of a small a. c. transformer, the B and C voltage being obtained from a built-in plate supply unit. Price $250, complete.

NO. 421. SOVEREIGN 238

Seven tubes of the a.c. heater type. Balanced t.r.f. Two dials. Volume control: resistance across 2nd audio. Watts consumed: 45. Console size: 37 x 52 x 15 inches. The heaters are supplied by a small a. c. transformer, while the plate is supplied by means of rectified a.c using a gaseous type rectifier. Price $325, including power unit and tubes.

NO. 422. SUPERVOX, JR. AND SR.

Four tubes; 1 t.r.f., detector, 2 transformer audio. All tubes a. c. heater type except last which is a 71. One dial. Volume controls: antenna coupler and resistance in r.f. plate. Watts required: 40. Console size: 28 x 30 x 16 inches. Shielded detector. Output device. The heaters are supplied by a small transformer while the 71 filament is supplied with a. c. Price $275 complete. The Supervox Sr. has one more stage of t. r. f., has two dials, requires 60 watts, is completely shielded and has output device. Price $450, complete.

NO. 488. U-FLEX 5

Four tubes; 2 t.r.f., crystal detector, 2 transformer audio. Reflexed. Three dials. Volume control: resistance in r.f. plate. Cabinet size: 28 x 9 x 9½ inches. A 01-A is used as a rectifier for the plate supply. Headphone connection. Price, $125.00

BATTERY OPERATED RECEIVERS

NO. 512. ALL-AMERICAN 44, 45, AND 66

Six tubes; 3 t.r.f. (01-A, detector) 01-A, 2 transformer audio (01-A and 71). Rice neutralized t.r.f. Drum control. Volume control: rheostat in r.f. Cabinet sizes: No. 44, 21 x 10 x 8 inches; No. 55, 25 x 38 x 18 inches; No. 66, 27½ x 43 x 20 inches. C-battery connections. Battery cable. Antenna: 75 to 125 feet. Prices: No. 44, $70; No. 55, $125 including loud speaker; No. 66, $200 including loud speaker.

NO. 428. AMERICAN C6

Five tubes; 2 t.r.f, detector, 2 transformer audio. All 01-A tubes. Semi balanced t.r.f. Three dials. Plate current 15 mA. Volume control: potentiometer. Cabinet sizes: table, 20 x 8½ x 10 inches; console, 36 x 40 x 17 inches. Partially shielded. Battery cable. C-battery connections. Antenna: 125 feet. Prices: table, $30; console, $65 including loud speaker.

NO 433. ARBORPHONE

Five tubes; 2 t.r.f., detector, 2 transformer audio. All 01-A tubes. Two dials. Plate current: 16 mA. Volume control: rheostat in r.f. and resistance in r.f. plate. C-battery connections. Binding posts. Antenna: taps for various lengths. Cabinet size: 24 x 9 x 10½ inches. Price: $65.

Better Results *from* POWER CIRCUITS

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HERE are the new Centralab units designed especially for use in socket power circuits to carry continuously and unusually heavy current for their size, providing smooth acting control under all conditions.

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This new unit is identical with the Power Rheostat except for an additional terminal, and is especially suited to obtain variable voltages for detector tube and variable "C" bias in socket power circuits. 15, 150, 250 ohms, **$1.50**; 2,000, **$1.75**; 5,000, **$2.00.**

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With an added semi-variable contact arm, this new potentiometer is identical to the above units. The 4th terminal is adjustable behind panel to any resistance value. 175 ohm unit gives 2 variable voltages in ABC power circuits. 250 ohms is used with the new Raytheon ABC. The 2,000 is used for "C" bias in such circuits as AmerTran Power Pack. Two 6,000 ohm units in series across output of a "B" eliminator gives best possible voltage regulation. 175, 250 ohms, **$2**; 2,000, 3,000, 5,000, **$2.25.**

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The type 285 transformers are available in two ratios as follows:

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The function of the Speaker Filter is to protect the speaker windings from the direct current while allowing an unimpeded flow of alternating frequency current. This reduces the amount of distortion and prolongs the life of the speaker. Such a device should always be used especially between a power tube in the last audio stage and the speaker.

Price $6.00

In buying parts for an audio amplifier it should be borne in mind that no better tone quality can be reproduced than is radiated from the broadcasting station or than can be sustained by the loudspeaker regardless of what method of coupling may be used.

The frequency range of the better broadcasting stations is about 80 to 5000 cycles; the frequency range of the better loudspeaker is about 80 to 7000 cycles; thus making the effective range of radio reproduction between 80 and 5000 cycles. This represents approximately the full orchestral and vocal range.

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While other methods of coupling may have a more uniform frequency curve over a wider range than a transformer, there is much to be said in favor of using good transformers because of the greater gain in amplification per stage and the lower operating cost.

The General Radio Type 285 Transformers are designed to have a high inductance value, but with lower capacity. This combination sustains both the upper and lower ends of the amplification curve to the same degree as the middle portion and is accomplished by using a larger core of a very high quality of selected steel and proper adjustment of coil turns.

When you overhaul your old receiver or build your new one why not assure yourself of good tone quality with plenty of volume at moderate cost by using a pair of General Radio Type 285 transformers?

Have you thought of operating your set entirely from the light socket by using the new A. C. tubes and a plate supply unit?

Write for our circular showing how to rewire the filament circuits of a standard four tube set to use the new A. C. tubes.

GENERAL RADIO COMPANY
Cambridge Massachusetts

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PARTS AND ACCESSORIES

NO. 431. AUDIOLA 6

Six tubes; 3 t.r.f. (01-A), detector (00-A), 2 transformer audio (01-A and 71). Drum control. Plate current: 20 mA. Volume control: resistance in r.f. plate. Stage shielding. Battery cable. C-battery connection. Antenna: 50 to 100 feet. Cabinet size: 28½ x 11 x 14½ inches. Price not established.

NO. 432. AUDIOLA 8

Eight tubes; 4 t.r.f. (01-A), detector (00-A), 1 transformer audio (01-A), push-pull audio (12 or 71). Bridge balanced t.r.f. Drum control. Volume control: resistance in r.f. plate. Stage shielding. Battery cable. C-battery connections. Antenna: 10 to 100 feet. Cabinet size: 28½ x 11 x 149 inches. Price not established.

NO. 485. BOSWORTH B6

Five tubes; 2 t.r.f. (01-A), detector (01-A), 2 transformer audio (01-A and 71). Two dials. Volume control: variable grid resistances. Battery cable. C-battery connections. Antenna: 25 feet or longer. Cabinet size 15 x 7 x 8 inches. Price $75.

NO. 513. COUNTERPHASE SIX

Six tubes; 3 t.r.f. (01-A), detector (00-A), 2 transformer audio (01-A and 12). Counterphase t.r.f. Two dials. Plate current: 32 mA. Volume control: rheostat on 2nd and 3rd r.f. Coils shielded. Battery cable. C-battery connections. Antenna: 75 to 100 feet. Console size: 18¾ x 40½ x 15½ inches. Prices: Model 35, table, $110; Model 37, console, $175.

NO. 514. COUNTERPHASE EIGHT

Eight tubes; 4 t.r.f. (01-A), detector (00-A), 2 transformer audio (01-A and 12). Counterphase t.r.f. One dial. Plate current: 40 mA. Volume control: rheostat in 1st r.f. Copper stage shielding. Battery cable. C-battery connections. Antenna: 75 to 100 feet. Cabinet size: 30 x 12½ x 16 inches. Prices: Model 12, table, $225; Model 16, console, $335; Model 18, console, $365.

NO. 506. CROSLEY 601 BANDBOX

Six tubes; 3 t.r.f., detector, 2 transformer audio. All 01-A tubes. Balanced. t.r.f. One dial. Plate current: 40 mA. Volume control: rheostat in r.f. Shielded. Battery cable. C-battery connections. Antenna: 75 to 150 feet. Cabinet size: 17¼ x 5¼ x 7⅝. Price, $55.

NO. 462. CUSTOM BUILT 7 AND 9

Seven tubes; 5-01A, 1-00-A, 1-71. T.r.f. circuit. Two dials. Plate current: 40 mA. Volume control: special. Binding posts. C-battery connections. Output device. Antenna: 100 feet. Built-in A and B supply. Panel: 7 x 21. Price $275 completely equipped. The Custom Built 9 has 9 tubes with built-in speaker and loop. Price $375 completely equipped.

NO. 477. DAVEN BASS NOTE

Six tubes; 2 t.r.f. (01-A), detector (HMu), 3 resistance audio (HMu and power). Two dials. Plate current: 17 mA. Volume control: potentiometer. Battery cable, C-battery connections. Antenna: 50 to 100 feet. Cabinet size: 23½ x 12 x 16 inches. Price $150.

NO. 434. DAY-FAN 6

Six tubes; 3 t.r.f. (01-A), detector (01-A), 2 transformer audio (01-A and 12 or 71). One dial. Plate current: 12 to 15 mA. Volume control: rheostat on r.f. Shielded. Battery cable, C-battery connections. Output device. Antenna: 50 to 120 feet. Cabinet sizes: Daycraft 6, 32 x 30 x 34 inches; Day-Fan Jr., 15 x 7 x 7. Prices: Day-Fan 6, $110; Daycraft 6, $145 including loud speaker; Day-Fan Jr. not available.

NO. 435. DAY-FAN 7

Seven tubes; 3 t.r.f. (01-A), detector (01-A), 1 resistance audio (01-A), 2 transformer audio (01-A and 12 or 71). Plate current: 15 mA. Antenna: outside. Same as No. 434. Price $115.

NO. 497. EXCELL GRAND

Five tubes; 2 t.r.f., detector, 2 transformer audio. All 99 tubes. Na-Ald drum control Plate current: 15 mA. Volume control: rheostat in r.f. Binding posts. C-battery connections. Headphone connection. Antenna: 75 feet. Cabinet size: 21 x 16 x 14 inches. Price $100, including loud speaker.

NO. 503. FADA SPECIAL

Six tubes; 3 t.r.f. (01-A), detector (01-A), 2 transformer audio (01-A and 71). Neutrodyne. Two drum control. Plate current: 20 to 24mA. Volume control: rheostat on r.f. Coils shielded. Battery cable. C-battery connections. Headphone connection. Antenna: outdoor. Cabinet size: 20½ x 13¾ x 10¼ inches. Price $95.

NO. 504. FADA 7

Seven tubes; 4 t.r.f. (01-A), detector (01-A), 2 transformer audio (01-A and 71). Neutrodyne. Two drum control. Plate current: 43mA. Volume control: rheostat on r.f. Completely shielded. Battery cable. C-battery connections. Headphone connections. Output device. Antenna: outdoor or loop. Cabinet sizes: table, 25¼ x 13¼ x 11½ inches; console, 29 x 50 x 17 inches. Prices: table, $185; console, $285.

NO. 436. FEDERAL

Five tubes; 2 t.r.f. (01-A), detector (01-A), 2 transformer audio (01-A and 12 or 71). Balanced t.r.f. One dial. Plate current: 20.7 mA. Volume control: rheostat on r.f. Shielded. Battery cable. C-battery connections. Antenna: loop. Made in 6 models. Price varies from $250 to $1000 including loop.

NO. 505. FADA 8

Eight tubes. Same as No. 504 except for one extra stage of audio and different cabinet. Prices: table, $300; console, $400.

NO. 437. FERGUSON 10A

Seven tubes; 3 t.r.f. (01-A), detector (01-A), 3 audio (01-A and 12 or 71). One dial. Plate current: 18 to 25 mA. Volume control: rheostat on two r.f. Shielded. Battery cable. C-battery connections. Antenna: 100 feet. Cabinet size: 21½ x 12 x 15 inches. Price $150.

NO. 438. FERGUSON 14

Ten tubes; 3 untuned r.f., 3 t. r.f. (01-A), detector (01-A), 3 audio (01-A and 12 or 71). Special balanced t.r.f. One dial. Plate current: 30 to 35 mA. Volume control: rheostat in three r.f. Shielded. Battery cable, C-battery connections. Antenna: loop. Cabinet size: 24 x 12 x 16 inches. Price $235, including loop.

NO. 439. FERGUSON 12

Six tubes; 2 t.r.f. (01-A), detector (01-A), 1 transformer audio (01-A), 2 resistance audio (01-A and 12 or 71). Two dials. Plate current: 18 to 25 mA. Volume control: rheostat on two r.f. Partially shielded. Battery cable. C-battery connections. Antenna: 100 feet. Cabinet size: 22½ x 10 x 12 inches. Price $85. Consolette $145 including loud speaker.

NO. 440. FREED-EISEMANN NR-8, NR-9, AND NR-66

Six tubes; 3 t.r.f. (01-A), detector (01-A), 2 transformer audio (01-A and 71). Neutrodyne. NR-8, two dials; others one dial. Plate current: 30 mA. Volume control: rheostat on r.f. NR-8 and 9: chassis type shielding. NR-66, individual stage shielding. Battery cable. C-battery connections. Antenna: 100 feet. Cabinet sizes: NR-8 and 9, 19¾ x 10 x 10½ inches; NR-66 20 x 10½ x 12 inches. Prices: NR-8, $90; NR-9, $100; NR-66, $125.

NO. 441. FREED-EISEMANN NR-77

Seven tubes; 4 t.r.f. (01-A), detector (01-A), 2 transformer audio (01-A and 71). Neutrodyne. One dial. Plate current: 35 mA. Volume control: rheostat on r.f. Shielding. Battery cable. C-battery connections. Antenna: outside or loop. Cabinet size: 23 x 10½ x 13 inches. Price $175.

NO. 442. FREED-EISEMANN 800 AND 850

Eight tubes; 4 t.r.f. (01-A), detector (01-A), 1 transformer (01-A), 1 parallel audio (01-A or 71). Neutrodyne. One dial. Plate current: 35 mA. Volume control: rheostat on r.f. Shielded. Battery cable. C-battery connections. Output: two tubes in parallel or one power tube may be used. Antenna: outside or loop. Cabinet sizes: No. 800, 34 x 15½ x 13½ inches; No. 850, 36 x 65½ x 17½. Prices not available.

NO. 443. GREBE CR18 (SHORT-WAVE)

Two tubes; detector, 1 transformer audio. All 01-A tubes. Three-circuit regenerative. Two dials. Plate current: 8 mA. Volume control: rheostat on detector and regeneration. Headphone connection. Binding posts. Wavelength range: 8 to 210 meters. Antenna: 100 feet. Cabinet size: 16 x 7 x 7¼ inches. Price $100 including set of coils.

NO. 444. GREBE MU-1

Five tubes; 2 t.r.f. (01-A), detector (01-A), 2 transformer audio (01-A and 12 or 71). Balanced t.r.f. One, two, or three dials (operate singly or together). Plate current: 30mA. Volume control: rheostat on r.f. Binocular coils. Binding posts. C-battery connections. Antenna: 125 feet. Cabinet size: 22½ x 9¼ x 13 inches. Prices range from $95 to $320.

NO. 445. HARMONIC R AND S

Four tubes; 1 t.r.f., detector, 2 transformer audio. All 01-A tubes. S type has three resistance audio and 5 tubes. Regenerative detector and t.r.f. Three dials. Volume control: rheostat on r.f. Binding posts. C-battery connections. Headphone connection. Antenna: 100 feet. Cabinet size: 26 x 9 x 9 inches. Prices: R, $75; S. $100.

NO. 426. HOMER

Seven tubes; 4 t.r.f. (01-A); detector (01-A or 00A); 2 audio (01-A and 12 or 71). One knob tuning control. Volume control: rotor control in antenna circuit. Plate current: 22 to 25 mA. "Technidyne" circuit. Completely enclosed in aluminum box. Battery cable. C-battery connections. Cabinet size, 8¾ x 19½ x 9¼ inches. Chassis size, 6¾ x 17 x 8 inches. Prices: Chassis only, $80. Table cabinet, $95.

NO. 502. KENNEDY ROYAL 7. CONSOLETTE

Seven tubes; 4 t.r.f. (01-A), detector (00-A), 2 transformer audio (01-A and 71). One dial. Plate current: 42 mA. Volume control: rheostat on two r.f. Special r.f. coils. Battery cable. C-battery connections. Headphone connection. Antenna: outside or loop. Consolette size: 36½ x 35½ x 19 inches. Price $220.

NO. 498. KING "CRUSADER"

Six tubes; 2 t.r.f. (01-A), detector (00-A), 3 transformer audio (01-A and 71). Balanced t.r.f. One dial. Plate current: 20 mA. Volume control: rheostat on r.f. Coils shielded. Battery cable. C-battery connections. Antenna: outside. Panel: 11 x 7 inches. Price, $115.

NO. 499. KING "COMMANDER"

Six tubes; 3 t.r.f. (01-A), detector (00-A), 2 transformer audio (01-A and 71). Balanced t.r.f. One dial Plate current: 25 mA. Volume control: rheostat on r.f. Completely shielded. Battery cable. C-battery connections. Antenna: loop. Panel size: 12 x 8 inches. Price $220 including loop.

NO. 429. KING COLE VII AND VIII

Seven tubes; 3 t.r.f., detector, 1 resistance audio, 2 transformer audio. All 01-A tubes. Model VIII has one more stage t.r.f. (eight tubes). Model VII, two dials. Model VIII, one dial. Plate current: 15 to 50 mA. Volume control: primary shunt in r.f. Steel shielding. Battery cable and binding posts. C-battery connections. Output devices on some consoles. Antenna: 10 to 100 feet. Cabinet size: varies. Prices: Model VII, $80 to $160; Model VIII, $100 to $300.

NO. 500. KING "BARONET" AND "VIKING"

Six tubes; 2 t.r.f. (01-A), detector (00-A), 3 transformer audio (01-A and 71). Balanced t.r.f. One dial. Plate current: 19 mA. Volume control: rheostat in r.f. Battery cable. C-battery connections. Antenna: outside. Panel size: 18 x 7 inches. Prices: "Baronet," $70; "Viking," $140 including loud speaker.

NO. 501. KING "CHEVALIER"

Six tubes. Same as No. 500. Coils completely shielded. Panel size: 11 x 7 inches. Price, $210 including loud speaker.

NO. 447. LEUTZ "TRANSOCEANIC" AND "SILVER GHOST"

Nine tubes; 4 t.r.f. (01-A), detector (00-A), 1 transformer audio (01-A) 3 resistance audio (HMu and 71 or 10). Grid resistance in t.r.f. Wavelength range: 35 to 3600 meters. One to five dials. Plate current: 20 to 40 mA. Volume control: special. Shielded. Binding posts. C-battery connections. Voltmeter. Output device. Antenna: outside or loop. Cabinet sizes: "Transoceanic," 27 x 8½ x 13 1/16 inches; "Silver Ghost," 72 x 12 x 20 inches. Prices: "Transoceanic," $150; Other not available.

NO. 489. MOHAWK

Six tubes; 2 t.r.f. (01-A), detector (00-A), 3 audio (01-A and 71). One dial. Plate current: 40 mA. Volume control: rheostat on r.f. Battery cable. C-battery connections. Output device. Antenna: 60 feet. Panel size: 12½ x 8⅜ inches. Prices range from $65 to $245.

NO. 449. NORBERT "MIDGET"

One multivalve tube; detector, 2 transformer audio. Two dials. Plate current: 3 mA. Volume control: rheostat. Binding posts. C-battery connections. Headphone connection. Antenna: 75 to 150 feet. Cabinet size: 12 x 8 x 9 inches. Price $12 including multivalve.

NO. 450. NORBERT 2

Two tubes; 1 t.r.f., detector, 2 transformer audio. One multi-valve tube and one 01-A. Two dials. Plate current: 8 mA. Volume control: special. Battery cable. Headphone connection. C-battery connections. Antenna: 50 to 100 feet. Cabinet size: 20 x 7 x 5½ inches. Price $40.50 including multivalve and 01-A tube.

NO. 451. NORCO 66

Six tubes; 2 t.r.f. (01-A), detector (01-A), 3 impedance audio (01-A and 71). Drum control. Plate current: 20 mA. Volume control: modulator on audio. Shielded. Battery cable. C-battery connections. Output device. Antenna: 70 to 90 feet. Cabinet size: 18½ x 8½ x 13¾ inches. Price $130. Price of console, $250 including loud speaker.

NO. 452. ORIOLE 90

Five tubes; 2 t.r.f., detector, 2 transformer audio. All 01-A tubes. "Trinum" circuit. Two dials. Plate current: 18 mA. Volume control: rheostat on r. f. Battery cable. C-battery connections. Antenna: 50 to 100 feet. Cabinet size: 25½ x 11½ x 12½ inches. Price $85. Another model has 8 tubes, one dial, and is shielded. Price $185.

NO. 454. PARAMOUNT V AND VI

Five and six tubes. All 01-A t.r.f. circuit. Binding posts. C-battery connections. Antenna: 100 feet. Panel size: 26 x 7 inches. Prices: V, $65; VI, $75

NO. 453. PARAGON

Six tubes; 2 t.r.f. (01-A), detector (01-A), 3 double impedance audio (01-A and 71). One dial. Plate current: 40 mA. Volume control: resistance in r.f. plate. Shielded. Battery cable. C-battery connections. Output device. Antenna: 100 feet. Console size: 20 x 46 x 17 inches. Price not determined.

NO. 475. PENN C-6

Six tubes; 2 t.r.f. (01-A), detector (00-A), 3 truphonic audio (01-A). Phasatrol. One dial. Plate current: 15 mA. Volume control: potentiometer. Binding posts. C-battery connections. Antenna: 75 feet. Cabinet size: 24 x 10 x 15 inches. Prices range from $95 to $165. A console model having three dials and five tubes sells for $150.

NO. 480. PFANSTIEHL 30 AND 302

Six tubes; 3 t.r.f. (01-A), detector (01- 2A), transformer audio (01-A and 71). One dial. Plate current: 26 to 32 mA. Volume control: resistance in r.f. plate. Shielded. Battery cable. C-battery connections. Antenna: outside. Panel size: 17¾ x 8½ inches. Prices: No. 30 cabinet, $99.50; No. 302 console, $165 including loud speaker.

NO. 455. PREMIER 6-IN-LINE

Six tubes; 3 t.r.f. (01-A), detector (00-A), 2 transformer audio (01-A and 12). One or two dials. Plate current: 16 to 18 mA. Volume control: rheostat in r.f. Battery cable. C-battery connections. Antenna: 100 feet or loop. Cabinet size: 25 x 45 x 16 inches. Prices range from $60 to $150.

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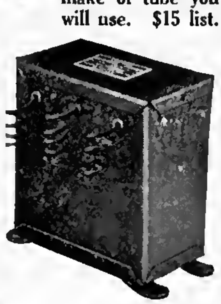

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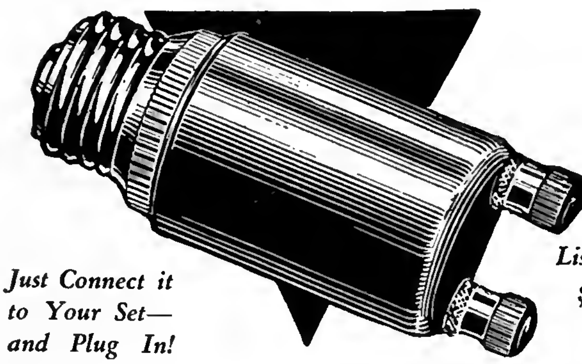

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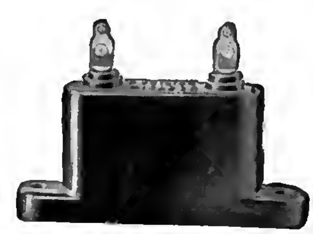

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NO. 481. PFANSTIEHL 32 AND 322

Seven tubes: 3 t.r.f. (01–A), detector (01–A), 3 audio (01–A and 71). One dial. Plate current: 23 to 32 mA. Volume control: resistance in r. f. plate. Shielded. Battery cable. C-battery connections. Output device. Antenna: outside. Panel: 17¾ x 8½ inches. Prices: No. 32 cabinet, $135; No. 322 console, $225 including loud speaker.

NO. 473. PRMCO 105 AND 110

Six tubes; 2 t.r.f., detector, 2 transformer audio, 1 resistance audio. All 01–A tubes. Volume control: rheostat on r.f. Battery cables. Headphone connection. Antenna: 100 feet. Panel size: 18 x 7 inches. Price No. 105, $45. The No. 110 has C-battery connections, shielding, and drum tuning control. Price $80.

NO. 456. RADIOLA 20

Five tubes: 2 t.r.f. (99), detector (99), 2 transformer audio (99 and 20). Balanced t.r.f. and regenerative detector. Two dials. Volume control: regenerative. Shielded. C-battery connections. Headphone connections. Antenna: 75 to 150 feet. Cabinet size: 19⅛ x 11⅜ x 16 inches. Price $115 including all tubes.

NO. 457. RADIOLA 25

Six tubes; oscillator (99), 2 detectors (99), 3 intermediate r.f. (99), 2 transformer audio (99 and 20). Drum control. Super-heterodyne with two reflexed stages. Volume control: potentiometer on intermediate grids. Shielded. C-battery connections. Headphone connection. Antenna: loop. Cabinet size: 28 x 37 x 19 inches. Price $165 with tubes and loop. Can be operated on a. c. with special attachments.

NO. 458. RADIOLA 28

Eight tubes; oscillator (99), 2 detectors (99), 3 intermediate r.f. (99), 2 transformer audio (99 and 20). Super-heterodyne. Drum control. Volume control same as model 25. Shielded. C-battery connections. Headphone connection. Antenna: loop. Console size 26½ x 63 x 17 inches. Price $260 with tubes and loop. Can be operated on a.c. with special attachments.

NO. 493. SONORA F

Seven tubes; 4 t.r.f. (01–A), detector (00–A), 2 transformer audio (01–A and 71). Special balanced t.r.f. Two dials. Plate current: 45 mA. Volume control: rheostat in r.f. Shielded. Battery cable. C-battery connections. Output device. Antenna: loop. Console size: 32 x 45½ x 17 inches. Prices range from $350 to $450 including loop and loud speaker.

NO. 494. SONORA E

Six tubes; 3 t.r.f. (01–A), detector (00–A), 2 transformer audio (01–A and 71). Special balanced t.r.f. Two dials. Plate current: 35 to 40 mA. Volume control: rheostat on r.f. Shielded. Battery cable. C-battery connections. Antenna: outside. Cabinet size: varies. Prices: table, $110; semi-console, $140; console, $240 including loud speaker.

NO. 495. SONORA D

Same as No. 494 except arrangement of tubes; 2 t.r.f., detector, 3 audio. Prices: table, $125; standard console, $185; "DeLuxe" console, $225.

NO. 482. STEWART-WARNER 705 AND 710

Six tubes; 3 t.r.f., detector, 2 transformer audio. All 01–A tubes. Balanced t.r.f. Two dials. Plate current: 10 to 25 mA. Volume control: resistance in r.f. plate. Shielded. Battery cable. C-battery connections. Antenna: 80 feet. Cabinet sizes: No. 705 table, 26¼ x 11¼ x 13$\frac{15}{16}$ inches; No. 710 console, 29¾ x 42 x 17⅛ inches. Tentative prices: No. 705, $115; No. 710 $265 including loud speaker.

NO. 483. STEWART-WARNER 525 AND 520

Same as No. 482 except no shielding. Cabinet sizes: No. 525 table, 19¾ x 10 x 11⅞ inches; No. 520 console, 22⅛ x 40 x 14$\frac{13}{16}$ inches. Tentative prices: No. 525, $75; No. 520, $117.50 including loud speaker.

NO. 459. STROMBERG-CARLSON 501 AND 502

Five tubes; 2 t.r.f. (01–A), detector (00–A), 2 transformer audio (01–A and 71). Neutrodyne. Two dials. Plate current: 25 to 35 mA. Volume control: rheostat on 1st r.f. Shielded. Battery cable. C-battery connections. Headphone connections. Output device. Panel voltmeter. Antenna: 60 to 100 feet. Cabinet sizes: No. 501, 25½ x 13 x 14 inches; No. 502, 28 $\frac{13}{16}$ x 50 $\frac{7}{16}$ x 16¾ inches. Prices: No. 501, $180; No. 502, $290.

NO. 460. STROMBERG-CARLSON 601 AND 602

Six tubes. Same as No. 549 except for extra t.r.f. stage. Cabinet sizes: No. 601, 27$\frac{5}{16}$ x 16¾ x 14$\frac{3}{16}$ inches; No. 602, 28¾ x 51½ x 19⅝ inches. Prices: No. 601, $225; No. 602, $330.

NO. 461. SUN

Five tubes; 2 t.r.f., detector, 2 transformer audio. All 01–A tubes. Two dials. Volume control: resistance in r.f. plate. Binding posts. Antenna: 100 feet. Cabinet size: 23 x 10 x 10 inches. Price, $80.

NO. 491. SUPERFLEX A4

Four tubes; 1 t.r.f., detector, 2 transformer audio. All 01–A tubes. Special circuit. One dial. Plate current 10 to 15 mA. Volume control: capacity. Battery cable. C-battery connections. Headphone connection. Antenna: outside. Cabinet sizes: table, 24 x 10 x 9½ inches; console, 25 x 44 x 14 inches. Prices: table, $80; console, $139.50.

NO. 486. VALLEY 71

Seven tubes; 4 t.r.f. (01–A), detector (01–A), 2 transformer audio (01–A and 71). One dial. Plate current: 35 mA. Volume control: rheostat on r.f. Partially shielded. Battery cable. C-battery connections. Headphone connection. Antenna: 50 to 100 feet. Cabinet size: 27 x 6 x 7 inches. Price $95.

NO. 471. VOLOTONE XX

Five tubes; 1 t.r.f. (01–A), detector (00–A), 3 resistance audio (HMu and 71). Balanced t.r.f. Two dials. Plate current: 18 mA. Volume control: rheostat on r.f. Battery cable. C-battery connections. Output device. Antenna: 100 feet. Cabinet size: 20½ x 8 x 12 inches. Price $50.

NO. 472. VOLOTONE VIII

Six tubes. Same as No. 471 with following exceptions; 2 t.r.f. stages. Three dials. Plate current: 20 mA. Cabinet size: 26½ x 8 x 12 inches. Price $140.

NO. 464. WRIGHT VII

Seven tubes; 3 t.r.f. (99), detector (99), 3 impedance audio (99 and 20). Na-Ald audio amplifier. Two dials. Plate current: 17 mA. Volume control: resistance in r.f. plate. Battery cable. C-battery connections. Output device. Panel voltmeter. Antenna: 80 feet. Cabinet size: 25 x 15 x 17½ inches. Price $160.

NO. 478. ZIMPHONIC 6

Six tubes; 2 t.r.f. (01–A), detector (00–A), 3 audio (01–A and 12). One dial. Regeneration and t.r.f. Plate current: 22 to 24 mA. Volume control: resistance in r.f. plate. Coils shielded. Battery cable. C-battery connections. Headphone connection. Antenna: 75 to 100 feet. Panel size: 21 x 7 inches. Prices: table $90; console, $125.

NO. 479. ZIMPHONIC 7

Seven tubes; Same as No. 478 except for one more stage t.r.f. Completely shielded. Console size: 20 x 40 x 15 inches. Prices: table, $140; console, $175.

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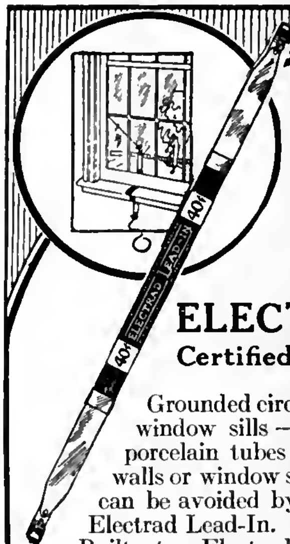

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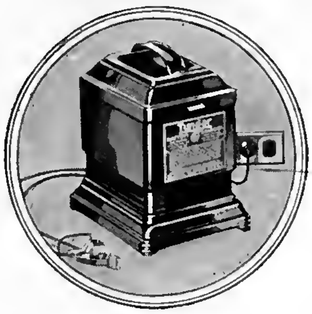

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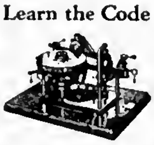

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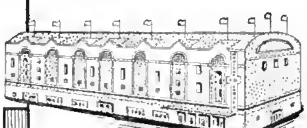

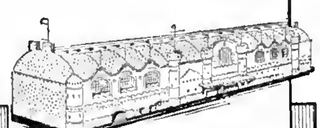

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69. Vacuum Tubes—A booklet giving the characteristics of the various tube types with a short description of where they may be used in the circuit. Radio Corporation of America.
77. Tubes—A booklet for the beginner who is interested in vacuum tubes. A non-technical consideration of the various elements in the tube as well as their position in the receiver. Cleartron Vacuum Tube Company.
87. Tube Tester—A complete description of how to build and how to operate a tube tester. Burton-Rogers Company.
91. Vacuum Tubes—A booklet giving the characteristics and uses of various types of tubes. This booklet may be obtained in English, Spanish, or Portuguese. DeForest Radio Company.
92. Resistors for A. C. Operated Receivers—A booklet giving circuit suggestions for building a. c. operated receivers, together with a diagram of the circuit used with the new 400-millampere rectifier tube. Carter Radio Company.
97. High-Resistance Voltmeters—A folder giving information on how to use a high-resistance voltmeter, special consideration being given the voltage measurement of socket-power devices. Westinghouse Electric & Manufacturing Company.
102. Radio Power Bulletins—Circuit diagrams, theory constants, and trouble-shooting hints for units employing the BH or B rectifier tubes. Raytheon Manufacturing Company.

Miscellaneous

38. Log Sheet—A list of broadcasting stations with columns for marking down dial settings. U. S. L. Radio, Incorporated.
41. Baby Radio Transmitter of 9XH-9EK—Description and circuit diagrams of dry-cell operated transmitter. Burgess Battery Company.
42. Arctic Radio Equipment—Description and circuit details of short-wave receiver and transmitter used in Arctic exploration. Burgess Battery Company.
43. Short-Wave Receiver of 9XH-9EK—Complete directions for assembly and operation of the receiver. Burgess Battery Company.
44. Aluminum for Radio—A booklet containing much radio information with hook-ups of basic circuits, with inductance-capacity tables and other pertinent data. Aluminum Company of America.
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67. Weather for Radio—A very interesting booklet on the relationship between weather and radio reception, with maps and data on forecasting the probable results. Taylor Instrument Companies.
73. Radio Simplified—A non-technical booklet giving pertinent data on various radio subjects. Of especial interest to the beginner and set owner. Crosley Radio Corporation.
74. The Experimenter—A monthly publication which gives technical facts, valuable tables, and pertinent information on various radio subjects. Interesting to the experimenter and to the technical radio man. General Radio Company.
75. For the Listener—General suggestions for the selecting, and the care of radio receivers. Valley Electric Company.
76. Radio Instruments—A description of various meters used in radio and electrical circuits together with a short discussion of their uses. Jewell Electrical Instrument Company.
78. Electrical Troubles—A pamphlet describing the use of electrical testing instruments in automotive work combined with a description of the cadmium test for storage batteries. Of interest to the owner of storage batteries. Burton Rogers Company.
95. Resistance Data—Successive bulletins regarding the use of resistors in various parts of the radio circuit. International Resistance Company.
96. Vacuum Tube Testing—A booklet giving pertinent data on how to test vacuum tubes with special reference to a tube testing unit. Jewell Electrical Instrument Company.
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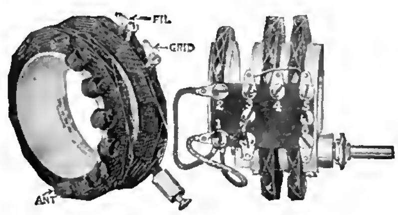

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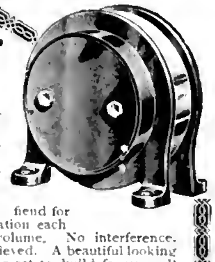
Magnaformer



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19 S. La Salle Street Dept. 56 Chicago

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Enclosed find 10c for which please send me blueprints and data as advertised.

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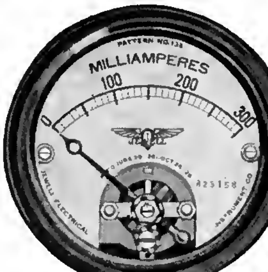

Pattern No. 135 Milliammeter

Use A Milliammeter

A sensitive milliammeter in series with the plates for indicating the current in these circuits and the power of the tubes or in the grid circuit for showing the grid current flowing, is the best means of observing the operating condition of a radio set.

The Jewell Pattern No. 135 milliammeter is a 2-inch round moving coil instrument for the set owner that will indicate the conditions given above, and will make an attractive addition to any set. Used in connection with the Jewell Pattern No. 135-B Voltmeter, which is the same size and appearance, it tells at a glance just when the filament voltage is at the proper value to give maximum set efficiency.

Write for Radio Instrument Catalog No. 15-C

Jewell Electrical Instrument Co.
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BROWNING-DRAKE, during the summer of 1924, gaineo an unprecedented popularity that has never waned because the Browning-Drake developments are based on the solid rock of scientific research. Browning-Drake sells more than twice as many parts as those designed for other kits. Prof. Browning and Dr. Drake designed the Official Kit Set to take care of modern broadcasting conditions. This set is dependable and it is unsurpassed for all around performance. Get your parts TO-DAY and BUILD the most popular kit set . . . the Official BROWNING-DRAKE.

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BROWNING-DRAKE RADIO

What Kit Shall I Buy?

THE list of kits herewith is printed as an extension of the scope of the Service Department of Radio Broadcast. *It is our purpose to list here the technical data about kits on which information is available. In some cases, the kit can be purchased from your dealer complete; in others, the descriptive booklet is supplied for a small charge and the parts can be purchased as the buyer likes. The Service Department will not undertake to handle cash remittances for parts, but when the coupon on page 326 is filled out, all the information requested will be forwarded.*

201. SC Four-Tube Receiver—Single control. One stage of tuned radio frequency, regenerative detector, and two stages of transformer-coupled audio amplification. Regeneration control is accomplished by means of a variable resistor across the tickler coil. Standard parts; cost approximately $58.85.

202. SC-II Five-Tube Receiver—Two stages of tuned radio frequency, detector, and two stages of transformer-coupled audio. Two tuning controls. Volume control consists of potentiometer grid bias on r.f. tubes. Standard parts cost approximately $60.35.

203. "HI-Q" Kit—A five-tube tuned radio-frequency set having two radio stages, a detector, and two transformer-coupled audio stages. A special method of coupling in the r.f. stages tends to make the amplification more nearly equal over the entire band. Price $63.05 without cabinet.

204. R. G. S. Kit—A four-tube inverse reflex circuit, having the equivalent of two tuned radio-frequency stages, detector, and three audio stages. Two controls. Price $69.70 without cabinet.

205. Pierce Airo Kit—A six-tube single-dial receiver; two stages of radio-frequency amplification, detector, and three stages of resistance-coupled audio. Volume control accomplished by variation of filament brilliancy of r.f. tubes or by adjusting compensating condensers. Complete chassis assembled but not wired costs $42.50.

206. H & H-T. r. f. Assembly—A five-tube set; three tuning dials, two steps of radio frequency, detector, and 2 transformer-coupled audio stages. Complete except for baseboard, panel, screws, wires, and accessories. Price $35.00.

207. Premier Five-Tube Ensemble—Two stages of tuned radio frequency, detector, and two steps of transformer-coupled audio. Three dials. Parts assembled but not wired. Price complete, except for cabinet, $35.00.

208. "Quadraformer VI"—A six-tube set with two tuning controls. Two stages of tuned radio frequency using specially designed shielded coils, a detector, one stage of transformer-coupled audio, and two stages of resistance-coupled audio. Gain control by means of tapped primaries on the r.f. transformers. Essential kit consists of three shielded double-range "Quadraformer" coils, a selectivity control, and an "Ampitrol," price $17.50. Complete parts $70.15.

209. Gen-Ral Five-Tube Set—Two stages of tuned radio frequency, detector, and two transformer-coupled audio stages. Volume is controlled by a resistor in the plate circuit of the r.f. tubes. Uses a special r.f. coil ("Duo-Former") with figure eight winding. Parts mounted but not wired, price $37.50.

210. Bremer-Tully Power-Six—A six-tube, dual-control set; three stages of neutralized tuned radio frequency, detector, and two transformer-coupled audio stages. Resistances in the grid circuit together with a phase shifting arrangement are used to prevent oscillation. Volume control accomplished by variation of B potential on r.f. tube. Essential kit consists of four r.f. transformers, two dual condensers, three small condensers, three choke coils, one 500,000-ohm resistor, three 1500-ohm resistors, and a set of color charts and diagrams. Price $41.50.

211. Bruno Drum Control Receivers—How to apply a drum tuning unit to such circuits as the three-tube regenerative receiver, four-tube Browning-Drake, five-tube Diamond-of-the-Air, and the "Grand" 6.

212. Infradyne Amplifier—A three-tube intermediate-frequency amplifier for the super-heterodyne and other special receivers, tuned to 3490 kc. (86 meters). Price $25.00.

213. Radio Broadcast "Lab" Receiver—A four-tube dual-control receiver with one stage of Rice neutralized tuned-radio frequency, regenerative detector (capacity controlled), and two stages of transformer-coupled audio. Approximate price, $78.15.

214. LC-27—A five-tube set with two stages of tuned-radio frequency, a detector, and two stages of transformer-coupled audio. Special coils and special means of neutralizing are employed. Output device. Price $85.20 without cabinet.

215. Loftin-White—A five-tube set with two stages of radio frequency, especially designed to give equal amplification at all frequencies, a detector, and two stages of transformer-coupled audio. Two controls. Output device. Price $85.10.

216. K.H.-27—A six-tube receiver with two stages of neutralized tuned radio frequency, a detector, three stages of choke-coupled audio, and an output device. Two controls. Price $86.00 without cabinet.

217. Aero Short-Wave Kit—Three plug-in coils designed to operate with a regenerative detector circuit and having a frequency range of from 19,990 to 2306 kc. (15 to 130 meters). Coils and plug only, price $12.50.

218. Diamond-of-the-Air—A five-tube set having one stage of tuned-radio frequency, a regenerative detector, one stage of transformer-coupled audio, and two stages of resistance-coupled audio. Volume control through regeneration. Two tuning dials.

219. Norden-Hauck Super 10—Ten tubes; five stages of tuned radio frequency, detector, and four stages of choke- and transformer-coupled audio frequency. Two controls. Price $291.40.

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Just as an engine can be no more useful than its throttle, so with the radio power unit and its controls. But the CLAROSTAT is an electrical throttle—positive settings, tremendous resistance range in several turns of knob, silent operation, ample capacity, fool proof, reliable and long life.

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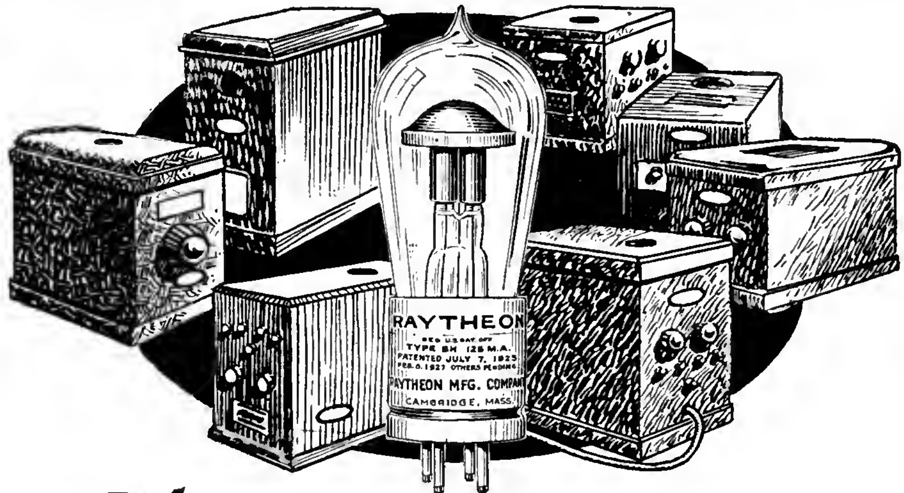

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221. LR4 Ultradyne—Nine-tube super-heterodyne; one stage of tuned radio frequency, one modulator, one oscillator, three intermediate-frequency stages, detector, and two transformer-coupled audio stages.

222. Greiff Multiplex—Four tubes (equivalent to six tubes); one stage of tuned radio frequency, one stage of transformer-coupled radio frequency, crystal detector, two stages of transformer-coupled audio, and one stage of impedance-coupled audio. Two controls. Price complete parts, $50.00.

223. Phonograph Amplifier—A five-tube amplifier device having an oscillator, a detector, one stage of transformer-coupled audio, and two stages of impedance-coupled audio. The phonograph signal is made to modulate the oscillator in much the same manner as an incoming signal from an antenna.

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RB927

A KEY TO RECENT RADIO ARTICLES

By E. G. SHALKHAUSER

This is the twenty-second installment of references to articles which have appeared recently in various radio periodicals. Each separate reference should be cut out and pasted on 4" x 6" cards for filing, or pasted in a scrap book either alphabetically or numerically. An outline of the Dewey Decimal System (employed here) appeared last in the January Radio Broadcast.

R343.7. Alternating-Current Supply. Socket-Power.
Radio Broadcast. May, 1927. Pp. 43–45. *B-Battery.*
"Perfecting the B Socket-Power Device," H. E. Rhodes.
The various parts of a good B socket-power device are discussed. The causes of "motor-boating" in these devices, and its possible elimination, are outlined, circuit diagrams and graphs of the operation of a typical B socket power unit being given.

R201.6. Measurements with High-Frequency Bridge. Measurements, *Vacuum-Tube.*
Radio Broadcast. May, 1927. Pp. 46–50.
"Methods of Measuring Tube Characteristics," K. Henney.
The writer discusses tube constants, their characteristics, and the bridge circuits used in obtaining these data. The various bridges used to measure amplification factor, plate impedance, mutual conductance, input conductance, and power output, are shown, and experimental data of a variety of tubes on the market are given.

R131. Characteristic Curves; General Properties. Grid Bias Voltages.
Radio. April, 1927. Pp. 26–28.
"A High-Mu Tube At Work," J. E. Anderson.
Here is presented a discussion on the effect of grid bias for various plate voltages when using high-mu tubes and resistance coupling. With the circuit arrangement shown and the curves obtained, the writer presents a detailed analysis of the curves and states why a negative bias is necessary.

R384.1. Wavemeters. Wavemeters, *Measurement of.*
Radio. April, 1927. Pp. 29–ff.
"How to Calibrate a Wavemeter," C. T. Burke.
Methods used in obtaining fundamental standards of frequency with the aid of quartz crystals and a series of coupled oscillators are outlined. How this standard may be used in calibrating other wavemeter circuits, methods of

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For UX 120 tubes in the UV 199 sockets of the Radiola Superheterodyne Semi-Portable, and Radiola Super VIII. These excellent Superheterodynes will deliver ample volume for loud speaker operation when equipped with the UX 120 used with the Na-Ald No. 420 Connectorald. Price $1.25.

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1 No. 1830 De Luxe 30-ohm Bakelite Rheostat, gold arrow knob.
4 No. 253 Frost-Radio Cord Tip jacks

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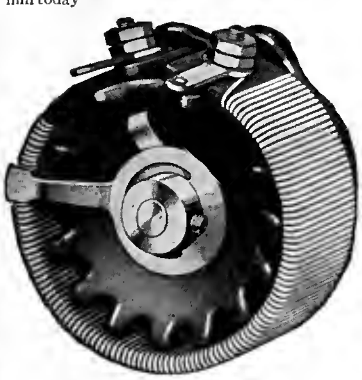

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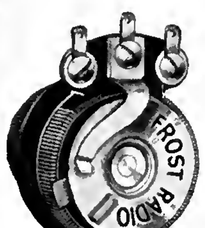

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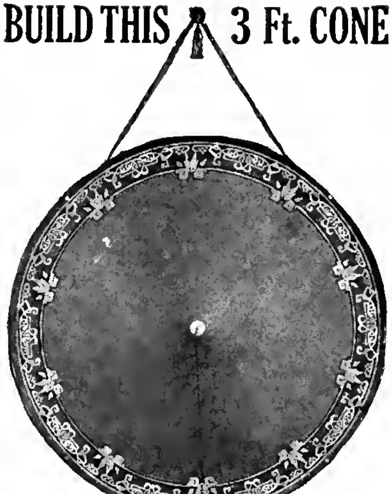

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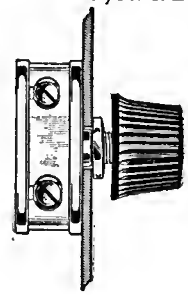

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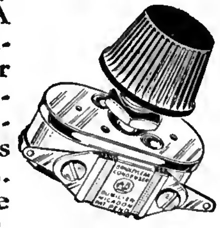

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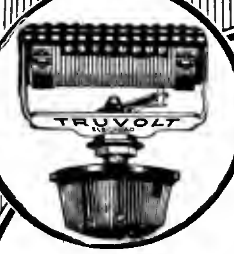

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3. Nichrome wire resistance—very low temperature coefficient. Wound on an asbestos-covered enamel core.

Type	Ohms Resistance	Milliamperes Current
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T-10	0 to 1,000	158
T-20	0 to 2,000	112
T-50	0 to 5,000	71
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T-250	0 to 25,000	32
T-500	0 to 50,000	22.5

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ELECTRAD

R270. SIGNAL INTENSITY MEASUREMENTS. SIGNAL INTENSITY.
Radio News. April, 1927. Pp. 1220-ff.
"A New Field for Experimentation," J. F. Rider.

This article describes a layout of apparatus which may be used to record the intensity of carrier waves of different stations broadcasting, in order to obtain data for the analysis of transmission problems and fading. The apparatus needed is listed; it consists of a receiver, equipped with meters, and an oscillator for purposes of receiver calibration. The method of plotting signal strength curves, and particulars on the proper operation of the set, are given.

R132.3. RESISTANCE COUPLING. COUPLING, *Resistance.*
Radio News. April, 1927. Pp. 1250-ff.
"Does Resistance Coupling Give Best Quality?" S. Harris.

The disadvantages, as compared to the advantages, of resistance-coupled amplifier circuits, are given. Two main disadvantages are said to be the presence of the blocking condenser, which reduces amplification at the lower frequencies, and the low amplification per stage as compared to transformer coupling. The effects of these disadvantages are discussed, and remedies are suggested.

R144. HIGH-FREQUENCY RESISTANCE. RESISTANCE, *High-Frequency.*
Physical Review. Jan., 1927. Pp. 165–173.
"The Resistance of Copper Wires at Very High Frequencies," W. M. Roberts.

At frequencies of the order of 10^7 cycles, the distributed capacity of single loops of wire are said to cause sufficient unequal current distribution in the loop to account for large apparent discrepancies between observed and calculated resistances. For a given frequency, more uniform current distribution is gained by decreasing the size of the loop and simultaneously increasing the capacity of the tuning condenser. Curves are plotted with ratio of observed to calculated resistance as ordinate and condenser setting as abscissa. For all curves taken, the ratio fell well below 1.45 and was still decreasing as far as data were taken. The presence of oxide on copper wire is said to have no appreciable effect on the resistance.

R376.3. LOUD-SPEAKING REPRODUCERS. LOUD-SPEAKERS.
RADIO BROADCAST. April, 1927. Pp. 587-590.
"A Fundamental Analysis of Loud Speakers," J. F. Nielsen.

The quality of radio broadcast programs when reproduced depends in part on the loud speaker. The nature of the signal which is to be reproduced determines entirely the method of loud-speaker construction. A study concerning facts of speech and musical tones and harmonics is, therefore, presented. The desirable characteristics of loud speakers and the mechanism that is to reproduce these characteristics is taken up in a mathematical discussion under the following: (1) The motor element, which converts the electrical impulses into corresponding mechanical vibrations; (2) the coupling system, which transmits the mechanical vibrations from motor to diaphragm; (3) the diaphragm or loading device, which radiates the mechanical vibrations into the air as waves of sound. Distortion is said to result from saturation of armature and pole faces, and from iron losses.

R113.5. METEOROLOGY. METEOROLOGY, *Earth Blankets.*
Popular Radio. April, 1927. Pp. 327-ff.
"The Three Blankets Around the Earth," E. E. Free.

The writer presents information relative to the nature of space surrounding the earth. Three layers of gases are said to be found varying in height and having different temperatures. The lower layer or blanket, about seven miles high, contains mixed gases and varies considerably in temperature. The middle layer, about 80 degrees below zero Fahrenheit, is about 25 miles in height. The upper layer, about 400 to 600 miles high, is supposed to have a temperature of about 80 degrees above zero Fahrenheit. This latter is said to serve as the protecting blanket, surrounding the earth, against the many meteors which would otherwise destroy everything on the surface. It also serves as the reflecting layer for many radio waves, being commonly called the Heaviside Layer. It is ionized by the ultraviolet rays from the sun. In it the aurora is said to be displayed. Above this layer, space at a temperature of 460 degrees below zero is supposed to exist.

R412. RADIO TELEPHONE SYSTEMS. TELEPHONY, *Trans-Atlantic.*
Radio News. March 1927. Pp. 1086-ff.
"'Hello, London!' 'Are You There, New York?'", G. C. B. Rowe.

The apparatus and the single side-band transmitter system as used in the new transatlantic radio telephone station are described. The principle of single side-band transmission, with its partial secrecy and saving of "watts per mile," is based on the heterodyne method of frequency amplification.

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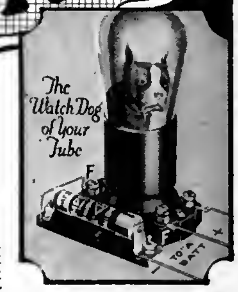

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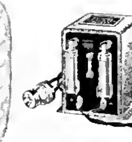
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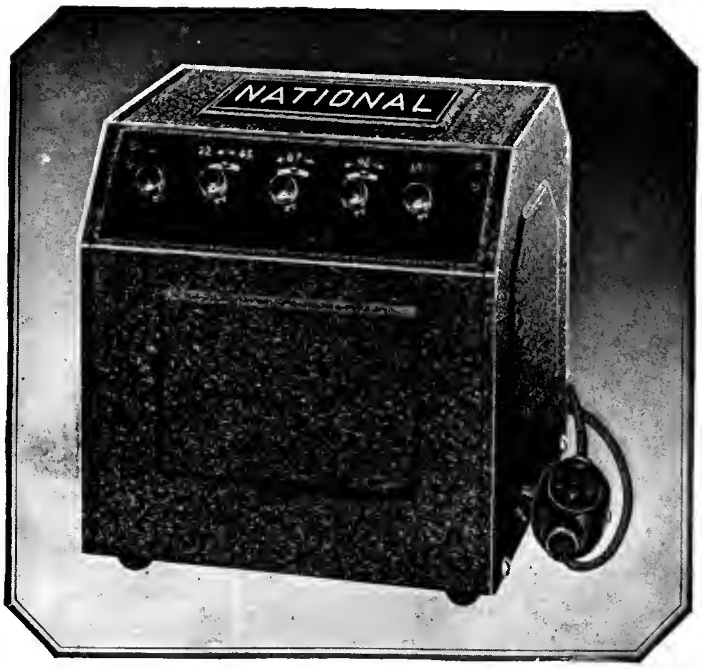


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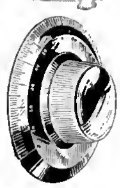
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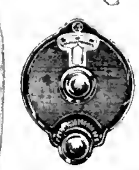
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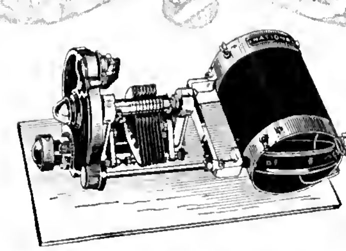
TUNING UNIT

RADIO BROADCAST

OCTOBER, 1927

WILLIS KINGSLEY WING, Editor

KEITH HENNEY, Director of the Laboratory

EDGAR H. FELIX, Contributing Editor

Vol. XI, No. 6

CONTENTS

Cover Design - - - - *From a Design by Harvey Hopkins Dunn*

Frontispiece *The Most Powerful Broadcasting Station in the World* 340

Now—You Can Receive Radio Pictures - - *Keith Henney* 341

The March of Radio - - - - - *An Editorial Interpretation* 344

Modern Radio Receivers are a Good Investment
Listening to World-Wide Broadcasting is Near
A Profound Study of Radio Law
The Danger of Direct Advertising on the Air
The Month in Radio
Licenses and What They Mean
The Columbia Broadcasting Chain

The 1928 "Hi-Q" Has an Extra R. F. Stage - *John B. Brennan* 348

Manufactured Receivers for the Coming Season - - - - - - 351

1928 Radio Receivers of Beauty and Utility - - - - - - - 352

The Neutrodyne Group - - - - - - - - - - - - - - 354

Servants of Your Light Socket - - - - - - - - - - - 356

Radiolas for 1928 - - - - - - - - - - - - - - - - 358

Some New Offerings for the 1928 Season - - - - - - - - - 360

A New Regulator Tube - - - - - - - - - *James Millen* 363

The 1928 "Equamatic" Receiver - - - - - - - *Julian Kay* 364

A New Principle of R. F. Tuning - - - - - *David Grimes* 367

Book Review - - - - - - - - - - - - - - *Carl Dreher* 369

Using Radio in Sales Promotion, by Edgar H. Felix

1928 Loud Speakers - - - - - - - - - - - - - - - - 370

Should the Small Station Exist? - - - - - - *John Wallace* 372

"The Listeners' Point of View"

Your A. C. Set - - - - - - - - - - - - - *Edgar H. Felix* 374

As the Broadcaster Sees It - - - - - - - - - - *Carl Dreher* 376

Home-Constructing Transformers and Chokes for Power-Supply Devices - - - - - - - - - - - - - - *Homer S. Davis* 379

"Radio Broadcast's" Laboratory Information Sheets - - - - - 388

No. 129 The Type 874 Glow Tube
No. 130 Data on Honeycomb Coils
No. 131 Resistance-Coupled Amplifier
No. 132 Resistance-Coupled Amplifier Circuit
No. 133 Care of Power Supply Units
No. 134 Loud Speaker Horns
No. 135 Closely Coupled Circuits
No. 136 Carrier Telephony

Manufacturers' Booklets Available - - - - - - - - - - - 394

What Kit Shall I Buy? - - - - - - - - - - - - - - - 396

A Key to Recent Radio Articles - - - - - - - - - - - 398

"Radio Broadcast's" Directory of Manufactured Receivers - - 402

Making Radio Installations Safe - - - - - - - *Edgar H. Felix* 410

Book Review - - - - - - - - - - - - - - - - - - 416

Practical Radio Construction and Repairing, by Moyer and Wostrel

AMONG OTHER THINGS. . .

SO MUCH is now being accomplished in the complete set field that beginning with this issue, RADIO BROADCAST will devote much of its space to reflecting the technical and other advances being made. The policy of this magazine remains as before, to present the news of radio surrounded by as much as possible of what the technical radio worker refers to as "dope." And much "dope" there is in this complete set side of radio as many articles which will appear in following issues will strikingly demonstrate. In all the other fields of radio endeavor which RADIO BROADCAST has covered heretofore—the construction of radio receiving apparatus, laboratory experiments, short-wave communication, broadcasting from the technical and program side, and many others which we have covered to the satisfaction of our readers, RADIO BROADCAST will be as active as before. The expansion in scope of our text pages is directly designed to keep our readers in close touch with all sides of radio.

WHERE is the radio experimenter who has not read of the rapid progress of the transmission of photographs by wire and radio and hoped that he would soon be able to share in the fascination of this new and intensely modern field? For the past few years, RADIO BROADCAST has watched the progress of the art, hoping that devices would be developed within the scope of the amateur laboratory and pocketbook. The leading article on page 341 describes the background of the Cooley "Rayfoto" system which in a very few weeks will be made available through the pages of RADIO BROADCAST to the home experimenter. To be able to construct a radio photograph receiver for less than $100 should appeal very strongly to the experimental fraternity who are crying for something new to do. Here, in a manner of speaking, it is.

MANY pages of this issue are devoted to showing the offerings of the set makers for the coming season. Later issues of this magazine will describe in greater detail interesting technical features of these many receivers from many manufacturers.

THOSE of a technical turn of mind will read with great interest David Grimes' story on page 367 describing the theoretical features of a radio receiving system which is one of the most interesting that has come to our attention in many moons. Articles to follow by Mr. Grimes will describe the circuit constants and practical information about the system.

THE Federal Radio Commission is making every effort to popularize the use of the expression "frequency in kilocycles" instead of the familiar "wavelength in meters." It is hard going for some, but doing one's thinking in kilocycles does remove many serious complications from calculations. Ever since its August, 1925, issue RADIO BROADCAST has standardized the use of kilocycle designations, always printing at the same time, the equivalent wavelength in meters. We are in sympathy with the wishes of the Radio Commission and invite the expression of our readers on this subject.

—WILLIS KINGSLEY WING.

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THE strides made in the past few years by the broadcasting stations in bettering the quality of their transmission have been remarkable. The same principles have been applied to the phonograph, resulting in the new records and machines which are miles in advance of the older type.

These improvements are now available to every listener-in. However, there are some radio receivers which will not reproduce the wonderful music being broadcast by the improved stations.

By applying the same principles to radio receivers which have proved so helpful in the broadcasting and phonograph fields it is now possible to make the most out of the broadcasting. By utilizing the scientific aids now available old and new receivers may be made to produce music which in every way resembles the original. There is as much difference between this new form of reproduction and the old as there is between the new phonograph and the old scratchy, squawky cylinder machine of yesteryear.

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There is little use in having this wonderful thing available if we do not make use of it. It can now be utilized very simply. Radio artists, editors and many musicians have expressed both pleasure and amazement on hearing the tone portrayal of symphony orchestras, as well as jazz bands which Nature's Sounding Board has made possible.

Nature's Sounding Board is known as the Lata Balsa Reproducer. It is more than a "loud speaker." It is science's latest contribution to the musical art. It will make any good radio receiver sound much more natural and pleasing.

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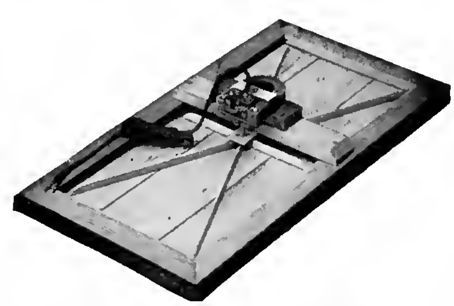

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LINCOLN

RADIO BROADCAST

VOLUME XI — NUMBER 6

OCTOBER, 1927

NOW—You Can Receive Radio Pictures!

You Can Build Your Receiver for Less Than One Hundred Dollars—How It Works

By KEITH HENNEY

Director of the Laboratory

THERE is an undeniable thrill in witnessing an extraordinary scientific event, such as receiving one's first broadcast program, or in talking across the Atlantic for the first time, or in seeing photographs that have been sent by radio from England, or in talking via short-wave amateur radio with a fellow "ham" on a steamship a thousand miles up the Amazon river. In fact, as the French astronomer, Camille Flammarion says, "Unless one has a stone instead of a heart and a lump of fat in the place of a brain, it is difficult not to feel some emotion over the achievements of science."

The writer's first contact with Austin G. Cooley, who has been responsible for the picture transmission system to be described in RADIO BROADCAST, produced one of those technical thrills. Cooley was working down in the "shack" at 2 GY, the short-wave station of the RADIO BROADCAST Laboratory, a small place with scarcely room enough to stow his extensive gear. On one bench was a metal drum on which a photograph of a young lady with a large and floppy hat turned over and over. On the other side of the "shack" was another rotating drum covered with photographic paper with a small spot of light playing on it, and filling the shack was an undefinable sound like that of a high speed motor whirring away with whining and somewhat obnoxious tone. In two or three minutes, Cooley stopped the motor, took the photographic paper from the receiving drum, developed it in rather dim daylight, and there was the young lady again, hat, white plumes and all. Between the transmitter and receiver was an artificial telephone line 300 miles long so that for all practical purposes the young lady's picture had been sent to Garden City from, say, Washington, D. C.

Since that time, Cooley has produced several picture systems, one of which is applicable to present wire telegraph channels so that facsimile copies of original messages may be transmitted at a cost not exceeding present rates. Another system—the one in which we as radio experimenters are interested has been developed to the extent that with a not very expensive attachment to the ordinary radio set, one can receive at home photographs, letters, telegrams, pictures, or text torn from newspapers. This system is known as the Cooley "Rayfoto."

These radio-transmitted pictures are comparatively good reproductions, quite satisfactory when one considers the simplicity of the apparatus and the compromises which were necessary in order to obtain them, it must be remembered that it is about seven years since the first small group of amateurs heard the human voice, and music, coming in by wireless. The early poor quality of reception must not be forgotten; nor must we lose sight of the fact that it has taken since 1835, when S. F. B. Morse performed his epoch-making experiment of transmitting slow and uncertain telegraph signals via wires, to send messages at the rate of several hundred characters per minute.

The Cooley pictures are better than most of the static-laden ones that have come across the Atlantic. Some of them are reproduced here. Improvement in detail and shading of the Cooley Rayfoto pictures will come. The important fact is that here is something the experimenter can have for his own and can have the sport of developing his experience as this apparatus is improved and refined.

Radio pictures at home—that's what the experimenter has been waiting for. Now it is possible. For less than $100, you can build your own picture receiver, connect it to your broadcast set and jump into a new and fascinating field of experiment. Exclusive articles in RADIO BROADCAST *in the November number and in following issues will tell you how to build and operate the receiver.*

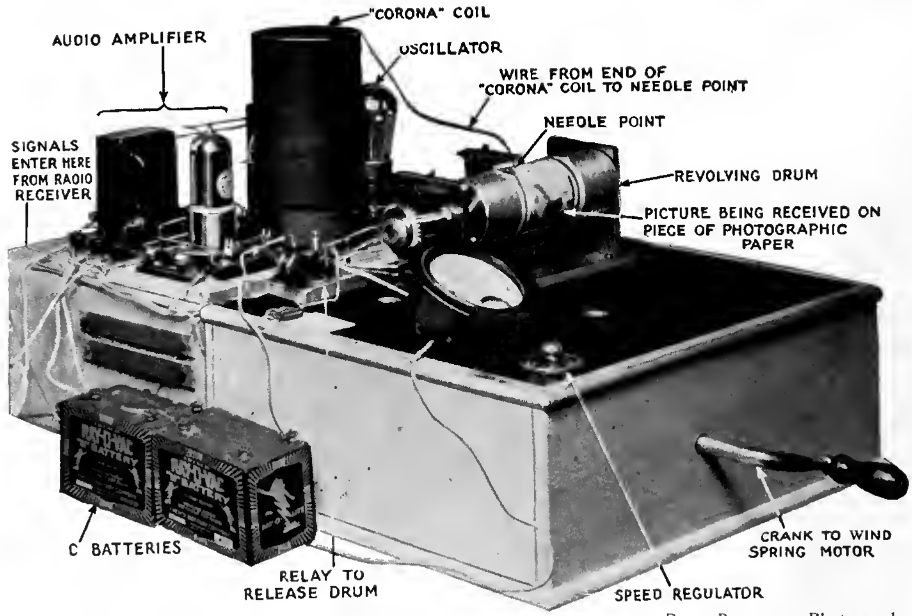
To know the Cooley apparatus is to know Cooley, to visualize the young M. I. T. student who preferred his own researches into the then unknown field of picture transmission to the prescribed studies with the result that he was dropped from the college register during his fourth year; his long nights of work, sleeping—when sleep was necessary—beside his apparatus on a laboratory bench. One should know of twenty-four-hour days in the Arctic on the MacMillan Expedition in 1926 when Cooley worked under great odds, trying to send picture signals by short waves back to the United States. This background is necessary to understand the years of effort that have gone before the present development. This development has been slow, and full of disappointments but the final result has been that his system is workable, comparatively simple to operate, and what is more important in the eyes of the average experimenter —it is inexpensive.

THE LURE OF HOME EXPERIMENT

WHY should one want to receive pictures by radio at home? As well ask: Why have thousands of experimenters built receivers for the reception of music, or code? In this, there has been always the thrill of accomplishment; making something with one's hands, something that works: creation. Secondly, there is the hope in everyone's heart that television, the art of transmitting scenes from life itself by wire or radio, shall become practical within his time. Before television shall be an accomplished fact, we must conquer the idiosyncrasies of the transmission of still life pictures, an art known as telephotography. By introducing legions of experimenters to the general problem of sending and receiving pictures by radio or wire, Cooley may have a share in advancing the day when the more difficult task of committing moving pictures to the ether shall be solved. The amateur has been thanked by engineers for his persistence in developing short-wave channels; many have said that to him alone belongs the credit for advancing the art of communication by the use of those very high frequencies. At any rate, he has had his share in making possible communication by short waves across vast distances with inexpensive apparatus. Who knows what his share may be when the ultimate success of telephotography and television has been achieved?

The transmission of a picture by the Cooley system differs from the transmission of music in one important respect: it takes a single audio frequency and performs tricks on it which at the receiving end are translated from sounds to other effects which influence a photographic paper. For example, good broadcasting requires that a band of frequencies 10,000 cycles wide shall be transmitted. These frequencies at the receiver are reconverted to sound waves. The picture system takes a given frequency, say 1000 cycles, and transmits its form of intelligence on it. In a way it is less complicated than broadcasting music; in other ways broadcasting pictures is more complex.

The broadcasting station which may elect to transmit pictures as well as music or speeches will use its present equipment. Since pictures according to the Cooley system are first translated into sound impulses, and since the phonograph record is a means of recording for future use such sound impulses, thereby defeating two of nature's limitations, time and space, the broadcasting station that will invest in a phonograph turn-table needs no other equipment to fill the ether with pictures.



RADIO BROADCAST Photograph

THE COOLEY "RAYFOTO" RECEIVER

Simplicity is the keynote of the Cooley picture transmission system. Signals in the form of an audio frequency tone enter at the point marked on this photograph, are amplified in a single-stage transformer-coupled amplifier, after which they are placed on the oscillator circuit through a modulation transformer not visible here. The signals in the oscillator circuit drive the corona circuit whose output is conducted to the rotating drum and photographic paper by the wire and needle point shown here. The drum is rotated by the familiar spring motor which usually turns phonographic records. The milliammeter, which is essential, usually reads the oscillator current

YOUR REGULAR RADIO RECEIVER IS USED

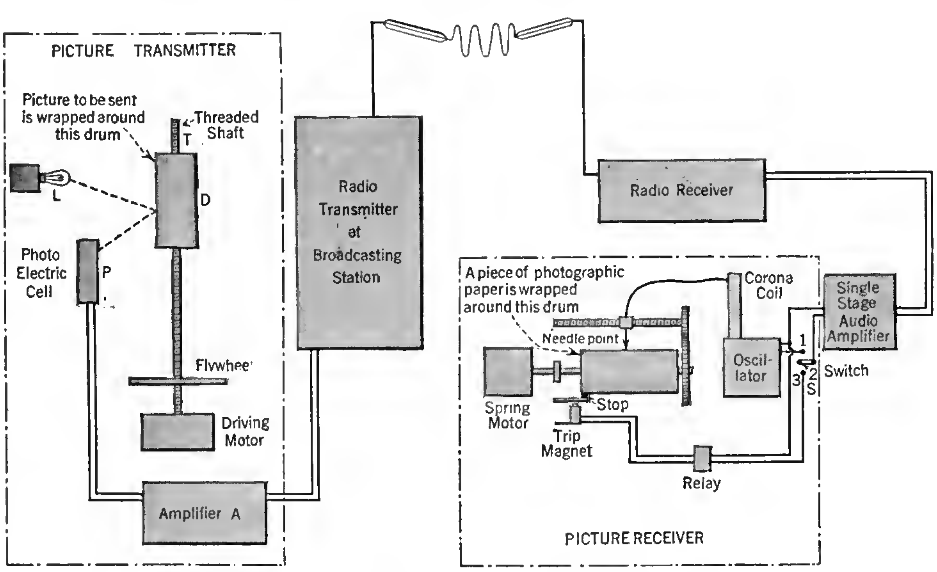
THOSE who will receive pictures will use their present broadcasting receiving set which should be equipped and operated so that overloading and severe distortion of other sorts do not occur. As in transmitting sounds, distortion at the receiving end produces an unintelligible or garbled reproduction. The receiver must be within the "service area" of the transmitter—that is, inside the distance at which fading takes place; the operator must be able to develop and fix ordinary developing-out paper, such as Azo, Velox, or other papers with which the amateur photographer is already well familiar. Here is an opportunity for the radio enthusiast who has dropped his photographic hobby to bring developing trays from the attic, and to renew his acquaintance with hydroquinone, metol, HQ, and hyposulphite of soda!

The present simplified system transmits and receives original photographs full of strong contrast, such as newspaper photographs, or those in which a loss of detail will not mar the recognizable features of the transmitted picture. The examples reproduced here will give an idea of the work that can be done. These limitations are largely due to the simplification of the receiving equipment, and, as experimenters become more familiar with the present apparatus, more refinements will naturally follow, refinements which will make it possible to receive greater detail, and naturally better pictures.

The process of getting the picture into the ether is not too complicated for anyone to understand. The picture is wrapped around an aluminum drum which revolves in front of a very strong light. As the drum revolves it moves along a shaft, so that the beam of light eventually has covered the entire picture, illuminating a small bit of it at a time. The light which is reflected by the picture passes into a sensitive photo-electric cell, another of modern science's marvels. When the beam of light falls on a black portion of the picture, most of the light will be absorbed and little reflected and consequently what passes into the photo-electric cell will be small—just as the part that comes to the eye is small; which explains what we mean by the word "black."

This sensitive photo-electric cell, whose history dates back many years and touches the lives of many famous scientists, consists of a potassium plate and a second metallic electrode which has a battery attached to it maintaining it at a potential positive with respect to the potassium, much as the plate of a vacuum tube is maintained positive with respect to the filament by the B batteries. When light shines on this potassium plate, electrons, those omnipresent negative electrical charges, are given off, their passage to the second electrode toward which they are attracted constituting an electric current. This minute current, usually of the order of a few millionths of an ampere is greatly amplified and interrupted by another current of 1000-cycle frequency. The result is that what were originally black and white visual images have been translated into sound impulses which are then impressed on the radio transmitter, or a telephone line, and are sent out like speech or music.

At the receiving end the process must be reversed, i. e. sound impulses must be translated into light impressions, back into those original black and white spots. Assuming that nothing happens in the intervening space, no static is picked up, no fading has lost the signal, at the receiving end the conventional broadcasting set may be used, and if a loud speaker is attached to the output of the receiver in the normal manner we should hear this varying note which is about two octaves above middle C on the piano.



HOW THE COMPLETE SYSTEM WORKS

The owner of receiving apparatus need not worry about how the pictures get on the air, but in case he is interested, here is a layout of the complete system, transmitter, waves in the ether, receiver and all! The switch at the right of the receiving equipment and the trip magnet are part of the start-stop system that insures synchronism between transmitter and receiver

WHY LOCAL AMPLIFICATION IS NEEDED

IN MOST cases it will be necessary to boost this wavering note to sufficient strength to operate the rest of the translating apparatus which consists of an oscillator, similar to that used in superheterodyne receivers except that its wavelength is usually above the broadcasting band, and finally what Cooley calls a "corona" coil. It will remind old-time electrical experimenters of the Tesla coil, a device used to transform a.c. voltages into other voltages high enough to produce electrical discharges across intervening space, in this case about a quarter of an inch.

Under ordinary conditions, the carrier of the transmitter tuned-in but no picture being on the air, the oscillator will be oscillating so feebly that no corona is taking place, but when the signal arrives it supplies power to the oscillator so that a nice fat discharge is produced whose

Radio Broadcast Photographs

THE COMPLETE RECEIVING APPARATUS

Here is the entire receiving apparatus. The receiver in this case was a well known set operating from a loop, picking up signals on 208 meters which originated in another part of the Laboratory. They are tuned-in and sent through the picture apparatus which is described in greater detail in the other photographs

intensity varies with the shading of the transmitted picture.

The counterpart of the rotating drum of the transmitter will be found at the receiver. Here, instead of an electrical motor we use for sake of simplicity a phonograph turn-table which is geared to a small aluminum drum around which the sensitive photographic paper is wrapped. The corona discharge sprays the paper from a fine needle and in some way not well understood affects the emulsion of the photographic paper. Whether this is an electrical or chemical effect or whether there is enough light from the corona to expose the paper is not fully known.

But for Cooley's purpose it does not matter. When developed, the paper shows black spots where the discharge was heavy; light spots where the corona was weak.

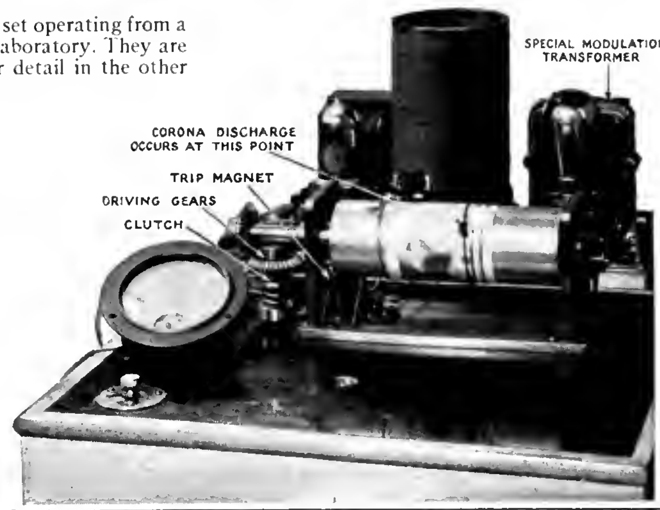
Now in all picture systems, some means must be provided to keep the receiver in exact synchronism with the sender; when the latter starts the receiver must start, and not in the middle of the picture which as anyone can see would have certain disadvantages! A simple scheme for holding the receiver and transmitter together has been employed. It is known as the "start-stop" system, and is very simple and flexible. In operation the receiving drum revolves slightly faster than the transmitting drum and it therefore completes a revolution in a slightly shorter time. At the end of each revolution the receiver drum is held by a trigger until the transmitting drum completes its revolution. A signal is transmitted then that releases the receiving drum so the two start off together. The radio signals are not strong enough in most cases to operate the trip magnet that releases the receiving drum at the beginning of each revolution so this magnet is operated through a more sensitive relay. Both the trip magnet and relay can be seen in the picture of the apparatus shown on this page. The single pole double throw switch S is really part of the trip magnet. When the armature of the trip magnet is against the stop on the drum, terminals 2 and 3 on the switch are pushed together and therefore all of the energy from the audio amplifier passes into the relay. When the synchronizing impulse is received it activates the relay and the trip magnet thus releases the drum and also causes the switch S to make contact between terminal 1 and 2 and then all of the energy passes into the oscillator.

The present apparatus transmits 4 x 5 photographs at a rate of one and one-half inch per minute or a little over 3 minutes for a picture.

The Cooley receiving apparatus consists of first of all one's broadcast receiver, then certain mechanical parts which will be on the market soon, and then certain electrical apparatus which any experimenter can build and operate. The total cost of the apparatus, exclusive of batteries, tubes, and broadcast receiver will be less than $100. All of the electric apparatus can be made from material easily available to the experimenter. Complete descriptions by Mr. Cooley of this equipment and how to operate it will follow.

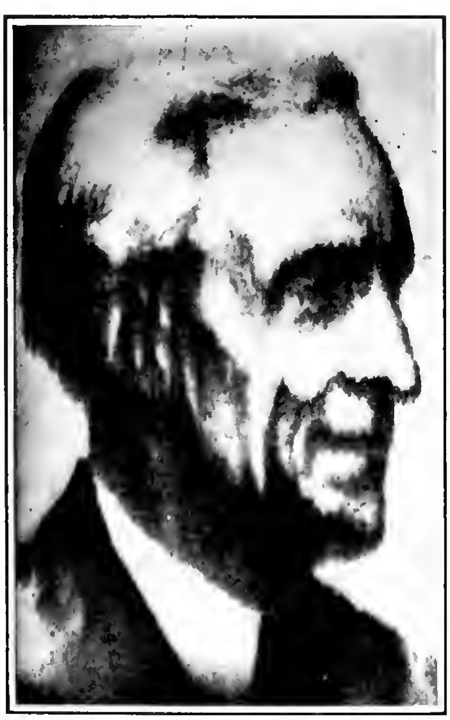
A word about the availability of pictures. Inasmuch as the original equipment for a broadcasting station need involve no more than the expense of a phonograph, there is a certain source of these radio pictures in every broadcast station. Broadcast stations will find in the transmission of the Cooley "Rayfotos" a sensational extension of their activities and by the time this article is in the hands of experimenters, and by the time the receiving equipment is ready, pictures will be on the air. The Cooley system is being exhibited at the New York Radio Show this month.

And there you are: Pictures by radio—and in your own home.



A CLOSE-UP

The modulation transformer, which was hidden in the view on page 342 by the corona coil is shown here. All of the parts for this apparatus have been especially designed, and will be available soon. A good idea of the gearing mechanism and of the width of the drum on which the picture is received may be had from this photograph. The picture may be as wide as the metal drum. The needle point actually rides on the paper as is shown here



WHAT THE PICTURES LOOK LIKE

These photographs have been transmitted by the Cooley Rayfoto system. Pictures may be five inches wide and about six inches long and a little over three minutes for each picture is required. These pictures have not been retouched

The March of Radio

News and Interpretation of Current Radio Events

Modern Radio Receivers Are a Good Investment

THE Radio World's Fair opens the radio season for the broadcast listener. Fitting its significance, the Fair is held in mid-September at the huge Madison Square Garden in New York.

No radio season has ever started more auspiciously. Technical progress, represented by simple, easily operated and maintained radio sets, many powered directly from the electric light mains, with broadened tonal range, bring the manufactured receiver to a standard so high that revolutionary change can no longer be expected. Greater broadcasting programs and improved receiving conditions make the possession of these modern receivers all the more desirable.

Every industry goes through the same cycle of growth; first, it has a discouraging struggle for recognition, then a boom period with almost day to day improvement, and finally, stabilization, with slow, continued and healthy progress, keen competition among leaders and the gradual elimination of the less capable who thrived only during the boom period.

In stating that radio has reached a slower level of development and that the purchaser may now select his receiver with the confidence that it will not be hopelessly obsolete within a year or two, or even four or five years, we draw our conclusion from fairly simple and indisputable premises. Improvement of any device is a matter of rendering it so simple that no technical knowledge is required for its operation, so rugged and self-sustaining that but little attention is needed to maintain it in good condition, and so pleasing in appearance that it harmonizes with the most luxurious surroundings.

High standards of simplicity have been attained in radio when we have many receivers in which five circuits are simultaneously controlled by one dial and calibrated so that stations may be promptly logged. The only perishable elements in some receiving sets now are the filaments of the vacuum tubes themselves which need be replaced perhaps only once a year. In tone quality, radio has reached a standard of reproduction far above that which satisfied the phonograph industry after twenty years of prosperity. This standard can be raised at will with our present knowledge and facilities, although the cost of doing so is prohibitive and the effect hardly noticeable to the average listener. As to appearance, there is still room for some improvement by the attainment of greater compactness in the more powerful receivers, but models are available for which no apologies need be made even in the most exacting surroundings.

Radio has certainly not reached its limit of development. Improvements will continue always and this year's sets will always be better than last. Two or three years ago, a radio receiver was but a one-year investment for those who would possess the best available in the market. This year's standards are making the latest and best models perhaps a five-year investment in approximately the best radio reception attainable.

It is a strange paradox that the substantial developments in manufactured receiving sets are not more widely appreciated by the technically minded radio enthusiast. From extensive contact with the better informed element of radio listeners, we have analyzed this lack of familiarity as attributable in part to the experimenter's preoccupation with the intricacies of set building and the failure of the radio set manufacturer to lay before this group, so invaluable to the building of reputations, the real facts about the design and construction of his receiving set. Glittering generalities about performance do not intrigue the radio experimenter who, in past years, has successfully excelled in these proclaimed qualities with his home-made contraptions.

But a new day has dawned. The experimenter cannot deny the superiority of the better manufactured sets. Already he is turning his attention to new fields. While building radio receivers was still an experiment, the successful outcome of which depended upon skill, ingenuity and patience, this hobby had no rival in the hearts of those who considered the soldering iron an instrument of conquest. The element of mystery is disappearing. Set building has become the following of a well established formula. The thrill of accomplishment still exists but the procedure is so well charted that the joy of exploration and discovery is practically gone. These missing elements, which satisfy the experimenter's insatiable desire to overcome obstacles and to conquer the unknown are being rapidly supplied by new lines of endeavor. Telephotography and, some day, television, international short-wave broadcast reception, modern installations with remote control of the radio receiver, laboratory experiments, home motion pictures, aviation, mechanical models and a thousand one avenues of expression beckon the experimentally inclined.

The pages which follow attempt to reflect accurately the trends in the interests of our readers. The manufactured receiver deserves an increasing amount of attention, as do new fields of development like telephotography and short-wave reception. We do not propose, in the least, to neglect the set builder, but rather to keep him in touch with the latest developments of the art. We

COLONEL LINDBERGH IN SCHENECTADY

"Aviation and radio are twin sisters engaged in the joint enterprise of overcoming time. Distances are no longer measured in miles, but in hours, minutes, and seconds. Colonel Lindbergh reduced the distance from New York to Paris from days to hours. Radio has brought all parts of the world into talking distance of the United States," said Martin P. Rice of the General Electric Company. Above: Martin P. Rice, and at the extreme right Colonel Lindbergh feel the broadened scope of our pages will appeal to each of the three principal elements of our reader audience, the experimental group; those professionally interested in radio, ranging from dealer to engineer to manufacturer; and the radio enthusiasts who follow these pages to keep abreast of progress in radio.

Listening to World-Wide Broadcasting is Near

PRIOR to the development of broadcasting, experimenters built receiving sets having a wavelength range of from 200 to 25,000 meters, so that they could eavesdrop on every available radio channel. Experience has taught us to build more efficient receivers for much narrower ranges. Indeed the present broadcast band is the widest for which a high grade receiving set with easy control can now be made. Many of the services conducted on non-broadcasting channels are gradually being rendered by radio telephony rather than radio telegraphy. The objection that laborious study of the radio code is necessary to listen to them is thereby eliminated.

Almost every day of the year, new radio services open up. The possessor of a long-wave receiver picks his signals from every section of the globe. A slight movement of the dials may transfer his attention from a station in Java to another in Iceland. There are now nearly one hundred stations which can be heard in any part of the world.

Perhaps the most important development of all, so far as the broadcast listener is concerned, is the increasing interest in short-wave broadcasting. 2 XAF, the 32-meter (9150-kc.) Schenectady transmitter of the General Electric Company, is actually supplying the world with radio programs. Its signals are frequently and regularly heard in England, South Africa, South America, New Zealand and Australia. An increasing number of American broadcasting stations, including WGY, KDKA, WRNY, WLW, WAAM, WRAH and WHK are, or soon will be, broadcasting their programs on short wavelengths. British, German, and Dutch stations are within range of American short-wave sets. Short-wave programs are readily heard at great distances during the summer when the program range of most standard wavelength broadcast receivers is very limited. Several companies are already preparing to meet the demand for short-wave receivers.

The question may arise whether short-wave broadcasting will not replace our present services. A short-wave transmitter is ideal for long distance transmission but, because of fading and the skip distance effect, is of little or no local service. Within two hundred to six hundred miles of short-wave stations, their signals are usually inaudible but even moderate power delivers a strong signal for immense distances beyond the dead area. Hence every high frequency station requires an exclusive channel, placing a definite limit on the number which may be accommodated throughout the world. Receiving sets, working on the high frequencies, are necessarily of the regenerative type and consequently, at the present time at least, no vast number of receiving sets can use these channels without causing destructive interference. Undoubtedly, the radiation problem will be overcome, but fading and transmission irregularities will prevent the use of short waves in the essential local and regional broadcasting services.

Since short-wave stations practically cover the earth with their signals, it is feasible to assign but one powerful short-wave broadcaster to a frequency. Consequently, it is desirable to select a short-wave broadcasting band at once and allot frequencies so as to meet the needs of all the countries of the earth. This matter should be considered in the International Radio Telegraph Conference, convening in Washington in October, lest confusion and congestion arise later. There is no need for a great number of short-wave broadcasters in any one country, and some means should be devised for limiting their increase before the problem becomes as serious as the congestion now obtaining on the conventional wavelengths.

A Profound Study of Radio Law

THE Law of Radio Communication by Stephen Davis, former Solicitor of the Department of Commerce, recently published by McGraw-Hill, is a valuable contribution to radio literature. It has been awarded the Linthicum Foundation Prize by the faculty of law of Northwestern University, a distinction which will be recognized by the legal profession as one of no small moment.

The book deals comprehensively with all phases of radio communication and interprets the Radio Act of 1927 in the light of precedents already established by the Courts. The book studies exhaustively the complex problems raised by the existence of broadcasting stations, although the author has been seriously handicapped by lack of established legal precedents and decisions on most vital issues. Clearly, many important legal questions which will harass the Courts during the next few months are yet to be settled.

The preponderance of evidence and precedents which Judge Davis cites leads one to conclude that the question of confiscation of property, involved in cancellation of station licenses, is one which will be decided against the regulatory power of the Commission. On the other hand, established stations, which find their service curtailed by interference from newcomers, seem to have ample grounds for securing restraining injunctions on the grounds of prior rights. Reading these parts of the Judge's book leads us to regret all the more that our suggestion that station priorities be recognized, was not embodied in the law. That was urged in these pages long before the Radio Act was finally drafted.

The author considers federal jurisdiction and its relation to state and local regulation of radio communication, copyright questions, libel and slander, as well as the significance of every phase of the recent Act.

HOW MUCH IT COSTS TO BROADCAST

Rate cards are used in selling "time" on the air just as publishers use rate cards in selling "space." The rates in these tables show exactly what it costs to send a program over the entire United States. A large part of the charges are consumed in the high cost of the special telephone wires connecting the stations

I. GENERAL BROADCAST ADVERTISING

A. Basic Rates for periods between 7:00 P. M. to 11:00 P. M. Local Time.

RED NETWORK
Available only as a Group

Cities	Charge Per Hr.	Charge Per ½ Hr.	Charge Per ¼ Hr.
New York	$600.00	$375.00	$234.38
Boston	250.00	156.25	97.66
Hartford	120.00	75.00	46.88
Providence	120.00	75.00	46.88
Worcester	120.00	75.00	46.88
Portland, Me.	120.00	75.00	46.88
Philadelphia	310.00	193.75	121.10
Washington	190.00	118.75	74.22
Schenectady	190.00	118.75	74.22
Buffalo	200.00	125.00	78.13
Pittsburgh	250.00	156.25	97.66
Cleveland	250.00	156.25	97.66
Detroit	340.00	212.50	126.56
Cincinnati	250.00	156.25	97.66
Chicago	460.00	287.50	179.69
Total for Network	$3770.00	$2356.25	$1466.46

BLUE NETWORK
Available only as a Group

Cities	Per Hr. Charge	Per ½ Hr. Charge	Charge Per ¼ Hr.
New York	$600.00	$375.00	$234.38
Boston	250.00	156.25	97.66
Springfield	210.00	131.25	82.03
Baltimore	190.00	118.75	74.22
Rochester	200.00	125.00	78.13
Pittsburgh	300.00	187.50	117.19
Detroit	340.00	212.50	126.56
Cincinnati	250.00	156.25	97.66
Chicago	460.00	287.50	179.69
Total for Network	$2800.00	$1750.00	$1087.53

SUPPLEMENTARY CITIES

	Cities	Charge Per Hr.	Charge Per ½ Hr.	Charge Per ¼ Hr.	
Selectively available	St. Louis	$210.00	$131.25	$82.03	*For use in conjunction with the Red or Blue Networks*
	Minn. St. Paul	210.00	131.25	82.03	
	MIDWESTERN GROUP				
Available only as a group	Davenport	$190.00	$118.75	$74.22	*For use in conjunction with the Red or Blue Networks*
	Des Moines	190.00	116.75	74.22	
	Omaha	190.00	116.75	74.22	
	Kansas City	190.00	118.75	74.22	
	Oklahoma City-Tulsa	190.00	118.75	74.22	
	Dallas-Ft. Worth	190.00	118.75	74.22	
	Total for Group	$1140.00	$712.50	$445.32	
	SOUTHERN GROUP				
Available only as a group	Louisville	$180.00	$112.50	$70.31	*For use in conjunction with the Red or Blue Networks*
	Nashville	190.00	118.75	74.22	
	Memphis	190.00	118.75	74.22	
	Atlanta	190.00	118.75	74.22	
	Total for Group	$750.00	$468.75	$292.97	
	PACIFIC COAST NETWORK				
Selectively available with San Francisco	San Francisco	$300.00	$187.50	$117.19	*Requires special program production in San Francisco studio.*
	Los Angeles	300.00	187.50	117.19	
	Portland	150.00	93.75	58.60	
	Seattle	200.00	125.00	78.13	
	Spokane	150.00	93.75	58.60	
	Total for Network	$1100.00	$687.50	$429.71	

B. Basic Rates for periods other than between 7:00 P. M. - 11:00 P. M. Local Time are one-half above rates.

counts on Basic Rates for number of periods under contract not to exceed one year ration:

Less than 25	Net
25 - 49	5%
50 - 99	15%
100 - 299	20%
200 and over	25%

For the time being, it is the only authority available to the lawyer handling cases for broadcasting stations. We hope, for the good of radio, that Judge Davis will soon find it necessary to write a revised edition occasioned by court decisions to the unanswered questions which he so ably raises. His book thoroughly establishes Judge Davis as the outstanding American authority on the law of radio communication.

The Danger of Direct Advertising on the Air

THE United States Radio Society has sent us its literature, including a code of regulations and by-laws for local affiliated chapters of the society. By following these regulations, any local radio organization may become affiliated in the national group, and means are provided for representation of each chapter in the national deliberations. In absence of local chapters, a membership can be secured by individuals who may write Paul A. Greene, Managing Director of the Society, at the Temple Bar Building in Cincinnati Ohio.

The Society recently forwarded the returns from a questionnaire to the Federal Radio Commission which emphasized the unpopularity of certain broadcasters permitting blatant advertising, particularly two well known nuisances in Shenandoah, Iowa. The St. Joseph, Missouri *Commercial News*, writing of these "advertising stations," says "one of the best known of these nuisance stations reported, the first week in February, that it had in a month sold about 45,000 pieces of dress goods, amounting to approximately 175,000 yards. Figuring the mileage, this amounts to 99 $\frac{4}{13}$ miles of dress goods." Continuing, the article comments on the competition which this direct advertising offers to the small local merchant.

One of the claims made to the Federal Radio Commission by one of these stations was that it lowered the price of goods to the farmer. Refuting this claim, the St. Joseph newspaper says:

One of the best known stations, not far from St. Joseph, recently put on an active sale of cans of smoked salt for use in butchering on the farm. It offered two cans of a good quality of smoked salt for $2.50, postage prepaid. Orders were accepted for not less than two cans. One Iowa farmer who fell for this great bargain was shown the identical product by his local merchant for only a dollar a can. Another radio bargain was ten pounds of prunes for $3.50, of a quality purchasable locally in one pound packages for twenty-eight cents.

The Month In Radio

HENRY OBERMEYER of the Consolidated Gas Company of New York informs us that his company received more than 31,000 letters from its customers as a result of a radio course on homemaking which required four and a half hours of broadcasting time to transmit. One of the important features of the gas company's radio campaign was that an amount equal to fifty per cent. of the broadcasting expense was spent in newspaper advertising to call the attention of radio listeners to the feature. It is an excellent example of successful commercial broadcasting which won its return by the real value of its service. ❦ ❦ ❦ The Bureau of Standards is prepared to calibrate crystal oscillators used in maintaining broadcasting stations on their assigned frequencies, for a nominal fee. Stations contemplating taking advantage of this service should first apply to the Bureau, giving call letters, assigned frequency, type, make and description of the oscillator to be calibrated. This information is required because the Bureau will not accept for calibration instruments which are not so constructed that they will remain in adjustment permanently. ❦ ❦ ❦ WHAM, Rochester, New York, which will soon have a 5000-watt equipment of the latest type, WTMJ, Milwaukee and WJAX, Jacksonville, Fla., have been added to one or the other of the N. B. C. chains, giving still greater coverage to its programs. ❦ ❦ ❦ The National Electric Manufacturers' Association recently completed a study of the question of the number of hours a week the listener uses his radio set. This information has an important bearing on the sale of tubes and maintenance accessories. According to the NEMA figures one listener out of a thousand uses his radio about twenty-two hours out of twenty-four; one out of a hundred, twenty hours out of twenty-four; one-tenth of the total more than seven hours a day and four out of five in excess of thirty hours a week, which means five hours a night, six nights out of seven. The statistics were evidently obtained by making a record of the listening habits of a handful of the most rabid enthusiasts who could be found. We would particularly like to meet the person who uses his radio receiver twenty-two hours out of twenty-four. It is quite apparent that Mark Twain was right about statistics. Editor's Note: Mark Twain said: "There are lies, damn lies and statistics." ❦ ❦ ❦ The Canadian radio industry is developing rapidly. There are now at least a dozen first class Canadian-made broadcast receivers, and several factories engaged in the manufacture of radio tubes and batteries. Broadcasting has prospered with the backing of such powerful concerns as the Canadian National Railways and the Northern Electric Company. A patent pool, similar to that of the Radio Corporation of America, is licensing a number of first class manufacturers. On April 1, licensed broadcast receiving stations numbered 134,486, as compared with 92,000 at the end of the previous year. The fees collected from the listener are applied to the elimination of interference and the proper administration of commercial radio telegraphy. ❦ ❦ ❦ Danish statistics inform us that, on April 1, 1927, there were 130,805 radio receivers in that country, almost equally divided between crystal and vacuum tube sets, and an increase of 50,000 over the previous year. ❦ ❦ ❦ There is a great increase in the demand for radio receiving sets in Brazil and broadcast enthusiasm is spreading throughout the country with great rapidity. Most of the stations are

A TRANSCONTINENTAL CANADIAN BROADCAST

For the first time in history, twenty-three Canadian stations from Halifax to Vancouver were hooked up in broadcasting the Diamond Jubilee Celebrations of the Dominion. A feature of the broadcast was the program of carillon music from the Peace Tower in the Parliament Buildings at Ottawa (in insert, left). The illustration below shows the control room in the Parliament Buildings with telephones leading to the telegraph and telephone offices. Commander C. P. Edwards, head of Canadian radio, is at the extreme right

along the seaboard and long range receivers are consequently in special demand. American receivers are making the greatest headway in the market.

LICENSES AND WHAT THEY MEAN

THE most important patent decision rendered during recent months, which is, however, still subject to future appeal, was that of Judge Thacher, favorable to the Radio Corporation against E. J. Edmond & Co., Atwater Kent jobbers. The decision establishes the validity and scope of the Alexanderson patent 1,173,079, generally known as the tuned radio frequency patent. The result of this decision has been to place all concerns making multi-tube sets, not holding R. C. A. licenses in considerable jeopardy. About twenty-four important concerns have already secured Radio Corporation licenses and those outside the pale are making strenuous efforts to secure licenses. So far, no set company licenses have been granted which do not guarantee a minimum royalty to the R. C. A. of $100,000 a year. Just what the future holds for small companies is, at the moment, doubtful. Radio dealers are universally demanding apparatus which is duly licensed and the position of those who cannot, because of small production, guarantee such substantial royalties is most doubtful. The Radio Corporation could not long withstand the adverse criticism which would result were they to force smaller manufacturers out of business.

The object of the patent law is to protect the rights of inventors so that they may derive just compensation for their inventive efforts. The use of patents for restraint of competition, even though patents themselves are an intentional and desirable monopoly, is not supported by public opinion. So long as a concern is willing to recognize inventors' rights and pay royalties it should not be prevented from engaging in competitive business. Dealers are justified in insisting upon licensed apparatus and it appears that the Radio Corporation and its licensees are the only ones who may legally make efficient, high grade radio receivers under present conditions. However, if patents are used in a coercive way to strangle smaller concerns, we doubt that it will result ultimately to the benefit of the patent holders. No one questions that the recent decisions have established definite supremacy of the R. C. A. in the patent situation, but the advantage should not, and probably will not, be used to force independents out of business. ❦ ❦ ❦ The Hazeltine Corporation won a vitally important decision against A. H. Grebe & Co. sustaining the Hazeltine patents 1,489,228 and 1,533,858. The distinction between the Rice and Hartley disclosures, upon which Grebe placed principal reliance, and that of Hazeltine, is clearly set forth in the decision. Although it is granted that both Rice and Hartley disclosed principles of neutralization, the superiority of the Hazeltine method, utilizing a capacity feed back of a voltage to neutralize the regenerative effect, is established as an improvement of great importance to the radio art. Professor J. H. Morecroft appeared as an expert for Grebe. The Court, in its opinion, quoted an item from the "March of Radio," which Professor Morecroft formerly prepared for RADIO BROADCAST, acknowledging the importance of the Hazeltine disclosure. ❦ ❦ ❦ A decision handed down in the Federal District Court at Baltimore sustained Messrs. Willoughby and Lowell over James Harris Rogers in their patent for a submarine reception system. Rogers claimed prior conception, but Willoughby and Lowell clearly anticipated him in reduction to practice. ❦ ❦ ❦ After yielding to a decree *pro confesso* secured by John A. Victoreen against the Radio Art Company and others; the latter developed a substantially different device from that previously judged to infringe. An action was brought requesting that Radio Art be adjudged guilty of contempt but, upon submission of a brief that the new device was substantially different from that on which the earlier decree had been granted, the Court ordered the plaintiff to file a new suit. The case is cited in the interests of those who have yielded to consent decrees. ❦ ❦ ❦ The Eisler Engineering Company of Newark announces that it successfully defended itself against the General Electric's suit which sought to prevent it from manufacturing tipless tubes. The case was started in October, 1924, and the final decision is of interest to all vacuum tube manufacturers. ❦ ❦ ❦ A suit has been filed by the Balsa Wood Company. Inc against the Balsa Laboratories Company, Inc. in connection with their patent 1,492,982, describing diaphragms for sound reproducing devices. ❦ ❦ ❦ One claim of V. K. Zworykin's patent 1,634,390, covering a secrecy system of transmission was denied because of an earlier patent, Alexanderson's 1,426,944. ❦ ❦ ❦ The Brandes Products Corporation has petitioned for a writ of certiorari which may bring the dispute regarding the Hopkins patent before the Supreme Court. Originally the Lektophone Corporation of Jersey City sued the Western Electric Company, which suit resulted in a decision in favor of the latter. The R. C. A. has already paid $200,000 for rights under the Hopkins patents, which will prove an unnecessary investment unless they are sustained before the Supreme Court. ❦ ❦ ❦ The Westinghouse Company secured an injunction against the Kenwood Radio Company in connection with Armstrong's radio patent 1,113,149.

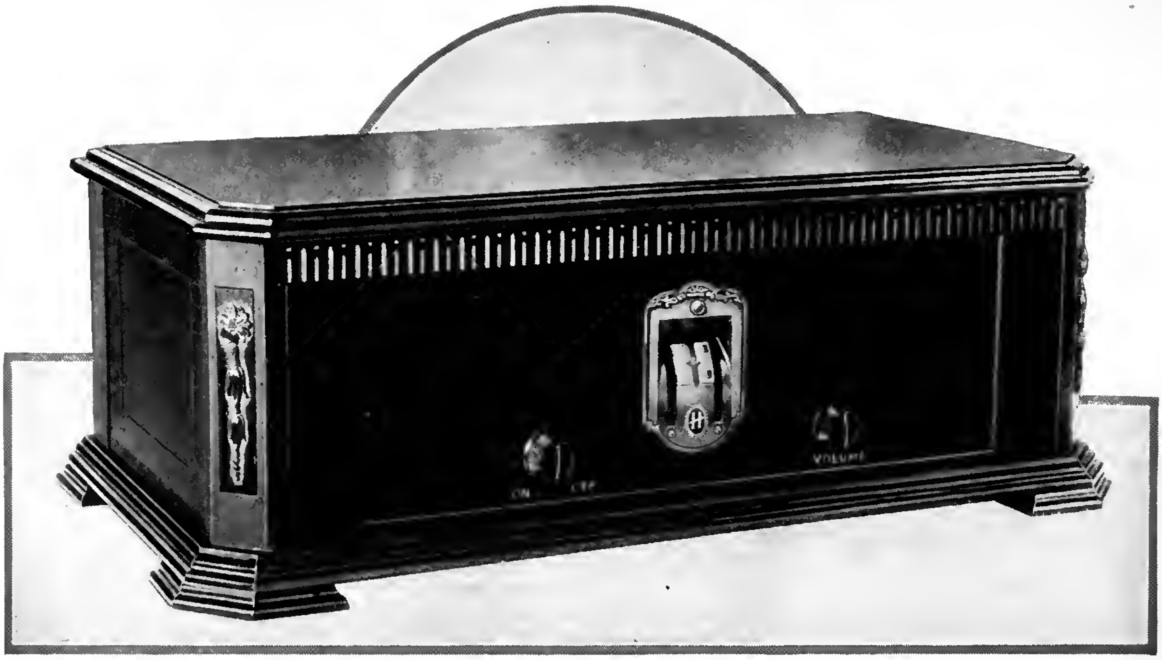
THE COLUMBIA BROADCASTING CHAIN

THE United Independent Broadcasters, of which Major J. Andrew White, pioneer sports announcer, is a leading official, has given out a list of stations which will form its new network. The key station is WOR, which is the third most popular station in New York, exceeded only by WEAF and WJZ in number of listeners. The other stations are WEAM and WNAC in New England; WFBL, WMAK, western New York; WCAU and WJAS, Pennsylvania; WADC, WAIU, WKRC, Ohio; WGHP, Michigan; WMAQ, Chicago; and KMOX, St. Louis. Although, in point of numbers and station standing, the stations comprising the chain are not everywhere in the lead, it would not take long, given good programs, for such a chain to corner a good part of the radio audience.

Nothing will help the broadcasting situation so much as real competition to the N. B. C. chains, so that both organizations will conduct a nip and tuck battle for program supremacy.

THE RADIO EQUIPMENT ABOARD THE "MORRISSEY" IN THE FAR NORTH

Edward Manley, of Marietta, Ohio, is shown before the radio apparatus aboard the Putnam-Baffin Island expedition. The *Morissey*, known to the short-wave code world as VOQ has a generator-powered short-wave transmitter, a battery-powered transmitter using a UX-852 tube (on the top shelf), a short- and long-wave receiver, and a portable battery-operated transmitter. Signals from VOQ have been clearly heard at the short-wave laboratory of RADIO BROADCAST and occasional radio dispatches from the expedition have appeared in the New York *Times*



The 1928 "Hi-Q" Has an Extra R. F. Stage

By JOHN B. BRENNAN

Cascaded Stages Result in Sharpness of Tuning but Avoid the Cutting Off of Side-Bands

IN ANY discussion centering upon the predominant requirements of a modern receiver, it will generally be admitted that there are two outstanding things to strive for—good quality and a high degree of selectivity. Strangely enough, these two coveted qualities are diametrically opposed to one another—difficult of attainment in the combination.

Nowadays, a receiver is judged by its ability to faithfully reproduce music and speech, and this critical attitude on the part of the listener has resulted in the setting up of a remarkably high standard so far as the audio channel of the modern receiver is concerned.

The other outstanding requirement, that of selectivity, represents a problem which did not exist in the early days of radio. To-day the United States has over six-hundred broadcasting stations whereas there were barely a hundred five years ago.

It needs no stretch of the imagination to realize that there is no receiver which, in a given location, can tune-in all six-hundred of these stations. With an exceptionally good receiver, however, listeners may tune-in more stations—not merely the far-distant stations—than with just a fairly good receiver. Yet, in spite of this, there is no advantage gained in such a case unless the reception is of good enough quality reproduction to warrant listening to it.

To illustrate briefly the difficulties involved, reference to Fig. 1 will prove helpful. Here a suppositional case is presented where the vertical rectangular sections represent the ten-kilocycle bands occupied by several stations whose carrier frequencies are equally separated by a space of twenty kilocycles. The curve b represents the tuning characteristic of a selective circuit which

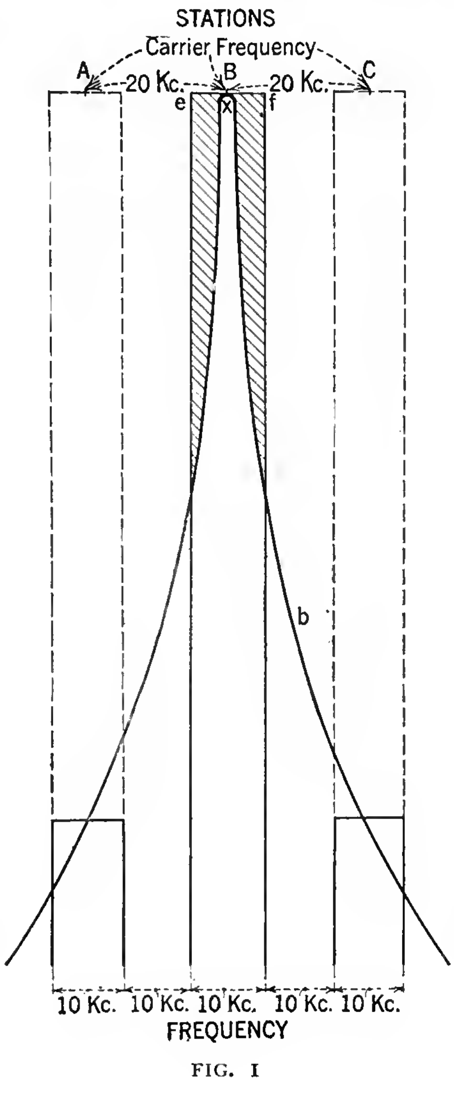


FIG. I

Variable Interstage Coupling Provides for Equal Amplification Throughout Broadcasting Band

is slightly regenerative and which is set for resonance with the incoming signal of station B. It will be observed that, while a section of the curve falls in that part of the space taken up by stations A and C, the amplification of the signals from thest two stations is much below the amplification of the signal to which the circuit is tuned. Maximum amplification of signal A is represented by X, the peak of the curve b. It may be said of this circuit that it is highly selective but it will also be observed that the quality of the signal is impaired due to the fact that all the side-band frequencies, e to f, within the ten-kilocycle band of the station to which the circuit is tuned, are not amplified equally. The shaded portion shows how unequal this amplification is and indicates the rapid cutting off of the side bands. A highly desirable curve would be one where equal amplification of all the frequencies within the band, e to f, is obtained, and where there will be no response obtained to stations in adjacent frequency bands.

Now, going to the other extreme, in circuits wherein there is no inherent regeneration, and where the characteristic curve indicates broadness of tuning, as in Fig. 2, it will be noted that the shaded portion has become greatly reduced and therefoie practically an equal amplification of frequencies within the band to which the circuit is tuned, is obtained. It will also be noted, however, that in such a circuit the amplification of signals obtained from adjacent stations, even though the circuit is not tuned to them, is sufficient to cause them being heard as a background to the desired signal. It has been determined that where a number of slightly broadly tuned stages are arranged in cascade, each successive stage filtering the output of the preceding stage, and

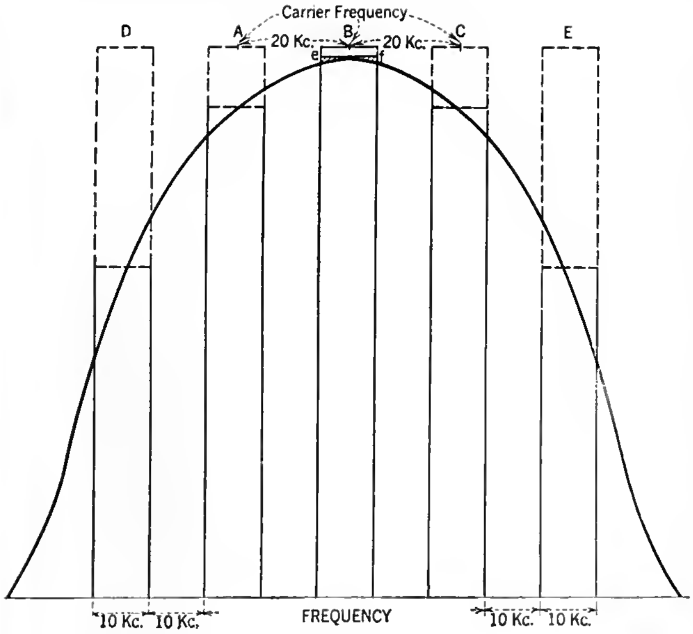


FIG. 2

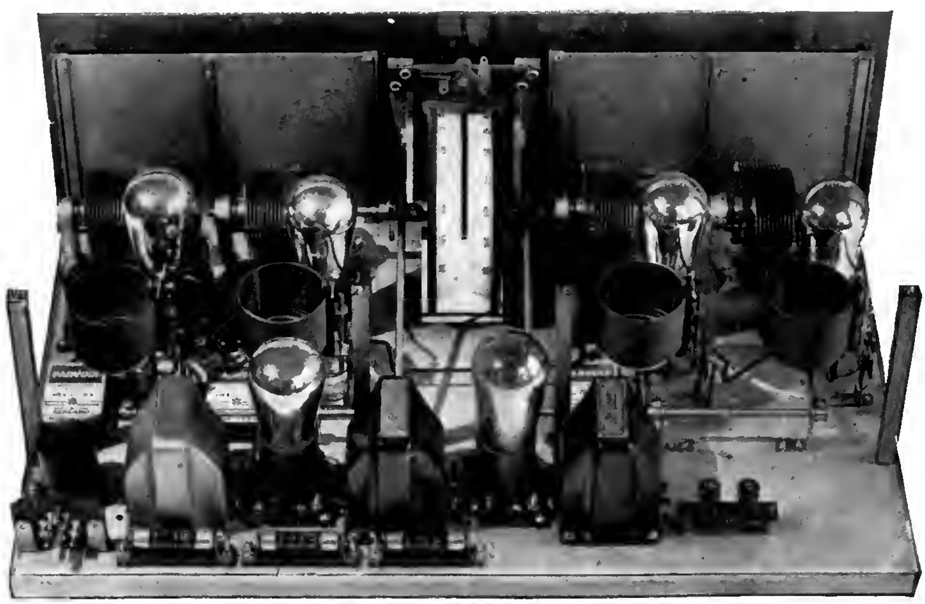
production into a practical receiver. It is well known that a three-stage radio-frequency amplifier can be built to give a high degree of amplification and smooth operating characteristics; that is, it will have freedom from self oscillation, etc., if it is desired to work at a single wavelength, say, five-hundred meters. However, where, under these conditions, the circuits are re-tuned to, say, two hundred meters, they will go into violent oscillation and destroy the stability which they formerly possessed. Explained in another way, this means that, due to the fact that radio-frequency amplifier circuits have the tendency to oscillate, this oscillation becoming more pronounced as the wavelength is decreased, a circuit satisfactory for operation at five hundred meters is wholly unsatisfactory for operation at two hundred meters, due to inherent oscillation, unless, of course, some corrective feature, either mechanical or electrical, is incorporated in the circuit to prevent this oscillation and yet at the same time maintain the circuit at its high degree of amplification.

It has been recognized that some system of securing uniform amplification at all broadcast frequencies is greatly to be desired and various methods for attaining this end have come into prominence during the last year. These systems in the main can be divided into two classes: (1) The mechanical control of coupling, such as is used in the King "Equamatic," "Hi-Q," and Lord systems and, (2) electrical systems, such as those relying on the function of combinations of capacity, inductance, and resistance—the Loftin-White and "Phasatrol" methods, for example.

A little calculation will readily show that these systems can be designed to produce a curve approaching the desired straight line indicating uniform amplification shown in Fig. 4. Since the resultant curve from the use of a fixed coupling between primary and secondary is so far removed from a straight line characteristic, as will be seen by Fig. 4, even remedial systems, where precautions have been taken to guard against inherent regeneration in the several stages, that the ideal response curve is approximately attained. This is graphically shown in Fig. 3.

From Fig. 2 we have observed that the response curve for a single stage is quite broad. It is reproduced again in Fig. 3 as curve No. 1. However, when a second tuned stage, having the same characteristics, is added, the curve obtained is somewhat altered in form. The top of the curve has practically remained the same but its sides have taken a deeper slope, as shown by curve No. 2. In adding a third stage, the curve obtained is similar to the curve No. 3, wherein there is a further constriction of the sides of the curve. The fourth stage confines the curve within limits which very nearly approach the ideal.

For those who desire a highly technical discussion on the points just outlined, it is recommended that reference be made to Professor L. A. Hazeltine's paper on the subject, which is contained in the June, 1926, issue of the *Proceedings of The Institute of Radio Engineers.*



FROM BEHIND THE PANEL

The shield walls have been removed for this photograph so that it may be clearly seen how all the parts are disposed

THE NEW "HI-Q" RECEIVER

IN THE new Hammarlund "Hi-Q" Six receiver, four tuned stages are employed and the final response curve obtained from their use is similar to No. 4 of Fig. 3. In order to secure this result it was necessary to take precautions in setting up the four tuned stages to prevent the desired signal being received by any other way than through the antenna into the first tuned stage, and so on, up to the detector stage. Therefore, the necessity for completely shielding each of the stages arose. Also, each of the several tuned stages had to be completely filtered by the use of radio-frequency chokes and bypass condensers so that there were not present any intercoupling effects which would cause unstableness in operation and thereby defeat the purpose of the use of these several stages. Were not the radio-frequency currents confined to their own individual stages by means of chokes and bypass condensers, and also by the individual stage shields, intercoupling effects would undoubtedly be caused either by capacitative coupling from the wiring of the circuits, inductive coupling between the coils of the various tuned circuits, or resistance coupling in the batteries, since one set of batteries is employed to furnish the B potential and its impedance is common to all the tubes.

It was realized that all this must be achieved without sacrificing the sensitivity of the circuits, or in other words, their ability to bring in weak signals. This means that the various interstage transformers employed in the tuned circuits must be efficient enough so that weak antenna signals are built up to a strength sufficient to give a good response in the loud speaker considering that two stages of audio-frequency amplification are employed.

It is this desire for sensitivity that complicates the problem of combining these principal featuresof a high degree of selectivity and a high degree of re-

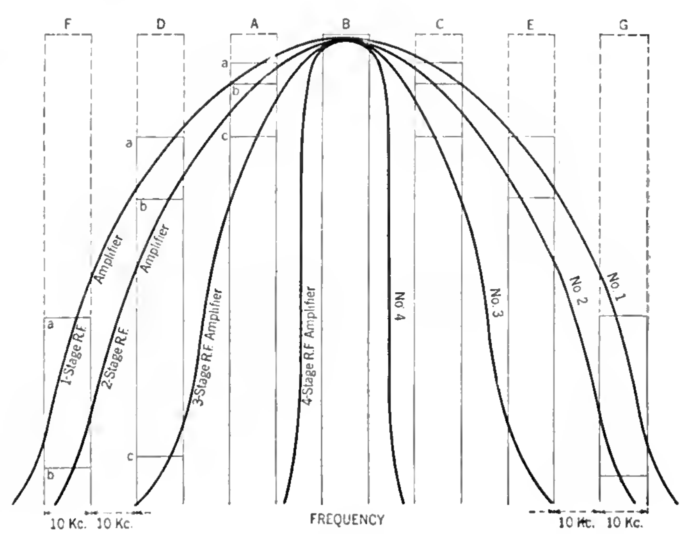
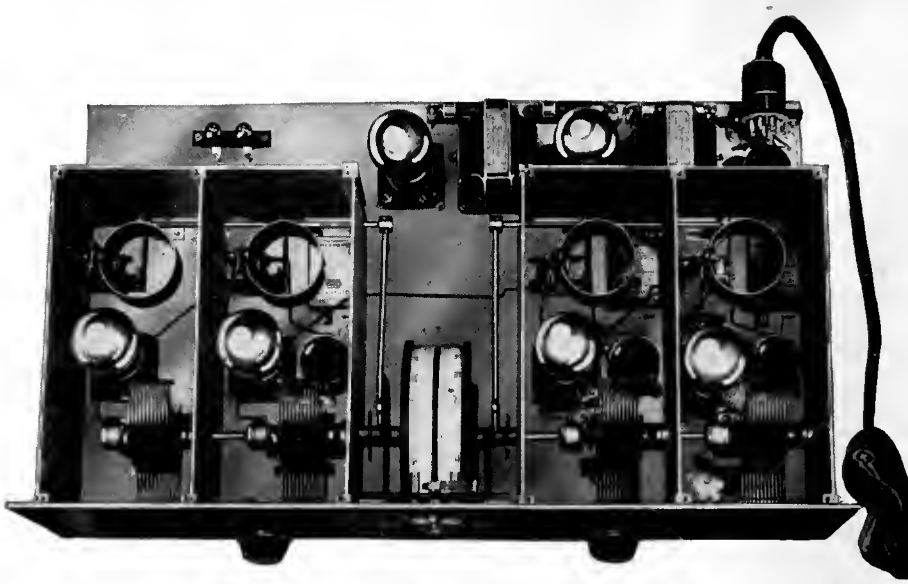


FIG. 3

though not absolutely perfect, are undoubtedly a step in the right direction.

In the Hammarlund "Hi-Q" Six the results obtained by the use of four well designed tuned stages depended not only upon complete isolation of each of the four stages by means of shielding but by a combination of mechanical and electrical systems which, in the end, produced as near as possible the desired straight line of amplification. The mechanical feature consisted of automatically varying the coupling between the several primary and secondary coils by means of a cam located on the shaft of the condensers, so that a variable degree of coupling was obtained to give an equal transfer of energy between primary and secondary regardless of whether the circuits were tuned to two hundred or five hundred meters. By the use of the cam method it is possible to secure the correct degree of coupling at any dial setting due to the fact that the shape of the cam can be predetermined to provide the desired coupling. Since all precautions are taken to prevent feedback by isolating the several tuned stages, through the use of radio-frequency chokes, bypass condensers, and individual stage shields, only the tube capacity of the tubes employed in these stages remains to cause undesired coupling. The electrical means referred to above is obtained by the use of grid "suppressors"—resistance units located in the grid circuits of these tubes. These grid "suppressors" will cancel the tendency of the tube capacity to act as a coupling agent and to cause feed-back.



READY FOR THE BATTERIES

This illustration clearly shows the gauged condenser arrangement employed in the new "Hi-Q" Six

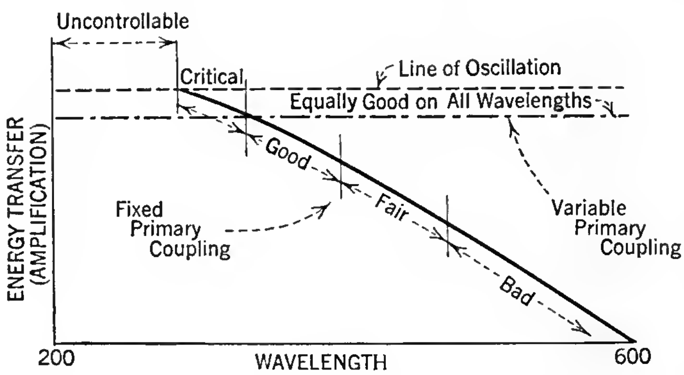
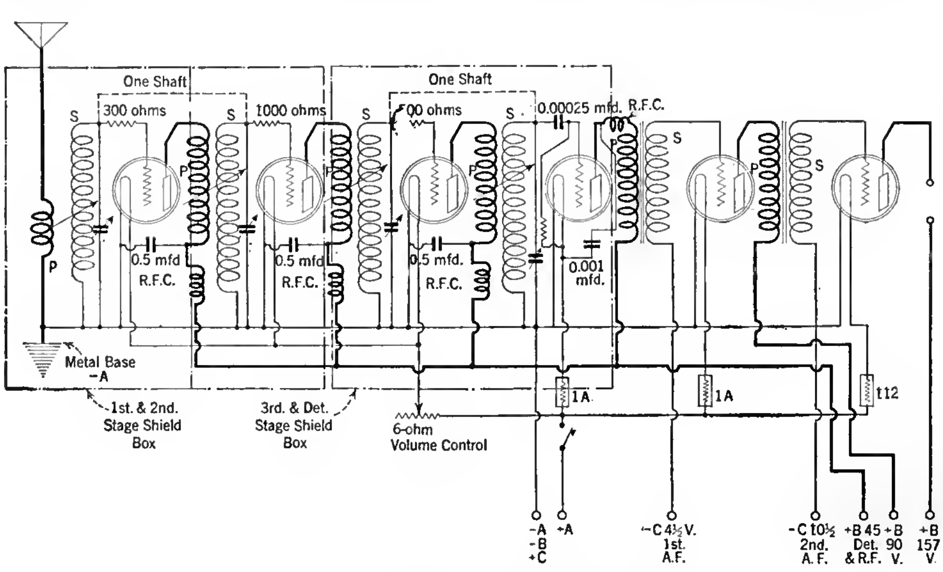


FIG. 4

From the detector grid to the loud speaker is a fixed circuit with constant audio amplification. The volume control, situated in the radio-frequency amplifier circuit, permits regulation of its overall amplification so that the correct amount of signal can be fed to the detector grid to produce a volume of signal from the loud speaker which is satisfactory to the listener. The control, a filament rheostat which regulates the voltage applied to the first three radio-frequency amplifier tube filaments, prevents the overloading of the detector, especially during reception from powerful local stations. Two stages of audio frequency amplification are employed, good tone of signals being maintained by the use of high-quality audio-frequency transformers. To secure perfect amplification it is necessary that the advantageous results to be obtained by the use of expensive transformers be not offset by the unintelligent use of tubes in the audio amplifier. In the last or power audio stage either a UX-112 (CX-112) or UX-171 (CX-371) type of tube should be employed with the correct B and C batteries.

From the accompanying photographs of the new "Hi-Q" Six receiver, it will be noted that directly behind the panel there are two metal boxes located at either end, between which is a central space in which is located the drum dials controlling the several tuning condensers. The left-hand box shield is divided into two compartments housing the first and second radio-frequency amplifier stages with their associated chokes and bypass condensers. In the right-hand box shield, also divided by means of a central wall, are located the third radio-frequency amplifier and the detector stages. The two tuning condensers in each of these box shields are located on common shafts which terminate at the central space in the drum dials. These dials are insulated from the shafts by means of insulated coupling units. The following parts are used in building the "Hi-Q" Six:

1—Samson Symphonic Transformer	$10.00
1—Samson Type HW-A3 Transformer (3-1 Ratio)	5.00
4—Hammarlund 0.0005-Mfd. Midline Condensers	22.00
4—Hammarlund "Hi-Q" Six Auto-Couple Coils	12.00
4—Hammarlund Type RFC-85 Radio-Frequency Chokes	8.00
1—Hammarlund Illuminated Drum Dial	6.00
1—Sangamo 0.00025-Mfd. Mica Fixed Condenser	.40
1—Sangamo 0.001-Mfd. Mica Fixed Condenser	.50
1—Pr. of Sangamo Grid Leak Clips	.10
1—Carter IR-6 "Imp" Rheostat, 6 Ohms	1.00
1—Carter "Imp" Battery Switch	.75
1—Durham Metallized Resistor, 2 Megohms	.50
3—Parvolt 0.5-Mfd. Series A Condenser	3.00
6—Benjamin No. 9040 Sockets	4.50
3—Eby Engraved Binding Posts	.45
2—Amperites No. 1-A	2.20
1—Amperite No. 112	1.10
1—Yaxley No. 660 Cable Connector and Cable	3.00
1—Hammarlund-Roberts "Hi-Q" Six Foundation Unit (containing drilled and engraved Westinghouse Bakelite Micarta panel, completely finished Van Doorn steel chassis, four complete heavy aluminum shields extension shafts, screws, cams, rocker arms, wire, nuts and all special hardware, required to complete receiver)	15.90
Total	$96.00

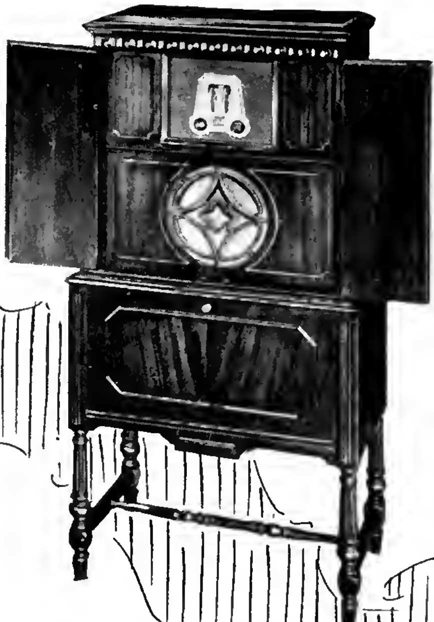


CIRCUIT DIAGRAM OF THE "HI-Q" SIX

The work of the artist and interior decorator—as well as the labors of the radio engineer—are evident in 1927–28 radio receivers. This Splitdorf "Abbey" set, designed by Noel S. Dunbar after an old-world jewel case is a six-tube receiver, priced at $100. This page and those which follow strikingly demonstrate how the manufacturer is successfully harmonizing technical receiver design with the decorative demands of the home. Modern receivers are not one-year investments because the receiver bought to-day will be up-to-date for some time to come; for this, the engineer is responsible and in later issues of this magazine we shall report much of his fascinating work.

1928 Radio Receivers

OFTEN it is said that a radio receiver, to be fully appreciated by the feminine half of the domestic republic, must be encased in housings which are esthetically as well as technically satisfactory. It is natural and right that, as radio has become more an accepted part of the equipment of every home, women have had an increasing voice in the selection of the radio receiver. What, then, do the radio manufacturers offer to the prospective purchaser? To be brief, the radio receiver of 1927-28 is a thing of beauty as well as of utility. On these two pages, and on others in this issue, are grouped illustrations of the sets which have come from the manufacturers' designing laboratories. Various makers have grappled with the important problem of appearance, and, as these illustrations show, have met it in widely different



FRESHMAN G-4

Here is a new electrically operated Freshman receiver, complete and ready to operate as delivered. The price is $225.00, which includes new RCA a. c. tubes

THE STEWART-WARNER 520

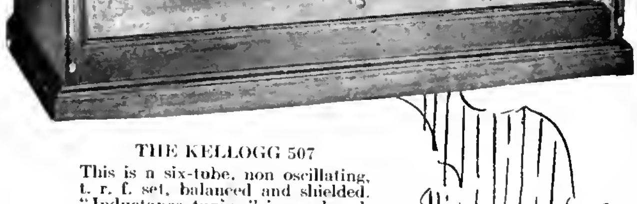
The tendency towards single-control is again manifest in this six-tube receiver. Two tuned and one untuned stages of r. f., detector, and two transformer-coupled audio stages, comprise the circuit. The cabinet is of dull polished walnut veneer. The price, $125.00

BOSCH 66

Another single-control receiver employing six tubes, this one being priced under a hundred dollars. The beauty of the cabinet is a feature but the efficiency of the circuit itself has in no way been neglected. The illuminated dial is graduated into both kilocycles and arbitrary numbers

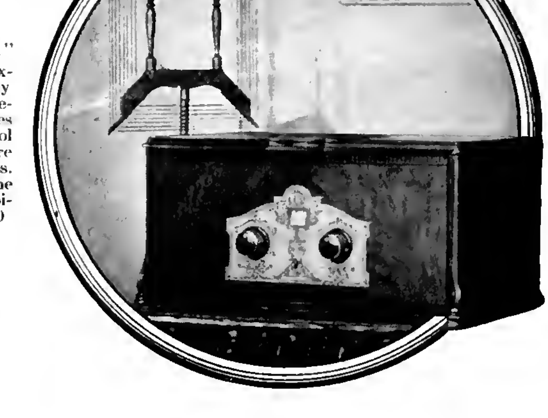
GREBE'S "SYNCHROPHASE" SEVEN

The five tuned stages (four r. f. and detector) are tuned by means of a single dial and vernier, the rigidity of the tuning condenser assembly insuring permanency of the accurate factory adjustment. The receiver has been carefully shielded, while the special coils employed enhance the selectivity and permit maximum amplification. These coils are of the binocular type and are wound with Litz wire



THE KELLOGG 507

This is a six-tube, non oscillating, t. r. f. set, balanced and shielded. "Inductance tuning" is employed, a system which requires no variable condensers and which permits equal amplification throughout the frequency spectrum covered. The price of the receiver is $190.00

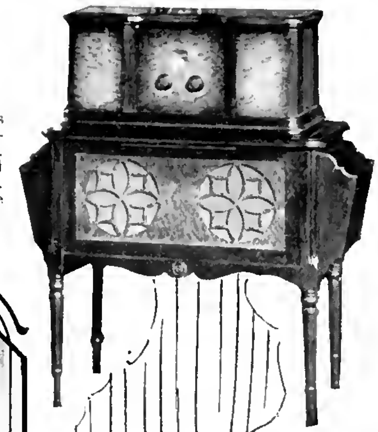


"COMMANDER"

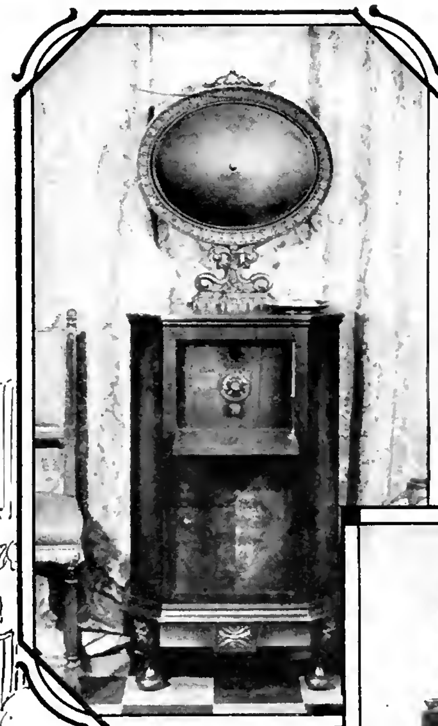
Here is a King six-tube completely shielded t. r. f. receiver which makes use of single control tuning. There are three r. f. stages. The loop may be folded into the cabinet. Price $220.00

# of Beauty and Utility

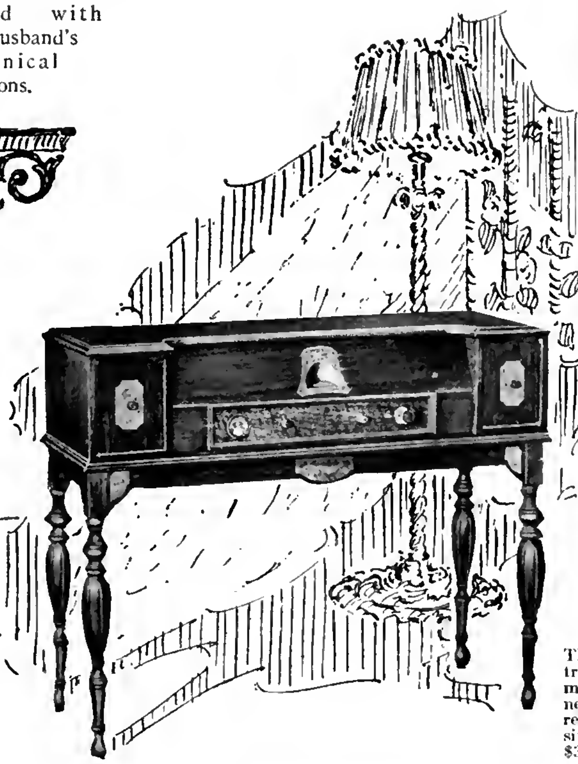
ways. Some of these models achieve their decorative effect through the dignity of utter simplicity; others are notable for the use of ornament in the treatment of the control elements. The metal tuning and control escutcheon is supplied with some decoration, slightly reminiscent of that simplicity to be found in the grouping of instruments on present day automobile dashboards. Illumination of the control escutcheon is also a feature which has much in common with the instrument panel on the modern motor car. From the representative models shown on these pages, the housewife can gain an excellent idea of the appearance of moderate priced radio receivers which are offered to suit her taste as well as that of her husband. Her ideas of the necessary limitations of her domestic decorative scheme should blend with her husband's technical opinions.



WORKRITE
This eight-tube receiver has all-metal chassis, and complete copper shielding. There is a single illuminated drum type dial control. Price, $160.00 without table



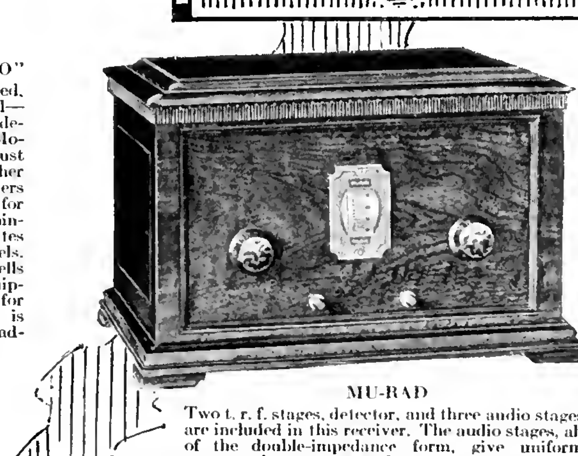
THE "WARWICK"
In a cabinet of Tudor period. A six-tube Splitdorf receiver, similar to that shown on page 351, is built in. Price, $275.00 with cone and power-supply unit



ZENITH
The Model 17E electric. A single-tube 400-mA. unit supplies the necessary power. The receiver itself employs six tubes. The price is $350.00. Spinet base, $20.00 extra

BELOW
The Kolster 6H consists of a six-tube receiver power cone reproducer, and B socket power unit. Space is provided for either an A socket power device or a storage battery, which is extra. Price, $265.00

THE "NAVAJO"
Six tubes, shielded, single-control—these words describe this new Mohawk receiver just as they do other prominent receivers of the season, for this circuit combination predominates in 1928 models. The "Navajo" sells for $67.50. Equipment to adapt it for a. c. operation is obtainable at additional cost



MU-RAD
Two t. r. f. stages, detector, and three audio stages are included in this receiver. The audio stages, all of the double-impedance form, give uniform response between 30 and 5000 cycles, according to the manufacturers. Single-control tuning is featured. Price $98.00. In a console, equipped for complete a. c. operation, the receiver sells for $265

THE 'BANDBOX'
This is a recent presentation of the Crosley Corporation. It is a six-tube neutrodyne made in two models, for battery or lamp-socket operation, is shielded, and has one-dial tuning. The prices are $55 and $65, for battery and a. c. operation respectively

The Neutrodyne Group

A LOOP NEUTRODYNE
It is a Freed-Eisemann eight-tube single-control receiver, retailing for $395.00 with a cone loud speaker, as illustrated

THE RADIO-PHONOGRAPH
This Stromberg-Carlson masterpiece consists of a complete a. c. operated seven-tube single tuning control receiver combined with a modern electric phonograph. A concealed loop obviates the use of outdoor antenna. Price is $1245 completely equipped with cone loud speaker

FADA
Three r. f. stages, two tuning controls, one-piece steel chassis, and equalized amplification, are features of the Fada "Special," retailing at $95.00

TO THE lay radio reader the term "Neutrodyne" means a type of receiver only—a well-known type of long standing merit. To the engineer the term signifies much more. It recalls the researches of Professor Louis Hazeltine of Stevens Institute of Technology; it brings the patent office to his mind; it indicates one of the present group of radio set manufacturers who have availed themselves of Professor Hazeltine's inventions.

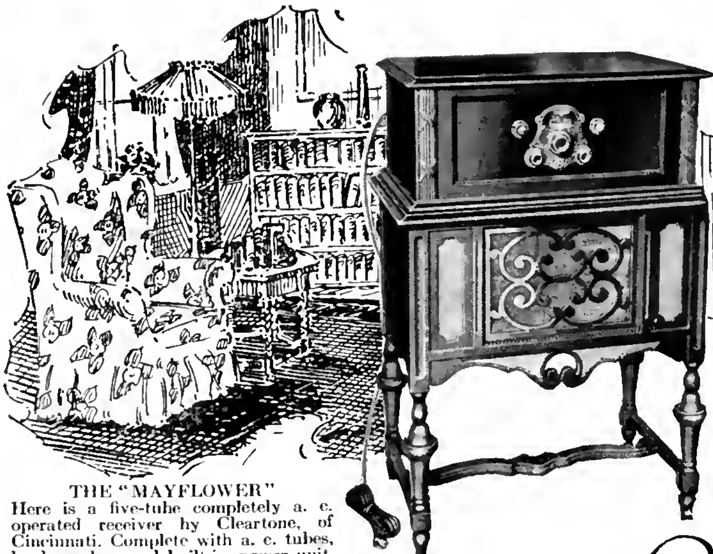
FOR THE "BANDBOX"
This console has been specially designed for the Crosley "Bandbox," illustrated on the left-hand page. The "Bandbox," the chassis of which is completely shielded, may quickly be removed from its metal cabinet and inserted in the more pretentious console

For four years, the neutrodyne group, now consisting of Amrad, Fada, Freed-Eisemann, Crosley, Murdock, Workrite, Gilfillan, Howard, Garod, and Stromberg-Carlson have built receivers that were representative of the best work of the best engineers. These receivers have become known for their reliability, their sensitivity, simplicity, and generally excellent service. They need no introduction to the American radio public. Of late, those who read the foreign radio press have noted the large number of times the French, English, Spanish, and German papers have described the neutrodyne, indicating that Europe is following advances in American radio with great interest.

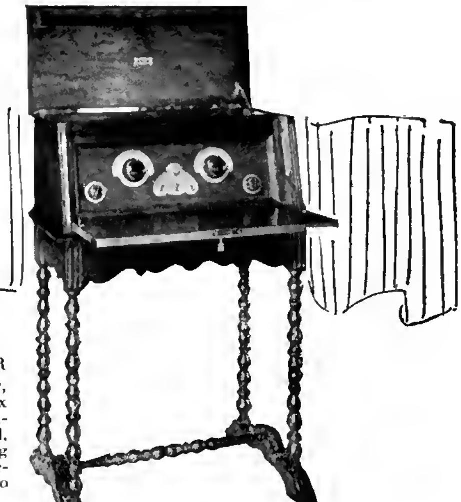
THE FADA 7
It is optional whether loop or antenna is used with this receiver, which has four stages of r. f. An improvement in the detector circuit reduces the possibilities of overloading. This seven-tube receiver sells for $185.00

For the coming radio season, the neutrodyne group has been more than busy, as the accompanying photographs will show. In common with other well organized receiver manufacturers, the group has spent money and time in research for better radio components, for even greater simplicity of operation, and for greater fidelity of reproduction. A glance will show cabinet work that cannot help but amuse those who remember the early days of radio, when a conglomeration of wires and roughly assembled apparatus, frequently boasting no kind of housing whatever, was principally useful in collecting dust.

AMRAD'S "THE WINDSOR"
This artistic cabinet houses a very efficient seven-tube neutrodyne chassis. Tuning is accomplished by a single dial and a further adjustment is provided for volume control. Either an antenna or loop may be used and all parts are copper shielded. A tone filter is incorporated. The price is $195



THE "MAYFLOWER"
Here is a five-tube completely a. c. operated receiver by Cleartone, of Cincinnati. Complete with a. c. tubes, loud speaker, and built-in power unit, the "Mayflower" lists at $250.00



A MARTI RECEIVER
Another electric receiver, this one employing six tubes, three of which constitute the audio channel, resistance coupling being featured. Tuning is accomplished by means of two dials

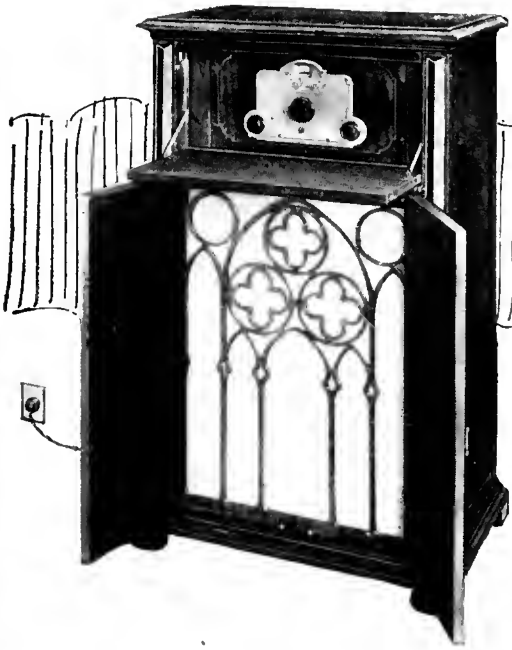
Servants of Your Light Socket

The Radio Receiver Powered Directly from the Light Socket is like the Automobile with a Self-Starter Pushing the Button Starts the Machine- -Models on This Page are Representative of the Season's A. C. Set Offerings.

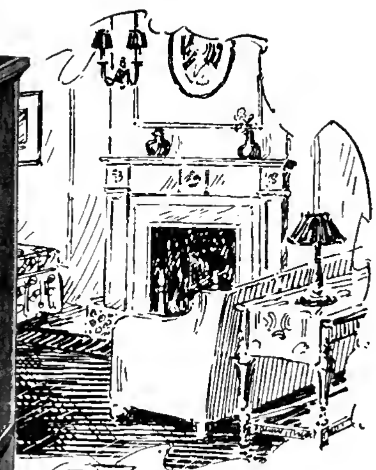
TO THE LEFT
The well-known Loftio-White circuit, six tubes, is employed in the Arborphone Model 253 receiver. Tuning is accomplished by means of a single dial calibrated in wavelengths. A Peerless cone loud speaker is included, and the receiver may be used with either batteries or socket-power devices. The cabinet is of matched walnut, curly maple and rosewood veneers, and gumwood. Price, $250.00

A NEW DEPARTURE IN POWER SUPPLY
The Day-Fan Electric Company, of Dayton, Ohio, has placed on the market receivers which are powered by motor generators, all batteries being eliminated. The efficiency of the motor generator principle of transforming alternating current to direct current has loog been recognized, but its application tc the powering of a radio receiver has hitherto been neglected, so far as receivers commercially available are concerned

AN ECONOMICAL A. C. RECEIVER
The manufacturers of this receiver, the Argus Radio Corporation, of New York City, state that the cost of operating this receiver is no more than one fifth of a cent per hour. The receiver is completely a. c. operated, and employs no batteries or chargers. There are six tubes in all, three of which are r. f. in a combination of tuned and untuned stages. The final audio stage employs a 210 type tube, a plate potential of 400 volts being applied to it. Provision is made so that the audio amplifier may be used in conjunction with a phonograph pick-up device. Price $195.00, less tubes and loud speaker

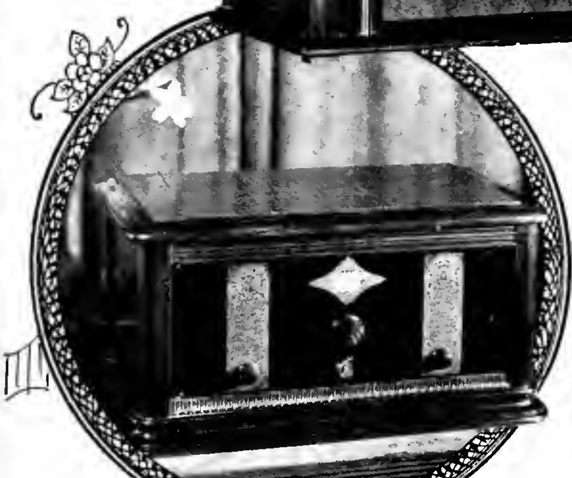


LEFT
This is a Freed-Eisemann electrically operated receiver, listing at $295.00. A neutrodyne circuit is used, and extraordinary selectivity is claimed by the manufacturers



AN ALL-AMERICAN HIBOY
The receiver employs six tubes, and may be obtained either to use the new a. c. tubes or for ordinary tubes, batteries or power units being required in the latter case

SPARTON MODEL 62
Everything, with the exception of the loud speaker, is self-contained in this new electric receiver by Sparks-Withington. No batteries are required. The price, $188.00



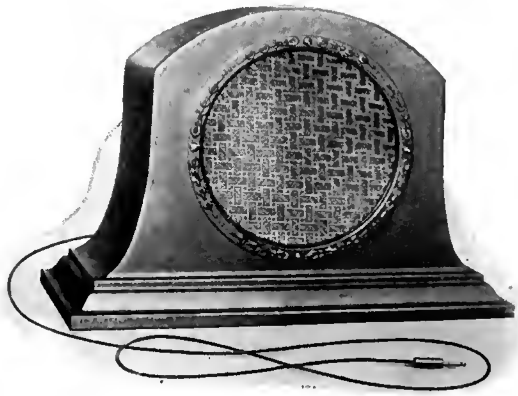
BUCKINGHAM
Here is a receiver which may be used with either batteries or power units. It employs six tubes, three of which are r. f. stages. The single-dial control system employed is a special Buckingham patent. The dial is illuminated and calibrated in both kilocycles and degrees

THE CASE CONSOLE
An enclosed loop, controlled from the front panel, obviates the necessity for an outdoor antenna. The receiver employs nine tubes and tuning is accomplished by means of a single dial. It is equipped with a Newcombe-Hawley loud speaker, which has an air column of seventy-two inches. The price of the console is $350.00, less accessories. The receiver is also obtainable for use with a. c. tubes, in which case the list price is $475.00 complete with tubes and ready to operate

ELKAY "SENIOR"
Complete a. c. operation with every necessary piece of equipment built in, unified tuning control, "Truphonic" audio amplification, total copper shielding, six tubes—thus can this new Elkay receiver be described. The list price is $195.00. Six McCullough a. c. tubes, and one Raytheon BH rectifier, are required as extras

TO THE LEFT
The electric receiver drawer of McMillan, Chicago. This drawer forms the nucleus of several attractive receivers by McMillan, ranging in price from $260.00 to $325.00. A table cabinet model lists at $170.00

THE NEW RADIOLA 17
A receiver which makes use of the new a. c. tubes in the first five stages and a 171 type tube in the final (second) audio stage. The receiver may therefore be supplied with A power from the house lighting circuit without the use of additional equipment. B and C batteries are also eliminated by the use of a suitable power device which is built in. Price $130.00



A NEW CONE
The new 100-A cone loud speaker priced at $35.00

Radiolas

THE super-heterodyne and the tuned radio-frequency circuit, with or without regenerative action, continue as the foundations of the 1927-28 line of receivers offered by the Radio Corporation of America. A parchment cone, with properly balanced drive for the moderate power of the battery set or again the high power of the socket-power set, likewise continues as the basis of the Radiola loud speaker offerings. Alternating-current operation, with certain refinements particularly by way of rectifier tubes of increased output and better voltage regulation, makes a bid for favor in the higher priced combinations. The Radio Corporation has also added the new a. c. tubes as a means of electrifying even the moderate-priced Radiolas, the UX-227 heater type for the detector socket and the rugged filament UX-226 for all other positions.

Starting out with the requirements of the modest home, there is the new Radiola 16, which fulfills the most rigid requirements of sensitivity, selectivity, ample volume, simplified operation, and excellent tone quality when used in combination with the new Radiola 100-A loud speaker. The Radiola 16 is a new uni-control six-tube receiver, embodying the well-known and perfected tuned radio-frequency circuit with three stages of radio-frequency amplification, a detector, and two stages of audio-frequency amplification, and utilizing five UX-201-A and one UX-112 tubes. The power tube in the last stage spells ample volume without possibility of distortion due to overloading. The internal construction of this Radiola is extremely rugged. The operation is reduced to one tuning control which can be logged for the station call letters. There is also a volume control, and a filament switch which starts and stops the reception of programs. To simplify the operation still further, the filament rheostats have been dispensed with. Radiola 16 may be operated from batteries or from a socket-power device. The cabinet of this receiver is of mahogany finish, and measures $16\frac{1}{2}''$ long, $8\frac{1}{4}''$ high, and $7\frac{1}{2}''$ deep. The weight is $14\frac{1}{2}$ pounds, and the price, $69.50 less accessories.

Next comes the Radiola 17, aimed to produce, for a moderate price, a receiver completely operated from the a. c. house lighting mains. Simplicity of operation and maintenance are the main features of Radiola 17. It has three stages of radio-frequency amplification, a detector, and two stages of audio-frequency amplification. The new UX-226 a. c. tubes are used in the radio-frequency stages and in the first audio-frequency stage, while the new UY-227 a. c. tube is used as a detector. The last audio-frequency stage employs a 171 power tube. The B and C voltages are obtained from a power supply unit built into the set and employing the new high-power UX-280 full-wave rectifier. There are only three controls on this set, one knob for tuning, one for volume control—to regulate the output of the receiver, and a power control switch to turn the receiver on or off.

Inside this new Radiola 17 is located a switch whereby adjustment may be made for any variation in local line voltages between 105 to 125 volts. The size of the mahogany cabinet is $25\frac{5}{16}''$ long, $7\frac{7}{8}''$ deep, and $8\frac{1}{8}''$ high. The receiver weighs $36\frac{1}{2}$ pounds, and retails for $130.00 without accessories.

The well-known Radiola 20, with its two stages of radio-frequency amplification, its regenerative detector, and two stages of audio frequency, employing the economical UX-199 and UX-120 dry-cell

A CUSTOM-BUILT RADIO RECEIVER
The Radiola 32 combines the well-known RCA eight-tube super-heterodyne and a baffleboard loud speaker in a single cabinet. Since a loop, directionally variable, is built in this receiver, it may be used where facilities for outdoor antenna erection are not available although binding posts are provided for antenna and ground if such are used. All current is obtained by plugging into the house lighting supply. The model is obtainable for either a. c. or d. c. operation. Price $895.00 complete

SIX TUBES AND SINGLE CONTROL

The new $69.50 Radiola 16. This receiver, like the 17 illustrated atop the previous page, also employs three r. f. stages, detector, and two transformer-coupled audio stages, but the tubes are not of the a. c. type. The output audio tube is of the 112 type as opposed to the 171 in the Radiola 17. Tuning is accomplished by means of a single control knob, but there are also a volume-control knob and a filament switch

for 1928

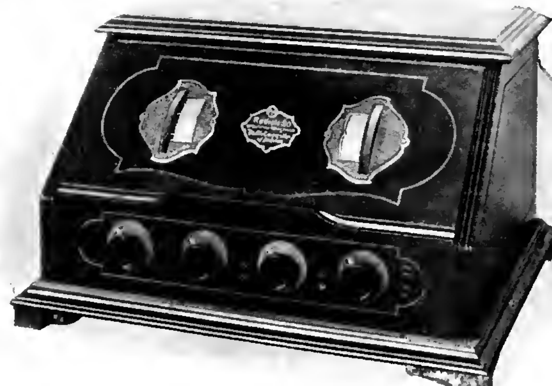
tubes, continues to occupy its place in the RCA line. This Radiola has proved a popular favorite, and for that reason it has been retained among the present offerings. It now lists for $78.00 less accessories. Likewise with Radiola 26, the six-tube portable super-heterodyne with its self-contained loop, loud speaker, and dry batteries, which has provided vacationists and travelers with satisfactory and convenient radio service, and which retails at $225.00 complete. Radiola 25, a six-tube super-heterodyne priced at $165.00 with tubes, is also being retained for 1928 offering.

Turning to the higher-priced offerings, there remain the well-known Radiola 28, or eight-tube super-heterodyne, and the Radiola 104 loud speaker, which, in combination, provide an exceptionally sensitive set which may be completely powered from the a. c. house lighting system. The price of the Radiola 28 is $260.00 with tubes. The 104 loud speaker units cost $275.00 or $310.00, for a.c. or d.c. operation respectively. Radiola 32, a newcomer to the Radio Corporation's line, with its handsome walnut grained cabinet in period design, consists of an eight-tube super-heterodyne, loop, Radiola 104 loud speaker, and is operated from the house lighting system. It provides maximum radio results in the most compact and attractive form. Certain refinements in design have permitted the inclusion of the powerful 104 loud speaker actually in the same cabinet as the super-heterodyne. The new 32 receiver has a self-contained loop which is turned by means of a knurled dial mounted near the loud speaker grille. Another feature is the small electric light bulb which is concealed in the top of the operating compartment to illuminate the dials and also to serve as a warning indicator when the current is turned on. The power is automatically switched off when the set is closed. The cabinet measures 52″ high, 72″ wide, and $17\frac{3}{4}$″ deep. The list price is $895.00, which is inclusive of all accessories.

A somewhat lower-priced model, but likewise characterized by a distinctive cabinet and entirely self-contained equipment, is the Radiola 30-A, comprising the eight-tube super-heterodyne with the new 100-A loud speaker and an arrangement whereby the set may be powered from the house lighting supply. The Radiola 30-A measures $42\frac{1}{2}$″ high, 29″ wide, and $17\frac{3}{4}$″ deep, and its list price is $495.00, including all the necessary accessories. Unlike the more expensive Radiola 32, no loop is contained in the cabinet of the 30-A, antenna and ground connections being provided on the rear. A short indoor antenna is recommended for use with this receiver.

Both of the latter, Radiolas, 32 and 30-A, may be had for alternating current or direct-current operation. Furthermore, the 104 loud speaker unit is now available in a direct-current model, as mentioned above.

The new Radiola 100-A loud speaker referred to above is the improved loud speaker for use with all receivers, whether they are operating on batteries or with socket-power equipment. The cone itself is of smaller diameter than the well-known 100 type, which it replaces and, in addition, embodies a newly designed drive that provides increased response with even better tone quality than its predecessor. The cone is enclosed in an attractive metal case, suggestive of a mantelpiece clock, with silk screen bezel, the whole being finished in dull bronze. This new cone loud speaker measures approximately 15″ x 11″ and retails for $35.



THE RADIOLA 20

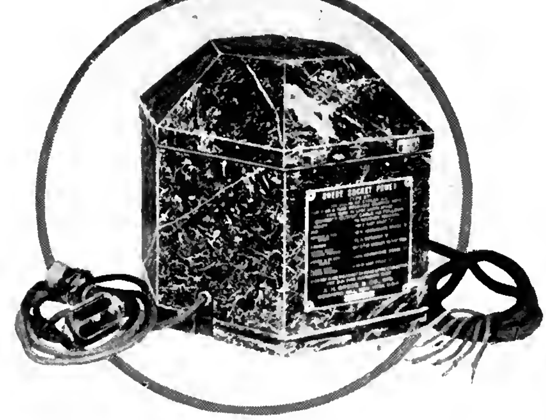
This is not a new season's model but it has been carried over on account of its popularity. It is a five-tube t. r. f. receiver with knurled-dial tuning. Its price is $78.00 and it may readily be adapted for a. c. operation

RADIOLA 30-A

The circuit employed in this new receiver is identically the same as that of the "Radiola" 36, *i. e.*, an eight-tube super-heterodyne and it is operated from the light socket. The 30-A retails for considerably less than the 32, however, its list price being $495.00 complete. The differentiating features of the less expensive model are: (1) The 100-A cone is employed instead of the more powerful and more expensive baffleboard loud speaker, and (2) no loop is supplied. Antenna and ground connections are provided, and for average reception an ordinary indoor antenna will be satisfactory

A POWER CONE REPRODUCER

In addition to the cone loud speaker, this Kolster power assembly comprises a B power device to furnish the necessary voltages to operate any commercial receiver. It is operated from the 60-cycle 110-volt a. c. house supply. The price is $150.00 without tubes. Two rectifier tubes (CX-316-B or UX-216-B), a regulator tube, and a power tube (CX-310 or UX-210), are necessary

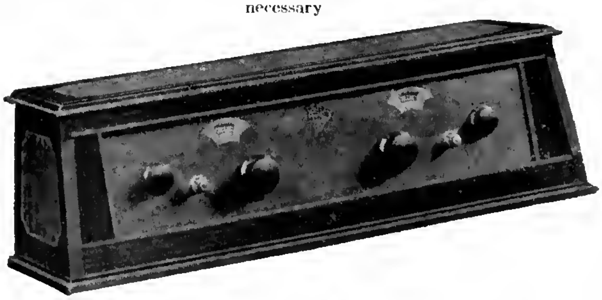


FOR B AND C VOLTAGES

Grebe offers an attractive socket power unit for radio receiving sets of from five to seven tubes. There are three B taps, 180, 90, and 22 volts, and two C values, 40 and 4 volts. Special design features have been applied to obviate "motor boating"

Some New Offerings for

Loud Speakers, Cabinets and Accessories offered by Various Makers Show Definite New Trends—



VALLEYTONE MODEL 52

A five-tube receiver to suit the average pocket, its list price being $85.00, less accessories. Tuning is accomplished by means of two dials. A simple switching arrangement built into the set makes the use of a power tube optional

LEFT

The "Spinet," a seven-tube balanced receiver by Colin B. Kennedy, Incorporated. There are four r. f. stages but just one tuning control. The finish is of two-tone antique mahogany, and there is ample storage space for power accessories. Price, $195.00

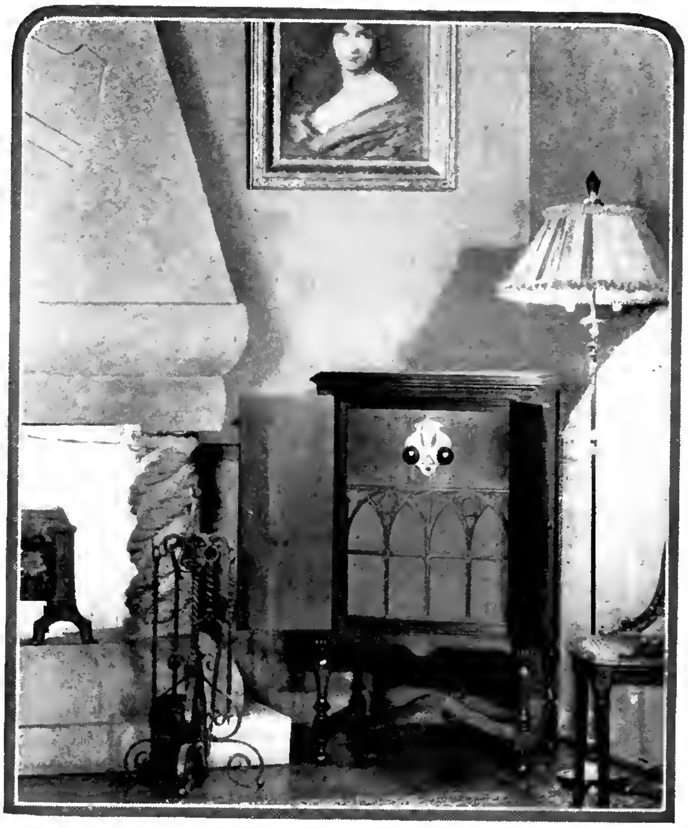
FOR THE SET CONSTRUCTOR

Keeping apace with the commercial set manufacturer, the home constructor nowadays builds his receiver into a luxurious piece of furniture. This beautiful walnut cabinet has a sliding frame for a radio panel not larger than 8 ⅜" x 21", and 14" deep behind panel. The list price varies from $80.00 for the straight cabinet to $105.00 to include a Peerless cone. It is a product of the Radio Master Corporation, Bay City, Michigan

THE BOSCH "NOBATTRY"
This attractive unit is designed to deliver three B voltages, the taps being labelled "low," "medium," and "high." The list price of the device is $18.00. Taps on the transformer provide for three separate voltage ranges

the 1928 Radio Season

All, while Serviceable and of Interesting Technical Design Are Made to Harmonize with Their Eventual Setting—the Home.



THE "MINSTREL"
A successful antenna operated receiver is this seven-tube, single-control, Apex set. The circuit employed is of the "Technidyne" variety, one that has become increasingly popular lately, and which makes use of a new form of neutralization. Less accessories, the "Minstrel" lists for $225.00

DESIGNED FOR A RADIO SET
Here is another example of the cabinet makers' efforts to produce a radio cabinet which is in every respect equally as beautiful as the furniture surrounding it. The finish of this particular cabinet is in walnut and maple, and it is equipped with a Farrand cone loud speaker. It is designed to accommodate all standard makes of radio receivers, and is a product of the Musical Products Distributing Company, New York City. Price, $95.00

ABOVE
This is the Pfanstiehl Model 30 six-tube receiver. Its chassis is carefully shielded and equipped with flexible cable connections. Price, $105.00

RIGHT
The "Baby Grand," by Audiola, Chicago, comes with either an eight-tube or six-tube chassis, the former listing at $275.00 and the latter at $225.00. There are two knobs on each model, one for tuning, and the second for volume control. Individual stage shielding adds to the general efficiency of the set. A special long air-column loud speaker is built in

B POWER

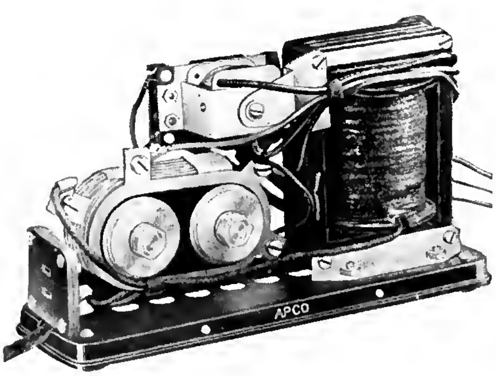
The Kellogg B power unit has the usual three taps, for "detector," "medium," and "high," but additional flexibility is obtainable by means of the knobs on the front panel. The detector voltage may be adjusted to any value up to 45, while the medium voltage tap may be set for anything up to 90 volts. The high-voltage tap is for a 171 type tube. Forty dollars is the price of the unit

AN ELLIPTICAL CONE

The frame and base of this new Splitdorf cone is of rich antique walnut finish, deeply carved, the result being a loud speaker which will enhance almost any setting. The elliptical shape of the cone makes possible deep richly resonant tones, the short diameter of the ellipse favoring the high notes, and the long diameter sustaining the deep tones. A combination of design features enables the loud speaker to handle great power. The list price is $35.00

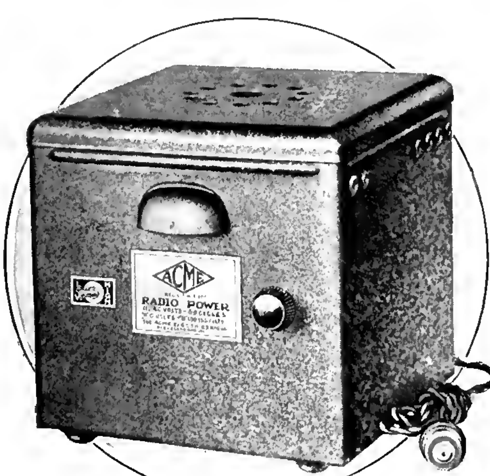
A UNIT THAT SUPPLIES BOTH A AND B CURRENT

Unlike many other units designed to supply both A and B current, this one does not use a storage battery in conjunction with a trickle charger. A rectifier and electrolytic filter condenser, combined in one cell, constitute the A unit. There are no tubes to burn out, the only attention necessary being the addition of water every three or four months. This Balkite "AB" is obtainable in two patterns, both with an output of 6 volts, 2 amperes, for the A supply, but one has a B output of 40 mA., 135 volts, while the second gives 55 mA., 180 volts. The prices are $59.50 and $67.50 respectively



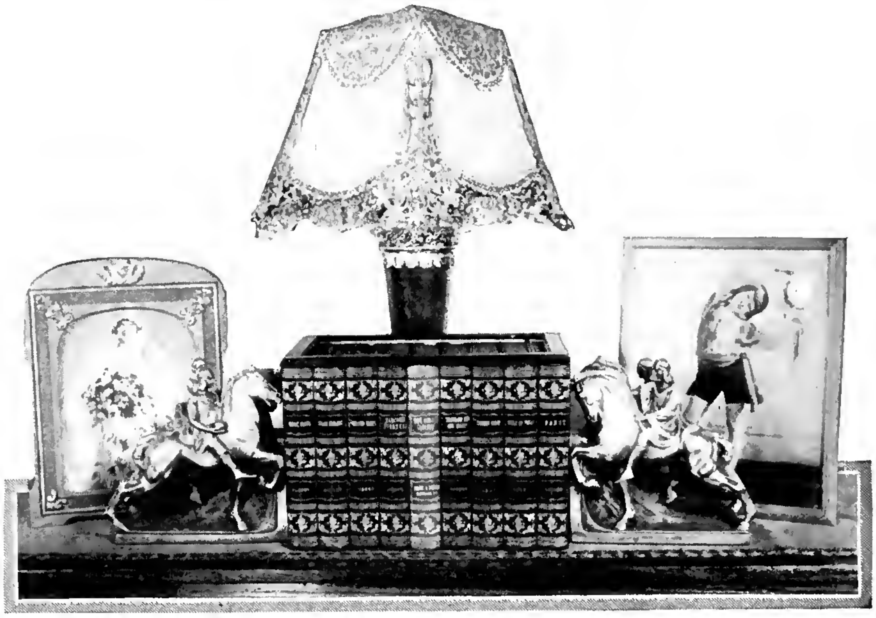
AN AUTOMATIC CHARGER

A charging unit developed by the Westinghouse Company is incorporated in this useful Apco device. Full-wave rectification is accomplished by means of a series of special analysis copper discs in the transformer circuit. An automatic relay is combined with the Westinghouse unit so that, once connected to the set, the charger is spontaneously set in operation when the receiver is not being used. The list price of this Apco unit is $16.50



A AND B POWER FROM ONE UNIT

Acme, of Cleveland, is responsible for this useful power combination. Included in the unit is a B socket-power device, a 40 ampere-hour storage battery, trickle charger, and automatic control switch. The unit may be obtained for 25- or 60-cycle house supply, and for sets with varying amounts of tubes, the prices being between $95.00 and $108.50



THREE LOUD SPEAKERS IN DISGUISE

The group of books, in the first place, is nothing less than a loud speaker in concealment. A forty-inch serpentine tone chamber winds behind the embossed leather book bindings. This "Choral Cabinet" lists at $50.00, or $75.00 if the equestrienne bronzes are included. The lamp too, in addition to serving its obvious purpose, hides an air-column loud speaker. Depending upon the finish, it lists at $35, $50.00, or $60.00. The carved picture frame to the left also conceals a loud speaker, the tone chamber of which is a thirty-inch serpentine winding. The hand carved black walnut model lists at $35.00, but other models are less expensive—even as low as $20.00. Manufactured by Frank R. Porter, Washington, District of Columbia

A New Regulator Tube

Why It Is Desirable to Employ a Regulator Tube in B Devices—Details of a New Glow Tube Which Involves Some Novel Features

THE voltage-regulator tube received its rather descriptive nickname, "glow tube," from the performance of some of the early models which, having an open top cathode, permitted an observer to see the ionized gas or "glow" in the space between the anode and cathode.

This tube is a device which, when connected across the 90-volt output of a B power-supply unit, will maintain that voltage at a constant value, regardless of any variations in load, within reasonable limits, applied to the power unit. Without the use of such a regulator, the voltage supplied by the device will fall off rapidly as the current drain is increased.

By using a regulator tube, it is possible to construct a B power unit, the 90-volt tap of which will, for all practical purposes, deliver just 90 volts to any radio receiver whether it has 3 or 10 tubes. In the case of the majority of radio receivers the 90-volt tap supplies the B power for the radio-frequency and first audio stages. In the case of a super-heterodyne, however, the 90-volt tap will also have to supply the B power for the intermediate-frequency amplifier. Incidentally, as the load drawn by the detector tube, in most sets, is substantially the same, a suitable resistor with mid-tap may be connected across the voltage regulator tube terminals to provide a fixed 45-volt tap. Now, it also happens that, when the regulator tube is used, variations in load on the 90- and 45-volt taps will have no effect upon the maximum voltage tap of the power unit. The voltage at this point will, however, vary with the load at the high-voltage tap; but as we know that the usual load to be applied to the high-voltage tap is a UX-171 or CX-371 type power tube, and that at 180 volts this tube will draw a plate current of 20 mA., we can so design our power unit to supply exactly 20 mA. at 180 volts.

The result is a fixed-voltage power device which will supply 45, 90, and 180 volts to almost any standard radio receiver. Fixed-voltage control, however, is but one of the many points of merit of a "glow-tube" equipped power-supply unit.

The action of the tube in holding the voltage of the output circuit constant serves also to eliminate the small ripples which may be present as a result of incomplete filtering, and thus makes possible a reduction in the capacity, and therefore the expense, of the final filter condenser. In fact, the tube, when in operation, has many properties in common with a large fixed condenser. One of these properties is extremely low a.c. impedance which, when combined with its instantaneous response as a voltage regulator, entirely eliminates the annoying "motor-boating" effect which generally results when an attempt is made to use one of the ordinary B power units with many forms of amplifiers.

A further advantage accruing from the construction of a B power unit employing a voltage regulator tube is an economical one. With its many electrical advantages, it need cost no more than that of a high-grade power unit of the conventional type. In the first place, the use of the "glow tube" results in a saving of the number of high-voltage filter condensers required—usually an expensive item. In the second place, it permits the use of fewer and lower voltage—and thus less expensive—bypass condensers at the various voltage taps.

RADIO BROADCAST Photograph

INNER CONSTRUCTION

The bulb has been removed to show the electrodes of the "R" tube

By JAMES MILLEN

The first type of voltage regulator tube to appear on the market was of the two-element type and, like the prototype of most things, had its disadvantages. Different tubes varied considerably in characteristics, some having a working voltage of as low as 70, while others had over 100. Then, the voltage across individual tubes would vary quite a bit between conditions of no load and full load. Another fault was that, should the power unit be heavily loaded for any reason, the tube would cease to glow and, before again becoming operative, the voltage across it would have to rise to a rather high value, which eliminated the possibility of partially providing for the initial cost of the tube by the use of low-voltage bypass condensers.

But perhaps the most serious objection to former voltage regulator tubes was the tendency of many of them to oscillate and introduce noise into the output circuit of the power unit. The use of a power unit equipped with such a tube would often introduce sufficient noise into the loud speaker to interfere with satisfactory reception. But now, after several years of research and experimental work, a new form of voltage regulator has been perfected.

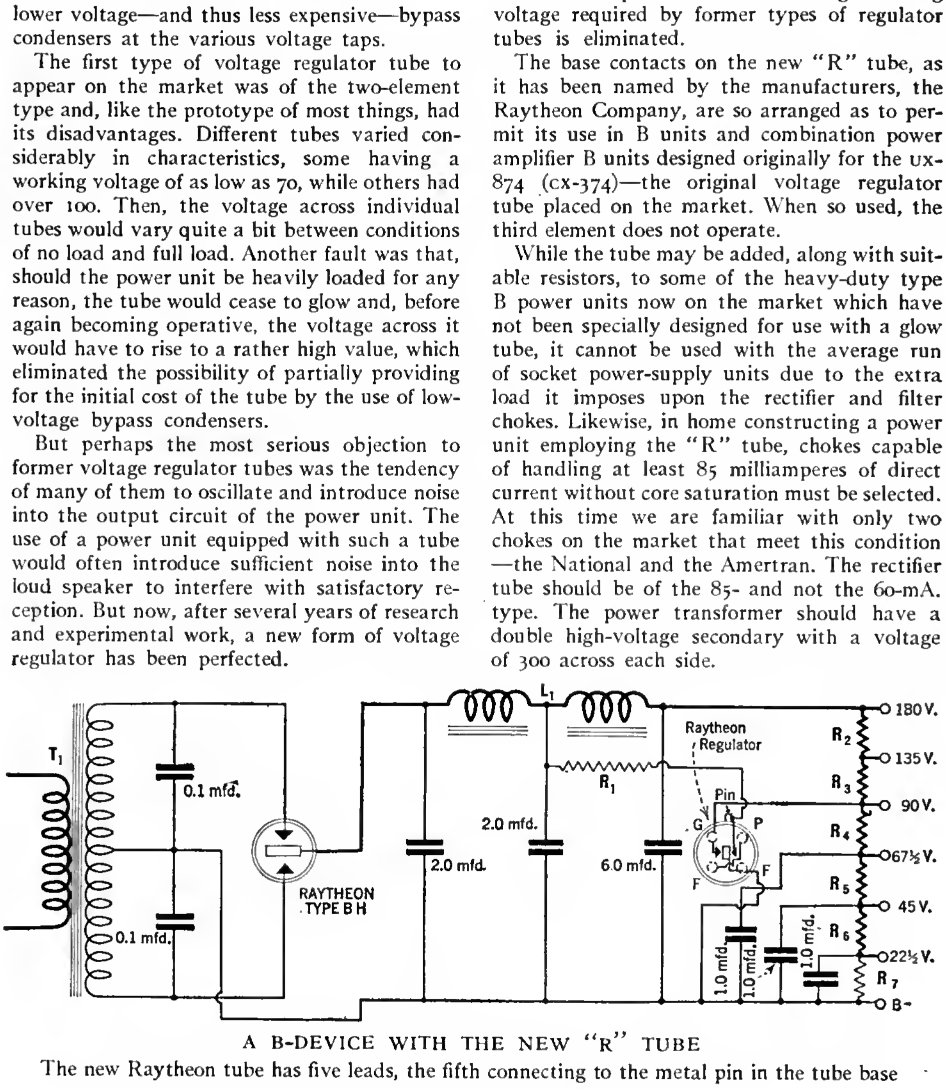
Its small size and low cost permit its ready use in many cases where the older form of tube was out of the question. Its silent non-oscillating operation, its long life, its close control of voltage (a variation of but 3 volts between a condition of no load and full load being allowed), and the use of a third or "keep-alive" element, are all features which make it one of the most interesting developments in the B power-supply field since the introduction of the filamentless full-wave gaseous conduction rectifiers.

The "keep alive" circuit is a most unique arrangement of what really amounts to a tube within a tube. The inner, or secondary tube, operates without load from a high-voltage point of the filter circuit and keeps the gas within the glass tube ionized at all times. Thus, should the voltage across the operating electrodes at any time fall below the value required to maintain the gas in an ionized state, the potential of the third element will be sufficient to maintain ionization. In order to minimize the extra drain on the rectifier and filter, a forty-thousand ohm resistor is employed to limit this parasitic current to approximately three milliamperes.

As a result of the third element and its associated "keep alive" circuit, the high starting voltage required by former types of regulator tubes is eliminated.

The base contacts on the new "R" tube, as it has been named by the manufacturers, the Raytheon Company, are so arranged as to permit its use in B units and combination power amplifier B units designed originally for the UX-874 (CX-374)—the original voltage regulator tube placed on the market. When so used, the third element does not operate.

While the tube may be added, along with suitable resistors, to some of the heavy-duty type B power units now on the market which have not been specially designed for use with a glow tube, it cannot be used with the average run of socket power-supply units due to the extra load it imposes upon the rectifier and filter chokes. Likewise, in home constructing a power unit employing the "R" tube, chokes capable of handling at least 85 milliamperes of direct current without core saturation must be selected. At this time we are familiar with only two chokes on the market that meet this condition—the National and the Amertran. The rectifier tube should be of the 85- and not the 60-mA. type. The power transformer should have a double high-voltage secondary with a voltage of 300 across each side.



A B-DEVICE WITH THE NEW "R" TUBE

The new Raytheon tube has five leads, the fifth connecting to the metal pin in the tube base

The 1928 "Equamatic" Receiver

RADIO BROADCAST Photograph

A SYMMETRICAL FRONT PANEL REWARDS THE CONSTRUCTOR OF THE 1928 "EQUAMATIC" RECEIVER

Automatic Variation of Coupling between Primaries and Secondaries of Coil Units Provides for Equal Amplification Throughout Broadcasting Band—Simplicity of Control Is Marked Improvement over Earlier Model

By JULIAN KAY

ONE of the most difficult disadvantages to overcome in amplifying high frequencies by means of successive tuned stages is the apparent discrimination of the amplifier against the lower radio frequencies. The longer-wave stations on the average tuned r.f. set come in comparatively poorly, while there is no end of amplification on the shorter-wave stations. Any one who has operated one of these sets will vouch for this fact, and any service man who must answer questions from his clients will agree that his main difficulty is in explaining why such-and-such a set will not get KSD or KYW, longer-wave stations, while it will get less powerful and often more distant shorter wavelength stations.

The Facts About This Receiver

Type of Circuit	Tuned radio-frequency.
Number of tubes.	Five. Two stages of r. f. with 201-A (301-A) tubes; detector, using special detector tube; first audio stage, 201-A (301-A); second audio stage, 112 (312) or other semi-power tube.
Features	Maximum r. f. gain obtained by use of special automatic variable coupling arrangement. Only two tuning controls although there are three tuned stages. Switch for one or two a. f. stages.
Frequency range	1500 kc. to 500 kc. (200–600 meters).

Now the reason for this lack of pep on the longer waves is not difficult to explain. Whenever a tube has inductance in its plate and grid circuits, that tube does its best to regenerate, and if a certain balance between these inductances is maintained, this regeneration will break into open oscillation. Squeals, howls, and general instability result. This inductance is, however, necessary to transfer energy from one circuit to another. The tendency to oscillate increases as the frequency increases and as the amount of inductance increases, and more inductance is needed to transfer energy on the lower frequencies than on the high; but with this maximum amount of inductance the set will probably be uncontrollable on shorter waves.

Thus, sets that get the longer-wave stations with maximum r.f. amplification cannot be held down on the shorter waves; those that are especially stable on short waves are as quiet as the proverbial grave for DX on the longer waves.

The receiver shown in the photographs in this article does not suffer from the faults enumerated above. It is the outgrowth of a popular receiver of last year, the Karas "Equamatic," and employs a mechanical means of maintaining "constant coupling" between the output of one tuned radio-frequency stage and the input of the next stage. This "constant coupling" means that the plate circuit of the preceding tube will have just enough inductance in it to transfer maximum energy at each frequency to which the circuit is tuned, but not enough inductance to make it oscillate. As the condensers are varied, the coupling is varied simultaneously, and in the proper proportion, to prevent troublesome oscillations, but at the same time to maintain more or less constant amplification over the entire broadcasting frequency band.

The "Equamatic" system is not new to the readers of RADIO BROADCAST, for it was described in several issues of this magazine in 1926 by Zeh Bouck. The receiver itself differs somewhat in various ways from the set of last year; in each of these several respects it is better than last year's set. In the first place, it is a two-dialed receiver, an obvious advantage over the three-dial receiver previously described. The change is accomplished by means of a lever pantograph arrangement which permanently connects together the variable tuning capacities of the second radio-frequency amplifier and the detector circuits. Additional means have been taken to insure maximum amplification and complete stability, partly by filtering the radio-frequency circuits with chokes and condensers and also by a new means of partially neutralizing the inter-electrode capacity of the tube—the capacity that causes regeneration. In addition, an output filter has been added to the layout so that a power tube can be used without the d.c. plate current of this tube going through the windings of the loud speaker.

The receiver, then, consists of a two-stage radio-frequency amplifier with constant gain over the entire broadcasting band, a grid leak and condenser detector, a conventional two-stage transformer-coupled amplifier, and an output filter. The antenna or first-stage amplifier is tuned with the left-hand dial, while the second dial takes care of the other two tuned circuits, which are made to tune exactly alike. Ease of adjustment is secured by means of the ganged condenser arrangement without apparent loss in either selectivity or sensitivity over the three-dial model described in RADIO BROADCAST for October, 1926.

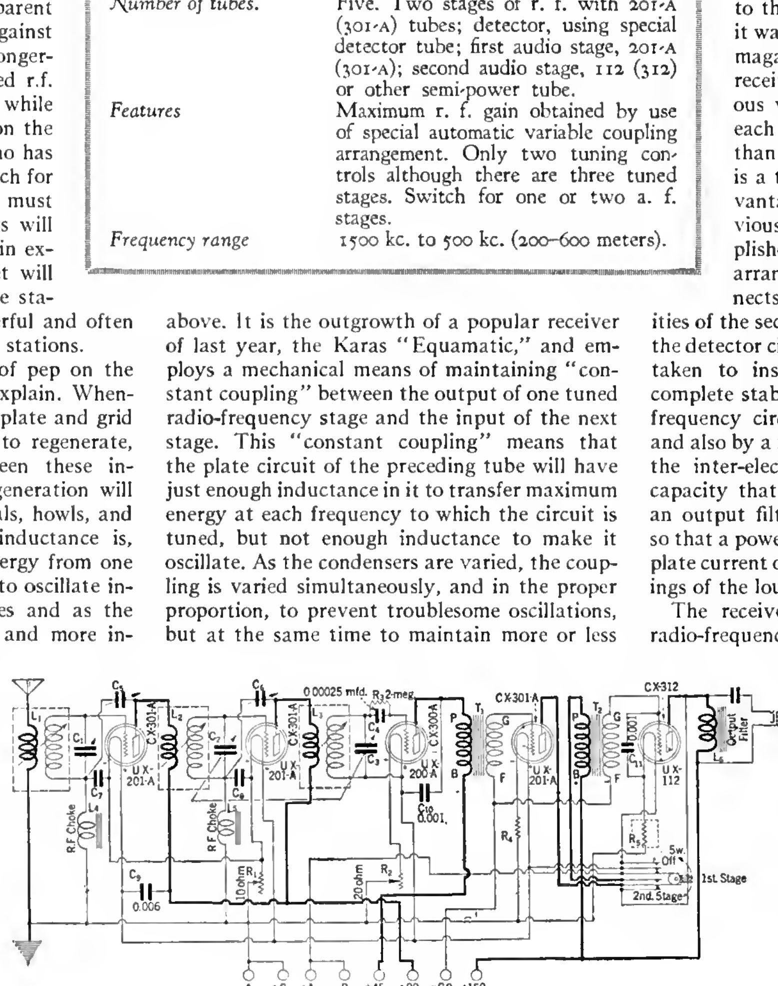
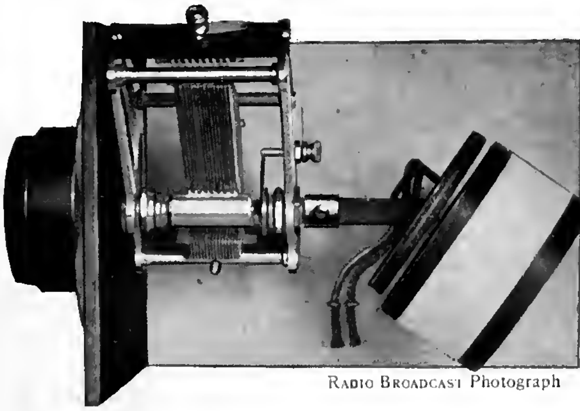


FIG. I

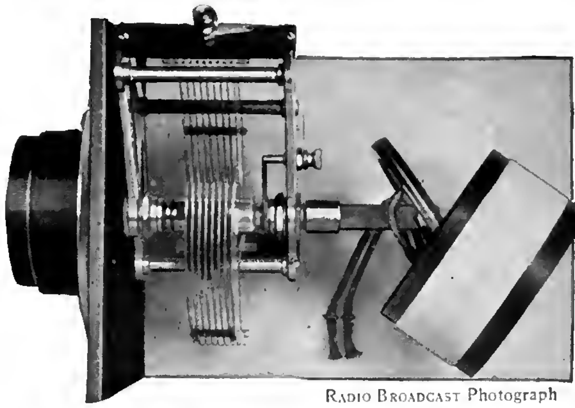
Circuit diagram of the new "Equamatic" receiver



Radio Broadcast Photograph

FIG. 2

Left. When the condenser is tuned for maximum wavelength, the coil should be coupled in this manner, allowing the largest transference of energy. *Right.* Minimum coupling, for shortest wavelength



Radio Broadcast Photograph

FIG. 3

A special Yaxley interstage and filament switch is employed to cut out the final audio amplifier when desired, automatically shutting off the filament current to the tube in this circuit. Thus the loud speaker can be operated on local stations from the first audio amplifier, and when more volume is desired, the second amplifier may be thrown into the circuit.

A list of parts for the receiver follows:

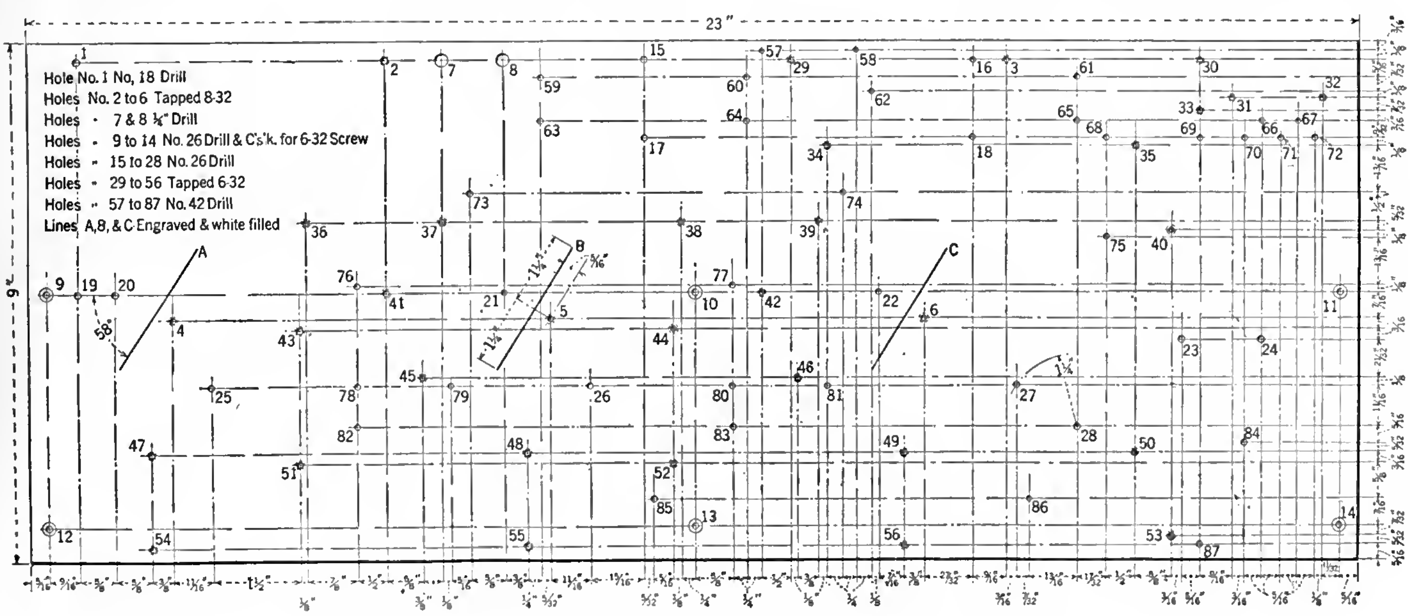
T_1, T_2,—Karas Type 28 Audio Transformers	$16.00
L_6—Karas Output Filter	8.00
C_1, C_2, C_3—Karas Type 17 0.00037-Mfd. Variable Condensers	15.75
L_1, L_2, L_3—Karas "Equamatic" Coils.	12.00
Two Karas Micrometric Dials 0–100	7.00
Three Karas Sub-Panel Brackets	.70
Karas Control System, Including Complete Hardware	3.00
L_4, L_5—Karas or Samson 100-Millihenry R. F. Chokes	5.00
Formica 7" x 24" Engraved Front Panel	5.68
Formica 9" x 23" Drilled Sub-Panel	6.00
R_1—Carter 10-Ohm Rheostat (Gold Arrow)	1.00
R_2—Carter 20-Ohm Rheostat (Gold Arrow)	1.00
Sw.—Yaxley No. 69–B Interstage Switch (Gold)	1.25
J—Carter No. 10 Tip Jacks	.20
C_4—Sangamo 0.00025-Mfd. Fixed Condenser with Clips	.50
R_3—Durham 2-Meg. Grid Leak	.45
R_4—1A Amperite	1.10
R_5—112 Amperite	1.10
Yaxley Cable Plug	3.00
Five Benjamin Cushion Sockets	3.75
C_5, C_6—Samson Mica Neutralizing Condensers	3.50
C_7, C_8—Sangamo 0.0001-Mfd. Fixed Condensers	.80
C_9—Sangamo 0.006-Mfd. Fixed Condenser	.85
C_{10}, C_{11}—Sangamo 0.001-Mfd. Fixed Condensers	1.00

The circuit diagram of the receiver is shown in Fig. 1, and panel and sub-panel layouts are also given in this article. Attention is called to the two neutralizing condensers connected from the plate of each radio-frequency tube to the lower end of each input inductance, providing an additional means of stabilizing the receiver at high frequencies. The photographs show how simply the receiver goes together. The sub-panel, provided by the Formica Company, has three white lines engraved in it to show the position of the three tuning coils, which can be easily adjusted since they are attached to the sub-panel by means of machine screws.

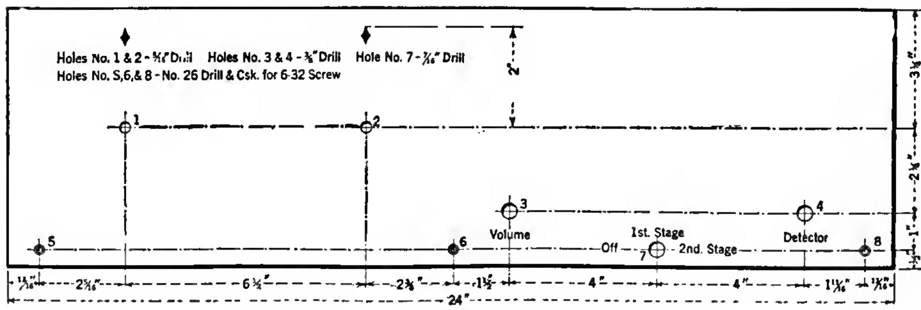
After the receiver is properly wired, the next step is to adjust the variable primary coils, which are rotated when the condensers are turned. The condensers should be turned until the plates completely interleave, and in this position the primary coils should be parallel to the larger secondary inductance, as shown in Fig. 2. They should be fixed in this position. Under these conditions, the loosest coupling will exist between primary and secondary at the highest frequencies, as shown in Fig. 3.

The receiver can now be connected to its A, B, and C batteries. The diagram shows that the r.f. tubes are run with 90 volts on the plate. A negative bias of about one volt is placed on the grid of the r.f. tubes, and is obtained through the drop across the filament rheostat. The C bias battery for the audio tubes is fixed in the receiver, as the photograph of the complete set shows. The final audio tube should be a UX-112 (CX-312), with about 135 to 150 volts on the plate and a grid bias of negative 9. A separate ground wire can be run to the set, or the A battery may be grounded instead. Either method of getting the receiver grounded will be satisfactory.

This receiver is inherently easier to adjust for a non-oscillating condition than a bridge circuit, where an accurate and exact balance is necessary. The three tuning condensers are turned to the longest wave setting, or 100 on dial, and then, as the wavelength is slowly decreased again, with both the dials being turned in synchronism, a point will be found where the set breaks into oscillation. Then the neutralizing condensers should be screwed down slightly until oscillation stops, and the wavelength decreased again by rotating the condenser dial. This process should be repeated until the shortest-wavelength adjustment, zero on the dials, is reached. In actual practice, it will be found that no oscillation will occur if the condensers are adjusted properly, and at the same time it will be discovered that the longer-wave stations will not have lost any of their original strength, a phenomenon that few balanced receivers possess.



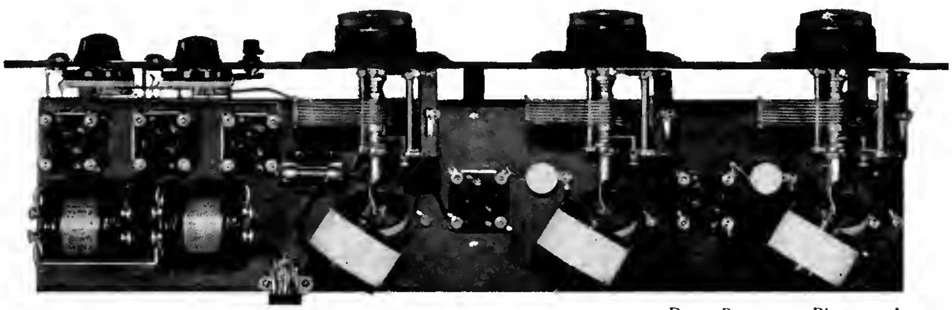
A SUB-PANEL TEMPLATE FOR THE 1928 "EQUAMATIC" RECEIVER



FRONT PANEL DRILLING INSTRUCTIONS

The builder of this new "Equamatic" receiver should have no difficulty in making a one hundred per cent. workable set at the first trial. The parts have been so placed that interaction between circuits, which ordinarily is a difficult problem with which to cope, is minimized, and the progressively increasing coupling between circuits at the longer wavelengths provides the proper interstage energy transfer. The first "Equamatic" coil, which transfers energy from the antenna circuit to the receiver proper, may be arranged to have a slightly different rate of change of coupling if desired—if the user wishes somewhat greater selectivity—for example. In this case, the coupling at the lowest frequency may be decreased by making the primary and secondary not parallel, but turned at a slight angle. In general, however, the greatest coupling should be used at all times, and a somewhat smaller antenna used if greater selectivity is desired.

The condensers which tune this receiver, if those specified are used, have a straight frequency-line characteristic, a decided advantage now that transmitting stations are again operating on ten-kilocycle separations. If it is desired to use a 171 type tube, somewhat different connections must be made to the last two tubes and their plate circuits. As wired according to Fig. 1, the last two tubes get the same B voltage, this being necessary on account of the interstage switch. Additional prongs would be necessary if the two audio tubes needed different B voltages. In the vicinity of broadcasting stations, however, the field strength is sufficient to give all the volume one can desire by using a semi-power tube of the 112 type. At some distance from stations, the 112 tube with its greater amplification factor will have an actual advantage over the 171 type, and louder signals will be obtained. Thus weaker stations will operate a loud speaker.



Radio Broadcast Photograph

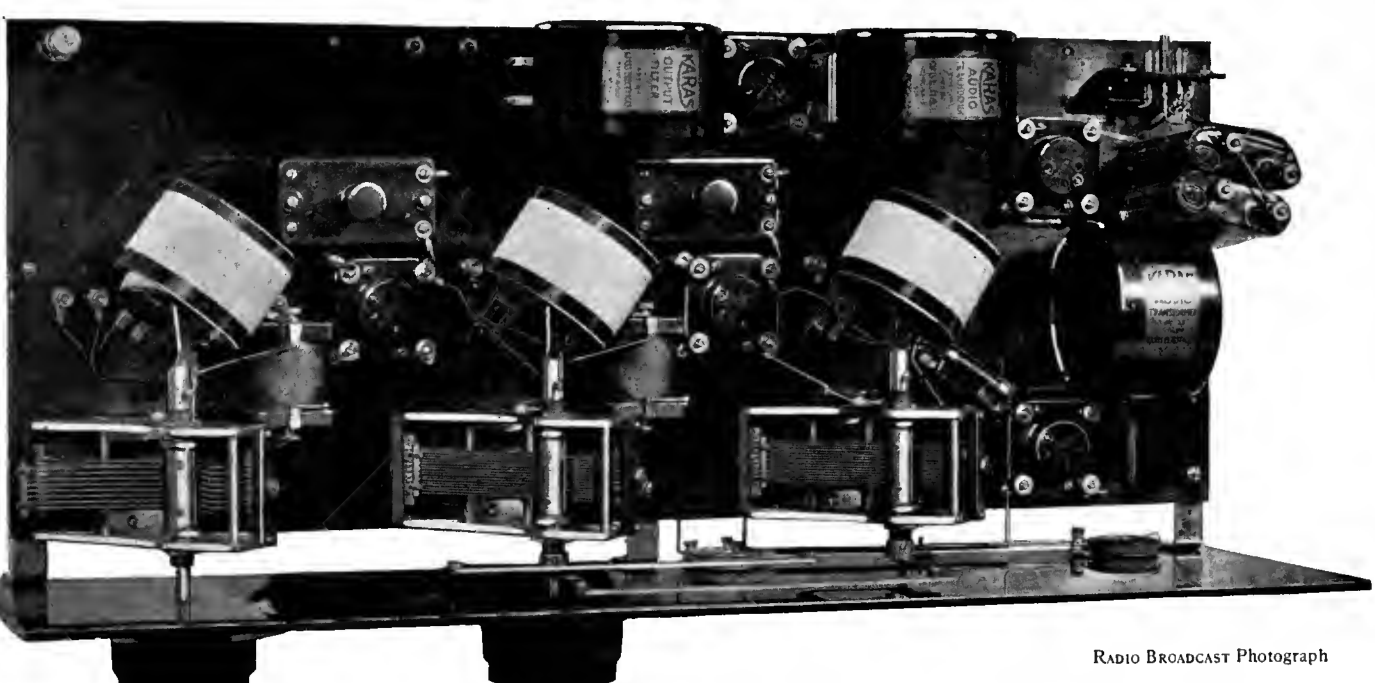
BY WAY OF CONTRAST

Here is the 1927 "Equamatic" which is now improved. Note the three-dial tuning

Now that we have outlined the electrical features of this new "Equamatic" circuit, there are several mechanical notes which should be brought to the attention of the home constructor. The condensers, for instance, are new, in that they are equipped with removable shafts so that insulated ones may be substituted for the metal ones, and complete insulation from hand capacity thereby realized. In some circuits this is important; in the present receiver, hand capacity will not be apparent owing to the fact that the rotor plates of the condensers are at ground potential. The output filter, which is new in this year's model, consists of a conventional choke and condenser combination and, as may be seen in an accompanying photograph, is built into a round metal box similar to the audio transformers. The latter, incidentally, have exceptionally high primary inductance, which is necessary for full reproduction of low audio frequencies. Their turns ratio is about 2.5 to 1.

In all receivers employing two or more tuned circuits, tuning is inherently sharp, making necessary some form of fine adjustment. In this receiver the designers have used the familiar Karas dials which, with their 63 to 1 reduction, and their exceptionally smooth action, make tuning a joy. The writer found that the receiver tuned with great ease although it was sharp enough to please a critical fan.

All in all, the home constructor should find this receiver a well designed, simple-to-construct, high-quality set, and in building one, he will be equipping himself with a receiver of which he can be deservedly proud.



Radio Broadcast Photograph

LOOKING DOWN ON THE 1928 "EQUAMATIC"

The arrangement of parts is neat and efficient. Note the lever pantograph arrangement which makes possible simultaneous adjustment of the second and third tuned circuits

A New Principle of R. F. Tuning

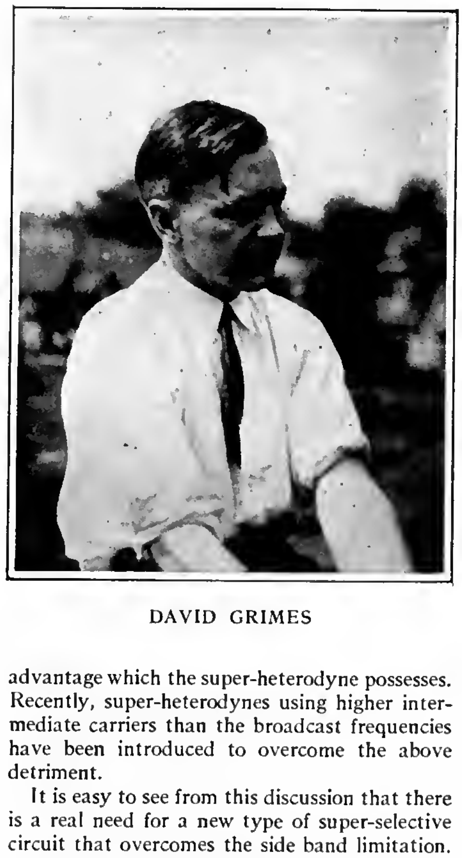
The "Octa-Monic" System Resonates the Second Harmonic Instead of the More Usual Fundamental—Increasing the Selectivity

By DAVID GRIMES

UP TO the present time there have been just three fundamental radio circuits, and every type of radio receiver has employed some variation of these three arrangements. First, there was the regenerative system; next radio-frequency amplification was developed; and last, the War and Major Armstrong produced the super-heterodyne.

Regeneration is a principle by which increased signals may be obtained by a properly phased feed-back or reënforcement of the incoming signals. When radio broadcasting first became popular in 1922, the regenerative type of circuit was generally used. The feed-back action made the receiver very sensitive for distant reception and very selective at the particular frequency for which the receiver was tuned. As the number of stations increased, and two or more powerful local stations became established in many communities, the regenerative receiver ceased to give satisfaction because of its broadness of tuning. Near-by locals could not, therefore, be tuned out. The necessity for extra selectivity was met by sets with tuned radio-frequency amplification. But the standard two-stage tuned radio-frequency sets soon became inadequate because inherent resistances in the vacuum tubes and associated circuits limited the ultimate selectivity to be obtained therefrom. Attempts to offset these resistances by feed-back circuits have been somewhat successful in increasing the selectivity but in nearly every case the audio quality has suffered. The RGS Inverse Duplex, described in the January, February, and March, 1927 issues of RADIO BROADCAST, employed a tuned radio-frequency circuit with an automatic negative resistance circuit which greatly increased the selectivity at all wavelengths. The limiting factor was the tone quality, however, as super-selectivity tends to cut the side-bands on a carrier wave, thus sacrificing the high pitch audio tones. The selectivity of the RGS Inverse Duplex was carried to such a point that a special audio circuit was employed to give extra amplification to the high-pitched tones in an effort to provide for the reduction in side-bands.

The super-heterodyne came into general use mainly because of its selective properties and its extreme sensitivity, permitting loop operation. But the side-band limitation so characteristic of a really selective tuned radio-frequency set became very noticeable in super-heterodyne circuits employing low-frequency intermediate transformers. Here the plus and minus 5000-cycle variation which must pass through to insure good tone quality is a very large percentage of the intermediate carrier wave of 30,000 or 50,000 cycles. The resonant curve must therefore be quite broad, which somewhat offsets the very advantage which the super-heterodyne possesses. Recently, super-heterodynes using higher intermediate carriers than the broadcast frequencies have been introduced to overcome the above detriment.



DAVID GRIMES

It is easy to see from this discussion that there is a real need for a new type of super-selective circuit that overcomes the side band limitation. With this thought in mind, a series of tests has been conducted during the last few months, which has resulted in the development of the "Octa-Monic" principle. This is a new system for obtaining a higher degree of selectivity and follows from the considerations below. It had long been realized that selectivity was a geometric function and that placing one tuning circuit after another created the geometric conditions. Naturally, every geometric function occurring in radio was then investigated with a view to employing that feature for selectivity. One of the most promising was the generation of second harmonics and it is this that forms the basis of the new RGS "Octa-Monic" receiver.

It is well known that a vacuum tube has a curved characteristic unless a very high external impedance exists in the plate circuit. This curved characteristic leads to distortion which is another name for the generation of harmonics. In the plate circuit of the average r. f. amplifier is only a small impedance, therefore in this circuit exist the second harmonic as well as the fundamental image of what occurs in the grid circuit. It is from this second harmonic that the "Octa-Monic" gets its name. The idea of securing increased selectivity, not through the use of additional circuits, but by the use of an inherent tube characteristic, is believed to be new.

Reference to Fig. 1 shows the familiar grid-voltage plate-current characteristic of a standard vacuum tube. The curve follows a square law, and in doing such, causes some interesting results. It is desirable when using such a tube for an amplifier to operate the grid voltage on a relatively straight part of the curve so that fairly undistorted amplification will result. For perfect amplification, this curve should be a straight line. The very fact that it is not, however, makes the vacuum tube a valuable device, as the non-linear performance permits its use as a modulator, oscillator, detector, and a harmonic generator. It is its use in this last capacity that is least understood and least employed.

Now, if a special negative C bias is placed on such a vacuum tube so that the grid variations take place about some such point as A in Fig. 1, the conditions will be favorable for the generation of second harmonics. Such harmonics are always the result of unequal amplification in the two halves of a carrier wave. By operating at point A it will be seen that each positive half of the carrier wave is amplified to a greater extent than each negative half. Such an unbalanced carried wave may be resolved into a balanced carrier wave of the same fundamental frequency plus another carrier wave of twice the frequency. This is graphically illustrated in Fig. 2 and is known as Fourier's Theorem. Briefly stated, it is as follows:

If we have any single valued periodic curve, that is, one having only one value of the ordinate to one value of the abscissa, and repeating itself at regular intervals, then, no matter how irregular the curve may be, provided it does not exhibit

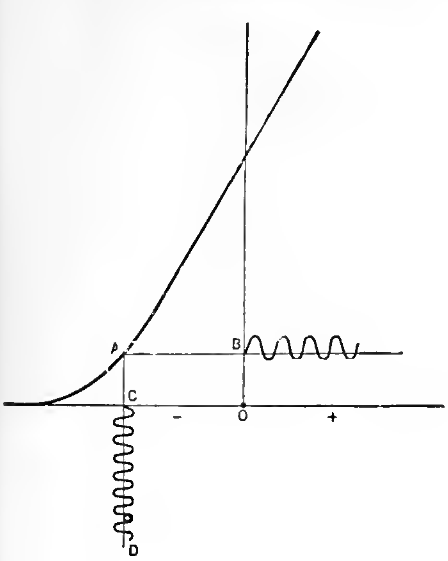


FIG. 1

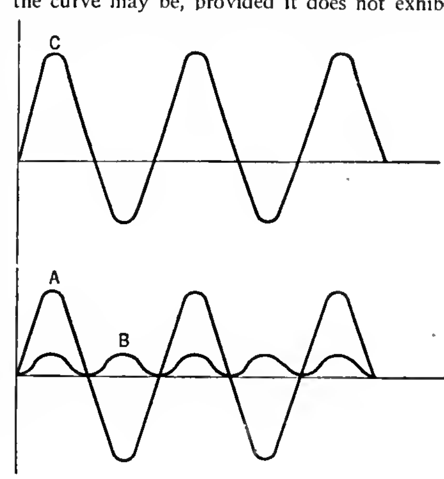


FIG. 2

discontinuities, it is always possible to imitate this curve exactly by adding the ordinates of superimposed simple periodic or sine curves of suitable amplitude and phase difference, having wavelengths which are in the integer relation to each other.

Curve C in Fig. 2 shows the unbalanced carrier wave in the plate circuit of the tube operated at point A on the characteristic curve in Fig. 1. Curve C is the equivalent of Curves A and B in Fig. 2. Curve A is the fundamental carrier wave similar to the one impressed on the grid of the tube. Curve B is the second harmonic wave.

None of the graphic representations pertaining to the second harmonic reveal the secret of selectivity. They merely indicate that such a second harmonic is present. The mathematical equation outlining the performance of the tube, however, does tell the story. The equation for the unbalanced carrier wave shown by Curve C in Fig. 2 is as follows:

$$C = 2\sigma\left(\frac{E_p}{\mu} + E_g + e\right) e \sin pt + \frac{\sigma e^2}{2} \cos (2\,pt + \pi)$$

The first part of the equation represents curve A in Fig. 2—the fundamental carrier. The second part of the equation represents Curve B in Fig. 2—the second harmonic component.

Now it will be noted that this second harmonic component is proportional to the square of the input voltage, e, and it is this squared function which gives the geometric requirement for selectivity. Reference is here made to Fig. 3, which shows a harmonic generator tube with the grid circuit tuned to some frequency, F, in the broadcast band. The resonant curve of this tuned input circuit is shown at A. Now the second harmonic currents, 2F, in the plate circuit of this tube, are proportional to the square of the input voltages on the grid. As the incoming frequencies are varied, slightly, from the true resonant value of the circuit, the voltages on the grid fall off according to curve A. As the voltage has decreased from its maximum, y, to the half way point at x, due to a change in frequency, a, the second harmonic current decrease is much more rapid and abrupt than in the case of the fundamental current, resulting in a very sharp resonant curve in the plate circuit of the harmonic generating tube. In these figures the fundamental and second harmonic have been plotted so that they have equal maximum amplitudes to show the relative sharpness of resonance.

The next step was to incorporate such a principle into a working receiving circuit. The first attempt is shown in Fig. 4. Here the antenna is coupled directly to the tuned input of the harmonic generating tube. The grid is tuned to the fundamental frequency of the broadcast station to be received. The second harmonics are set up in the plate circuit where there is a tuned transformer, whose tuning condenser resonates the secondary at the second harmonic frequency. Signals are changed to audio frequencies in the standard detector tube in the same manner as any other circuit. Selectivity superior to that obtained by a two-stage tuned radio-frequency system was noted, although the sensitivity of the arrangement was much less.

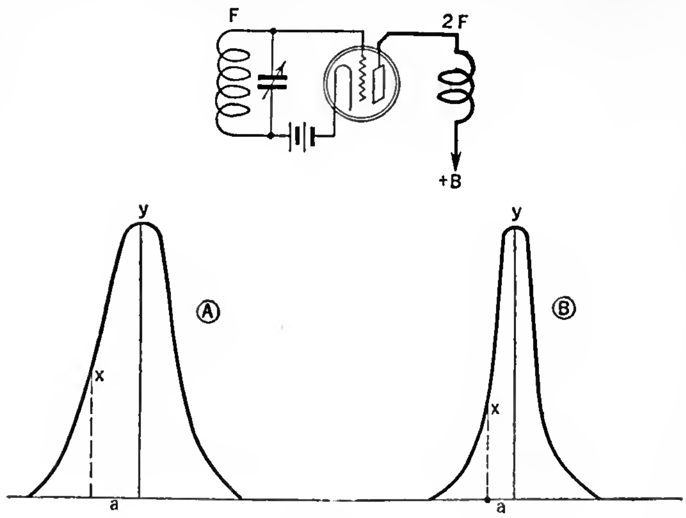


FIG. 3

This would obviously be so because no amplification is present in Fig. 4, and because the amplitude of the harmonic is less than that of the fundamental. In all of these diagrams, which are roughly drawn, no attempt has been made to show relative amplitude—only relative sharpness. In fact, quite a bit of energy is sacrificed in securing the second harmonic component. This sacrifice is more than justified because of the real selectivity obtained, and after all, amplification can always be added to a receiver. The additional amplification is easily added by the arrangements shown in Fig. 5, where one stage of radio frequency is placed ahead of the harmonic generator tube. This additional stage does not need to be particularly selective as the second harmonic principle gives all of this necessary. For this reason, the additional tube has been called a coupling or amplifying stage—the circuits being designed primarily for amplification and not for selectivity. Its input circuit is closely coupled to the antenna to give maximum energy pick-up with which to start. In order to gain some idea of the real improvement offered by the "Octa-Monic" as compared with tuned radio frequency, reference is made to Fig. 6. This shows the schematic arrangement of a standard two-stage tuned radio-frequency receiver with the resonant curves of the various parts of the circuit beneath and numbered to correspond. Curve 1 shows the sharpness of tuning in the grid of the first tube. Curve 2 indicates that the fundamental currents in the plate circuit of the first tube follow the same resonant curve. Of course, the energy is greater in the plate circuit but the curves have been drawn to the same scale for the purposes of comparison. Curve 3 shows a gain in selectivity through the addition of the second tuned circuit, while Curve 5 shows the final gain in selectivity through the employment of the 3rd tuned circuit. It can be seen that only

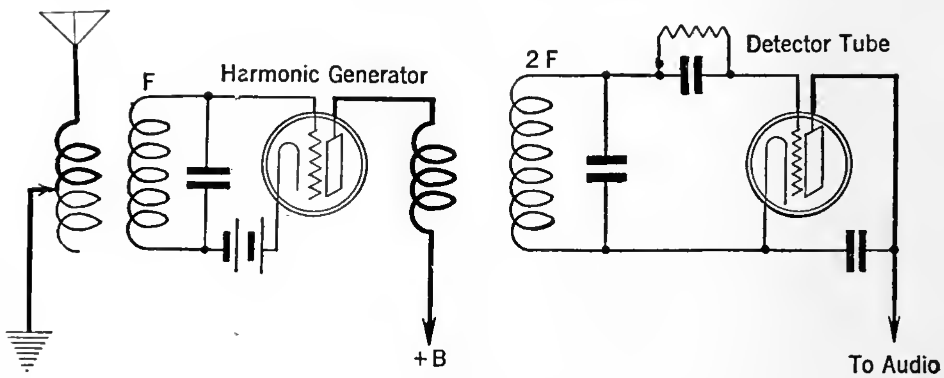


FIG. 4

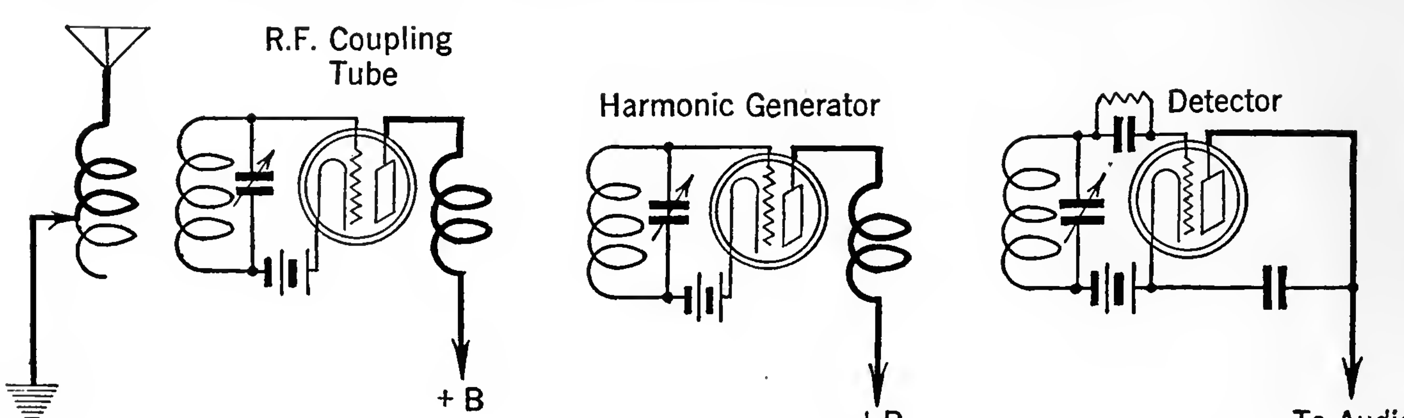


FIG. 5

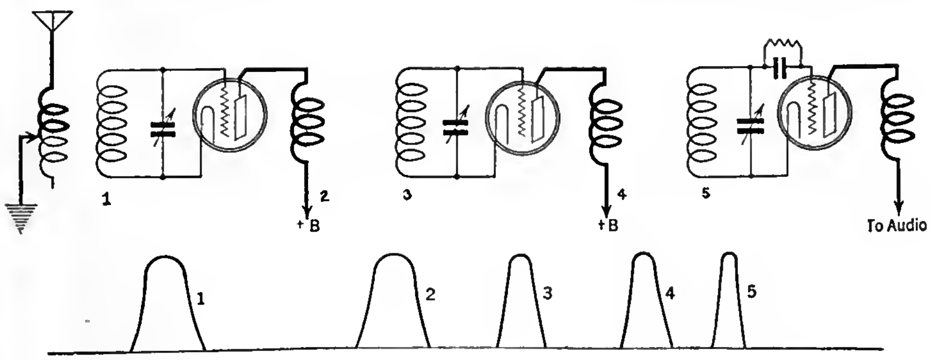


FIG. 6

band of the carrier frequency plus and minus 5000 cycles to insure good tone quality and 10,000 cycles variation is a much smaller percentage of the second harmonic currents than of the broadcast frequencies. For example, at 1000 kc. a 10,000-band represents 1 per cent. while in the second harmonic circuit this 10 kc. band is only 0.5 per cent. of 2000 kc. In this unique way a high degree of selectivity has been secured with a faithfulness of tone quality that is remarkable.

This RGS "Octa-Monic" arrangement is a fundamentally new development. The existence and generation of second harmonics has long been known, but the application of these currents to the selectivity problem is a new feature. It has created a fourth and distinct type of radio circuit.

The next article in the series will discuss this interesting development and will contain plenty of information in connection with the building of the RGS receiver.

the tuning circuits offer any selectivity whatsoever. Fig. 7 shows the schematic sketch of the "Octa-Monic" system and the associated resonant curves beneath the several circuits involved. Curve 1 indicates the sharpness of tuning in the grid circuit of the harmonic generator. This has the same shape as the first tuning circuit in the system. In the plate circuit the second harmonic currents follow the resonant Curve 2, and the harmonic tuning circuit in the input to the detector still further sharpen this up to resonant Curve 3. This resonant curve is similar in shape to the tuning curve No. 5, in the system. The resonant curves in Fig. 7 are drawn on the same scale for the sake of comparison. It must be remembered that Curve 2 representing the second harmonic selectivity has much less energy in it than Curve 1.

It would seem, offhand, that this excessive selectivity in the "Octa-Monic" would raise havoc with the side-bands, as is the case in tuned radio-frequency circuits. The very harmonic currents themselves, however, offer the solution. At the high frequencies existing in the harmonic circuit the resonant peak may be much sharper than at broadcast frequencies without harming quality. A tuned circuit must be able to pass a

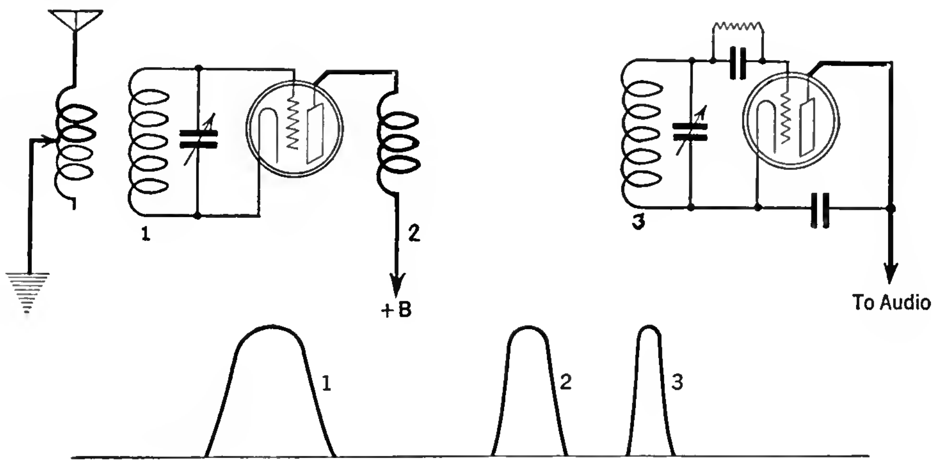


FIG. 7

Selling It by Radio

Using Radio in Sales Promotion: By Edgar H. Felix. Published by McGraw-Hill Book Co., Inc., New York City. 386 pages. Price, $5.00.

IT IS not without a touch of embarrassment that I prepare to review this pioneer work on the subject of broadcasting as an aid to merchandising. The author has written in kindly terms of my own masterpieces on various occasions, and transported me over the highways in his private fleet of Minerva sedans. In finding his work good, therefore, I lay myself open to the charge of log-rolling. To preserve my honor, I should like to pan the author and his treatise, but he has done too effective a job. The book is original, informing, and vigorous. Its blemishes are slight and will probably be visible only to the reviewers.

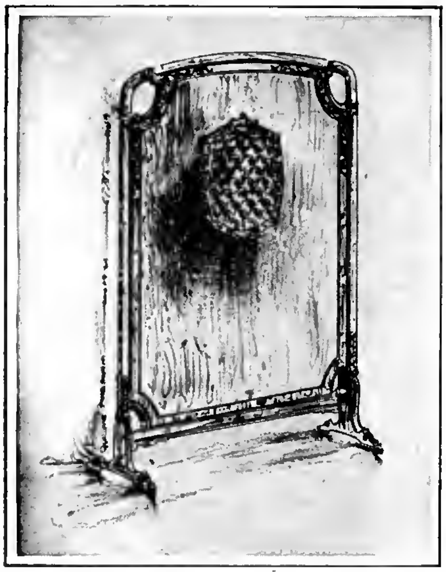
Using Radio in Sales Promotion is written primarily for advertisers; it aims to instruct the man who contemplates spending a part of his advertising appropriation for time on the air. Throughout it names names, gives examples drawn from experience, and answers the questions which must occur to the man who signs the checks. What interests the client interests the professional broadcaster equally, whether he (or she) owns, manages, operates, sells time, writes publicity, or performs in the studio. Professional advertising men are in a similar position. So there is Felix's potential audience —in these groups and their fringes. He is qualified to speak to all of them, for he has himself been a broadcaster, advertising man, merchandising consultant, and writer; and incidentally he is, among other things, a Contributing Editor of RADIO BROADCAST.

The author starts with a *résumé* of the seven-year history of the broadcasting art, and in his first chapter he sounds a note which recurs throughout the book; broadcasting is a medium, not for forthright advertising, but for securing the good will of the consuming public. Radio receivers are purchased for entertainment and instruction. A trade name, a brief slogan, a very few words of product description, may be mixed with the entertainment and instruction, but Felix always has his eye fixed on a psychological dividing line which cannot be crossed with either propriety or safety. Broadcasting is primarily for the advertiser who can afford to wait, who has the resources to build up public good will, who is not too short either in his bank account or his patience. As for the little fellow who demands sales tomorrow morning—Felix advises him to take his money to the local newspaper. The Midwestern broadcasting station which I am reliably informed at this writing, is selling over the air by direct description, gasoline, mattresses, gloves, overalls, radio apparatus, cancer and rupture cures, and a 50-cent chicken dinner, is outside of Felix's pale. "He (the broadcaster) does not earn the right to inflict selling propaganda in the midst of a broadcasting entertainment any more than an agreeable week-end guest may suddenly launch into an insurance solicitation at Sunday dinner," is the attitude expressed and implied on every other page of *Using Radio in Sales Promotion.*

The reason for the fundamental similarity of station programs is shrewdly analyzed in the second chapter. Almost all of them are planned to appeal to all tastes, thus including the largest possible audience. Artistic standards, not fundamental program appeal, are the variable quantity. Almost all the stations are shooting at the same target, but with guns of different calibre.

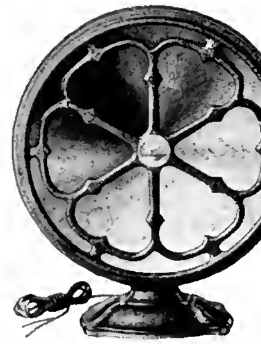
In the chapter on "Building a Broadcasting Station" and that on "The Broadcasting Station" near the end of the work, Felix discusses technical aspects of the broadcast situation, such as wavelength congestion, station organization, operation, and the like. He does not attempt to tell the reader how to build a station, and in fact advises him against trying it. What he does is to outline the formidable problems which must be faced, and the general economics of the situation. In discussing operation he describes the functions of the various members of the staff and the principles underlying their work. In many other chapters, as in those on "Potential Audiences of Broadcasting Stations" and "Selecting a Commercial Broadcasting Feature," Felix enters the engineering branch, and, dealing with field strengths and microphone characteristics, he exhibits only minor lapses from accuracy.

Using Radio in Sales Promotion is written in a business-like, straightforward style, but it is not devoid of sharp hits and epigrams. I quote a few: "An expert is usually one who has not yet learned enough of a subject to be aware of his ignorance."—"Broadcasting is free and therefore freely criticised."—CARL DREHER.



A DEPARTURE IN LOUD SPEAKERS
The Rola Model 20 combines a baffleboard loud speaker of remarkable efficiency with floor screen measuring three feet high by two feet wide. The price is $85

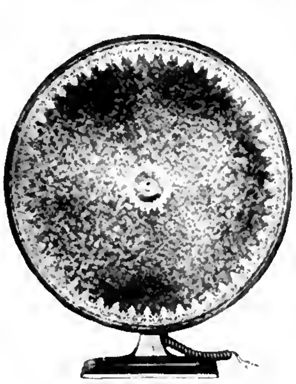
AN "ACME" OFFERING
This novel loud speaker makes use of a double cone arrangement, good amplification of the low notes being possible on account of the free edge cones. The manufacturers state that an output device is not necessary with this loud speaker. Price $25.00



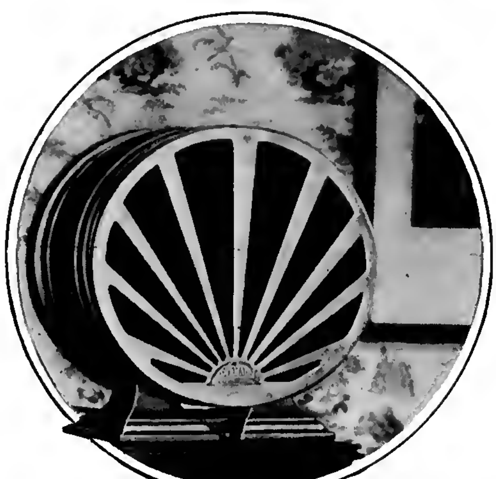
THE A. K. CONE
The new Atwater Kent Model E employs a novel method of cone suspension, permitting satisfactory response to minute vibrations. Price $30.00

THE CROSLEY MUSICONE
A baffleboard effect is obtained by the use of the tilt-table surface. Price $27.50

1928 Loud



TRIMM "CONCERTO"
A $10.00 cone, fourteen inches in diameter. The seventeen-inch cone retails for $16.00



OPERADIO
The "Junior" model has a 30-inch exponential air column while the "Senior" has one of 54-inches. The prices are $15.00 and $25.00

THE BOSCH "LIBRARY AMBATONE"

FADA "PEDESTAL"
This is a twenty-two inch free floating cone of attractive Grecian design. The overall height is fifty-five inches. Price $50.00

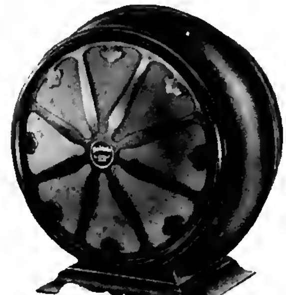
A NEW MAGNAVOX
Loud speaker and B supply in one unit, a. c. operated. A 210 type power tube should be used. The loud speaker is of the dynamic type. Price for the unit, $110.00

IN GOTHIC DESIGN
A beautiful and well-proportioned free-edge periphery cone. The reproduction from the "Peerless" is in keeping with its appearance. Price $35.00

THE "CASTLE"
A two-tone bronze relief pattern enhances the appearance of this Tower seventeen-inch cone. Price $9.50

GREBE "20–20"
The numerals denoting this model refer to the cone diameter and the fact that it is constructed at an angle of twenty degrees. Price $35.00

ALGONQUIN
A full floating cone of a moisture proof impregnated fabric. The Algonquin Electric Company retails this cone at $15.00



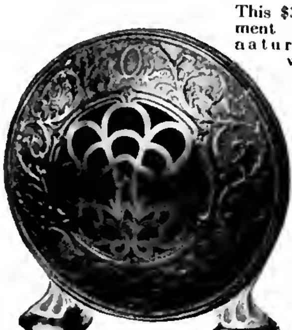
BALDWIN
A special unit is responsible for the good tone of the Baldwin "99." This instrument sells for $28.50

ANOTHER ROLA ART MODEL
A large and effective baffle surface is responsible for excellent tone quality. Rola manufactures less expensive models, from $28.50 up. The one illustrated is priced at $45.00

Speakers

AN INNOVATION
An up-to-date post-war map of the world surrounds the Symphonic Globe loud speaker, a $35.00 product of the Symphonic Sales Corporation

A 22-INCH CONE
The new Sparton loud speaker, a product of the Sparks-Withington Company, retails at $30.00



UTAH
This $30.00 instrument is of 5-ply natural finished walnut

IN DISGUISE
A cone loud speaker in tip-table form—the Teletone Model 70. Price $40.00

THE MOHAWK "PYRAMONIC."
The pyramidal construction in the diaphragm is responsible for very excellent quality from this $25.00 instrument

THE "ADVENTURER"
Another bas-relief pattern of the Tower Manufacturing Corporation. The ship is suitably and vividly colored. The price $9.50

ANOTHER PEDESTAL
The Baldwin loud speaker illustrated elsewhere on this page is also obtainable in the attractive form shown here. Price $39.50

The Listeners' Point of View

SHOULD THE SMALL STATION EXIST?

By JOHN WALLACE

THE case for the small broadcaster is seldom heard, because he is small, possibly and because the public through habit and for other reasons, directs its attention to the larger and better-known stations. Has the small broadcaster a place? Does he serve a local need? How can the small station better serve its public? An interesting letter from a reader in Devils Lake, North Dakota, discussing this topic follows:

I have been reading with a great deal of interest your department in RADIO BROADCAST and obtained very much enjoyment out of it. Numerous things that you say however lead me to believe that you are about as biased an individual as ever wrote.

The particular thing that seems to cause you the greatest amount of worry is the small station. I own and operate a small station, as far as power output goes. Some of the things you say get under my hide. Picture yourself out here in North Dakota, living in a small town or on a farm vainly twisting the dials looking for entertainment. None to be had. Then, "This is KFJM The University of North Dakota" or WDAY or KFYR or KDLR as the case might be. A program of good entertainment for an hour or two comes on the air. You listen, you are pleased, you swear by the small station, you pick up a paper and note the many excellent programs being sent out from a multitude of stations, *none of which are heard here*, except a few months in winter. Would you favor the abolishing of the small station? Would you dismantle your radio set in February and not use it again until November? Would you if you turned on your set night after night and listen for stations that cannot be heard? Would you? Or would you listen to the very excellent programs from our local small station?

The programs sent out here are not the high type of the big Eastern stations but they fill the bill. An example of our type of program, Monday evening at 9:30-10:00 the Oriental Trio, the pianist a graduate of one of the largest schools in the country, a student of a noted teacher in Berlin, the soloist a former member of the Minneapolis Symphony, the violinist a former member of the Detroit Symphony all doing their best. At 10:00 P. M. an hour of dance music played by an 8-piece organization composed of men who have been playing together for three years and who know and understand music. At 11:00 P. M. fifteen minutes of the finest kind of pipe organ music. And on a Wednesday evening a program of band music played by a band of sixty boys, "The Governor's Boy Concert Band of Devils Lake" an organization of six years standing under the leadership of the finest bandmaster in this section of the country and playing overtures and marches of the highest class. The soloist with the band is a lady who has recently returned from that famous music school in Philadelphia where you must have talent to get in. That was our program last week. Daily we run the noon hour program playing the finest available recordings of symphony orchestra and famous singers, played through an electric pick up. Daily we broadcast the weather reports and market information and the station is eagerly listened to.

You may wonder at our quality. We have the finest and newest type microphones, the best amplifying equipment that we can buy, tested and balanced pick up lines, a monitoring operator at each end, every piece of equipment meter-checked at both ends and we pride ourselves on good quality. KDLR has a studio 18 by 25 built by ourselves following Sabine's formulas. For band concerts we have a band shell, the only in the state of North Dakota, that will seat a 100-piece band, built so that the focal point is 50 feet from the front of the shell and here we pick up every instrument with but one "mike." The shell so built that a speaker in the shell can talk in a whisper and the "mike" will pick it up and put it through an amplifier at any volume desired without its being overridden by hiss.

You, living in a city with the choice of a score of fine stations at your command, find cause to kick and kick loud, long, and lustily at what you hear. Come out here once and hear one station or possibly two, both in the same state, and after you are here awhile I guarantee you will go back home and enjoy what you hear. Then after you are home give a thought to the rest of the world and try to do a little boosting and cease knocking that about which you apparently know so little.

I hope that you have not been bored by the length of this thing but allow me to say another thing, you have a wonderful magazine, but do use a little judgment.

BERT WICK Operator, KDLR.

Mr. Wick's point is well taken—even if he does take us to task at the same time. In our own defense, let us say that he overestimates our dislike of the small station. We have not said many harsh words about it. More than likely he reaches this conclusion because of the fact that we ignore the small station in these columns. If we do neglect it too much, there are two reasons. First, the small local stations, being low powered, are difficult to "get" often enough to enable fair comment. Secondly, local stations are of especial interest only to the persons within their limited range and hence do not logically demand space in an article that considers radio nationally.

Our correspondent asks us: "Would you favor the abolishing of the small station?" Our answer is yes and no. For small stations situated as are those he mentions in his letter he gives an excellent vindication. There are long periods during which it is impossible for isolated communities to receive the distant stations, even though powerful, with any sort of satisfactory reception. They are entitled to local stations, of low power, to fill in these hiatuses. Moreover the very fact that the program is local must give it a certain interest to those in the hinterlands—who take a keen interest in local things, in contrast to the city dwellers who don't know their alderman's name nor the people in the apartment below. The farmers and other dwellers in the Centerville area are just as likely to prefer the wares of Centerville's 10-watt broadcasting station to those of WCCO as they are likely to prefer the Centerville *Bugle* to the Minneapolis *Tribune*. Probably they are personally acquainted with most of the performers who appear before the Centerville station's microphone, or at least they know the announcer's cousin Nellie or their nephew goes to the same District school as the Staff Organist's son. Hence their interest in the local program is natural enough, and since they enjoy it they are entitled to it.

THE SMALL STATION HAS NO PLACE IN CITIES

BUT we are all in favor of abolishing the small station from the metropolitan areas. If the Hyde Park district of Chicago, say, wants to publish a little four-page newspaper to retail the local gossip to the provincial minded of its neighborhood, and to advertise the wares of its local drug stores and meat markets, well and good. Nobody outside that section has to buy the paper, nor need even know that it exists. But when that same Neighborhood Association starts to operate a radio station to afford opportunity to the piano pupils of the neighborhood and to peddle the aforementioned meat market's wares, it becomes, however low its power, somewhat of a public nuisance. Even where it doesn't actually interfere with the first-class stations it needlessly clutters up the dials and is an unpleasant distraction while tuning. This complaint holds also for stations in suburbs and in small towns within a hundred miles or so of some large city.

We have never heard our correspondent's station KDLR; we hope to hear it when DX is again possible. Certainly the program he describes sounds like a very creditable one. Mere magnitude and wealth are not the only requisites for a good broadcasting station. While large financial resources must necessarily allow a station to present more varied and elaborate offerings they do not guarantee artistry in that station's mode of presentation.

It is perfectly possible for some small station, somewhere, to achieve a reputation equal, or even superior, to the large city stations. Whether or not you like the "Little Theater" there is no denying the fact that some Little Theater productions, financed on a shoe string, are superior in artistry and in manifestation of good taste to many of the costly Broadway productions. The same opportunity presents itself in the operating of a small radio station. An individual gifted with good taste and a certain sort of genius which we shall not attempt to label could, conceivably, operate a station *in time* which listeners the country over would labor with flattened ears to pick up. He would have to be an individual of extraordinary personality and that personality would have to manifest itself in every detail of the programs he offered. He would have to have complete supervision over every item he broadcasts and, essentially, do all his own announcing. In contrast to the impersonal, routine, and frequently "high hat" manner affected by the metropolitan stations, his mode of presentation would have to be decidedly personal and intimate. He would have to establish a very real bond between himself and his audience. The musical programs he offered would have to express his own tastes, as would every other sort of program he offered from time to time. And if he were a big enough man, his tastes would be broad, and he would, in consequence, attract a big enough audience. He would not have to have a lot of artists, but the few he had would have to be good, and show, in all their work, his fine Italian hand.

His position as "editor" of all that his station offered would very closely parallel that famous instance in the history of American journalism wherein an editor of unusual genius, though attached to an unimportant newspaper in an unimportant Mid-Western town, gathered to himself such fame that his editorials were quoted the country over and his newspaper even enjoyed a scattered circulation over many remote states.

And finally his reward would be—considered in the form of dross dollars—about as great as is the financial reward of the operator of a Little Theater.

Why Not a Station Operated by a Foreign Language Group?

THERE are several broadcasting stations, mostly among the smaller ones, devoted to some special group of listeners. For instance there are the two labor stations which aim their output especially at the man in overalls; and then the stations operated by some religious group, as the Roman Catholic and Christian Scientist. It has puzzled us, from time to time, that no station has ever come into existence operated by a foreign born, or foreign descended, group for the benefit of its fellows in this country who cling to the mother tongue.

While we have no statistics at hand to lend weight to this proposal, isn't it said that there are as many Italian speaking people in New York as in the city of Naples, and more Swedes in Chicago than in the city of Stockholm? If these statements be exaggerated at least the "foreign-language" populations of these cities do run into large figures. Chicago, besides its vast area around Belmont Avenue where one can examine the store signs for blocks without seeing a name that does not end in *-son*, has populous settlements of persons of Polish descent, Italian and German. These people particularly the older generation, have recourse among themselves almost exclusively to their former native tongue. Their sons and daughters though they prefer the American idiom, have, nevertheless been acquainted with the second language since childhood. It seems to us they should be interested in hearing programs conducted entirely in their own language, featuring artists and speakers of their race, and in general devoted to their racial interests. The Great War is remote enough now so that no idiot would be likely to call the manoeuvre unAmerican.

There have been foreign language programs from various stations in the United States, but only intermittently. Some French programs were broadcast by a New York station. WIBO in Chicago has for nearly two years broadcast a program in Swedish every Sunday morning from 8:35 to 10:00. Inquiry at WIBO reveals the fact that this program has been enthusiastically received by Swedish people, not only in Chicago but by long distance experts in Wisconsin and Minnesota—both of which states have a large Swedish population. The same station recently inaugurated a program in German on Sunday afternoons from 2:30 to 3:30.

There is no doubt at all that a foreign language station, properly situated, would enjoy a large enough audience to make its efforts worth while. Nor does there seem to be much doubt that it could get artists; suppose an Italian station sent out a call for Italian singers! But there may be some question as to how well it could support itself. Perhaps here is the rub and the reason that none has so far appeared. However the foreign communities in the large cities manage to support flourishing newspapers, which are packed with advertising. If the bonds of a common fatherland hold these people close enough together to make a newspaper self supporting, it would seem, by analogy, that an unpretentious broadcasting station would not be an impossibility.

The value to those, like ourself, who do their best talking and listening in the American patois, would be, perhaps, not large. But it would be a great thing for students of foreign languages to have a station they could tune-in on, on occasions, to supplement their reading and writing work. Moreover it would give a pleasant cosmopolitan tang to the air. And picture the delight of a listener out in Kansas tuning through to some Italian station in New York and imagining he had got Rome!

Thumb-Nail Reviews

WE WRITE in the middle of the summer, at a time when DX conditions are at their worst, so instead of trying to review some static-mingled distant squawks we shall confine ourself to considering some of the chain features which are received over a wide area.

The summer season, may we say, has been better than any previous summer in radio's history. Many features quite up to winter time standards were heard. The stations supported the annual vociferous protestation that "there is no summer slump in radio!" So many different agencies are engaged in re-iterating this phrase every year, particularly radio manufacturers, that it occurs to us that they do protest too much, and that a slump none the less exists. If it does exist it is because radio listeners have been able to discover other doings more intriguing than sitting in the front parlor of a warm summer's evening, and not because the stations have not made an effort to please.

AN ESKIMO LULLABY AT WGY

In the Schenectady studio, Trixie Ahkla, Eskimo, sings a good night lullaby for her two sons Miles and Billy. Up North, where the night is long, this domestic duty need be discharged only once a year

THE RADIOTRONS (Blue Network) These artists in their program of alternated orchestra and voice strike a mood that nicely ties the whole shebang together. In the case of the program we have in mind the flavor persisting throughout was a decidedly saccharine one; such numbers as Tumble Down Shack in Athlone, When You're in Love, Listening, Honolulu Moon, and Selections from the "Red Mill" following each other in sentimental succession. But Erva Giles has a beautiful soprano voice for these songs and the Radiotron's much featured Vaughn De Leath always delights us with her mellow alto and throaty half-spoken passages.

IPANA TROUBADOURS (Red Network)—continue to be one of the most reliable orchestras that are to be heard weekly. Their plucked instrument. section (they have another section—strings) continues to lead in its field, which is probably to be expected considering all the practice it has had over the past two and a half years.

ELK'S MALE QUARTET (Blue Network)—The quartet is an unfailing radio standby. Mayhap our interest in the quartet springs from the fact that every one of us is a potential singer in a quartet and stands ready to contribute his services thereat under proper stimulus, such as a shower room, a clam bake, or a couple of stiff snorts. Be that as it may, the Elks' is an excellent quartet.

CONTINENTALS (Blue Network)—The Continentals is a very able organization made up of a chorus and soloists under the direction of Cesare Sodero and specializing in opera selections. The soloists include Astrid Fjelde, soprano—and an excellent one; Elizabeth Lennox, contralto; Julian Oliver, tenor, and Frederic Baer, baritone. The program is well selected and does not stick too exclusively to the threadbare arias. Tuesday evenings at nine Eastern time.

STROMBERG-CARLSON ORCHESTRA (Blue Network)—This is George Olson's band, playing under a trade name, and a first rate band it is, as others than ourself will assure you. Perhaps much of the credit for the smooth and beguiling manner in which it plays is due to its orchestrator, one Eddie Kilfeather, who specially arranges many of its numbers.

STADIUM CONCERT (Blue Network)—The Stadium concerts occupied, as last year, first place on the list of summer offerings. We were afforded mingled emotions in hearing our Mr. Stock as guest conductor of the Philharmonic musicians, what with the current prospects of having no Chicago Symphony Orchestra this coming season, due to wage disputes. (We wonder why the Orchestral Association didn't offer to sell broadcasting privileges to meet the increased demand for funds). To quibble about minor points: we saw no reason why the announcer should descend from his ponderous and dignified perch at intervals to refer to one of his fellow workers as "Jimmy." If they will be high-hat let them be consistent.

CITIES SERVICE CONCERT (Red Network)—An orchestra under the direction of Rosario Bourdon and a chorus called the Cavaliers. But what shall we say about them? we have exhausted our critical imagination. At any rate they are consistently good. They specialize in the lighter composers, Herbert, Friml, Straus, and so forth, with other occasional novelties.

ROYAL HOUR (Blue Network)—After having distributed roses the length of this column it is now our privilege to get mad. The Royal Hour's thirty-minute broadcast is a throw-back to radio's worst days. Advertising is jammed in so thickly that the musical part hardly has a chance to stick its nose out before it is drowned in further advertising. Every number on the program is introduced with a labored reference to the sponsoring company and its product.

Your A. C. Set

How to Search for Defects When Your A. C. Operated Receiver Goes Dead

EDGAR H. FELIX

CALL THE SERVICE MAN

"Shut off the power, call for a trained professional service expert, and leave the set alone" —the advice to perplexed owners of a. c. sets in time of trouble by the head of the service department of one of the largest radio manufacturing concerns

THE head of the service department of one of the largest radio manufacturing concerns in the country was asked at a meeting recently what advice he would give to the owner of an a.c. operated set which has suddenly gone out of order.

"Shut off the power, call for a trained professional service expert, and leave the set alone," was his answer. "The troubles that arise with a.c. receivers are few and easily remedied by experts, but an experimentally inclined novice who doesn't know what he is doing can actually do great damage if he starts to tinker aimlessly. When a person gets sick, he calls on his doctor; when his automobile goes out of order, he brings it to the service station; but when a radio set goes wrong, three out of five listeners proceed boldly with soldering irons to change wires, to short-circuit transformers, to reverse connections, and to apply high voltages here and there, just to find out what happens. A competent man, familiar with the functioning of radio sets and their associated power supply, makes an inspection, analyzes the difficulty, and replaces whatever is necessary in a few minutes at a minimum of expense; a venturesome experimenter usually tinkers until he has done serious damage, then calls in an expert and, when he gets the bill, wonders why radio repairs are expensive. There is nothing mysterious or really troublesome about modern a. c. sets, and servicing them is usually a matter of the utmost simplicity."

Careless tinkering may prove an unhealthy pastime for the would-be radio expert who is accustomed to learn his radio by practical experience. Large condensers of several microfarads capacity, charged to 500 volts, may impress their effectiveness upon him with such force that he will find himself involuntarily, violently, and uncontrollably seated on the floor several feet from the radio set. But, if he temper his examination with knowledge, most of the likely faults of a. c. operated sets can be readily identified by their symptoms and, in some cases, the necessary measures for repair taken.

Servicing the a. c. set has brought a new dignity to the job of repairing radio sets because it has converted the receiver to an electric power device of considerable magnitude. Indeed, so marked is the change involved in the engineering design of a. c. sets that some of the earlier models, designed by radio engineers, failed principally because of inadequate knowledge of power engineering.

The excessive service grief which attended some 1925 and 1926 a. c. sets has been largely cured by the application of the principles of power engineering to radio. These pioneer models taught us the stresses and surges to which the filter condensers are subject with the consequence that the latest receivers have condensers of considerably greater voltage-carrying power than those of past seasons. New rectifier tubes of greatly increased capacity have solved voltage regulation and life problems, while such refinements as ballast tubes and regulator tubes give the designer wide latitude in his work. Also we have new types of tubes which avoid the use of a rectifier by using alternating current for the A supply. All of these advances have brought us to the threshold of a new era in radio set design and the elimination of the burden of maintenance attention. Given capable engineering and adequate quality of materials, the modern alternating-current set, whether it be of one type or another, is reasonably reliable and a marked improvement in convenience over its less advanced predecessor.

Certain parts of the alternating-current receiver, however, depreciate with long use. It is no more possible to design a wear-proof radio receiver than it is to design a wear-proof automobile. Vacuum tubes lose their emission and condensers, unless of tremendously greater voltage capacity than their service requirements demand, eventually break down. It is only a matter of time, however, when the service attention required by a.c. sets will be reduced to a matter of annual inspection to replace rundown tubes. Indeed, some of the latest sets have actually reached that stage.

But we cannot expect a radio receiver to require no attention whatever. Filter condensers are really moving parts. They are constantly subjected to considerable voltages, and are charged and discharged rapidly and continuously. The atomic structure of their components is constantly strained so that in time they become less capable of resisting these rapidly changing voltage strains. The experience of the last two years has resulted in the widespread use of bypass and filter condensers which will, under ordinary conditions, serve for a period of years, rather than months, as was the standard heretofore. To mention but one, if you have opportunity to look at the output condenser in the power supply of a Stromberg-Carlson a. c. receiver, you will observe that its size compares with that of condensers used in receivers of a year or two ago almost as does a match box with a steamer trunk! Expensive as these improvements are, they are an economy because they approach the ideal—"plug the set into the light socket and the receiver is ready to operate for a period of years without attention."

TWO TYPES OF A. C. SETS

IN GENERAL, there are two outstanding types of alternating-current sets—first, those in which the alternating current of the line is converted into direct current by rectifiers, smoothed by filters and then used to power filaments of the more familiar type of vacuum tubes and, second, those with tubes utilizing raw alternating current, either of the rugged filament or heater element type. Already considerable experience has been gained with the first type of set and its service and engineering difficulties are quite well known. With the second, there is less experience, and which of the two kinds will prove the ultimate winner is hard to say at this writing.

Tubes using raw a. c. for their A supply nevertheless need d.c. for B and C power, and therefore a rectifier of some kind is necessary unless A and C batteries are employed. The use of these tubes requires the introduction of an appreciable 60-cycle a. c. current right into the radio receiver, in and near the radio-frequency elements, introducing hum difficulties, and the life of the tubes under ordinary service conditions is yet to be determined. Considering that RCA, Cunningham, McCullough, Van Horne, and others are making a.c. tubes, it is certain that there has been much fruitful development work done since the first of this type of tube was introduced several years ago.

As to the first type of receiver, that is, those using conventional tubes, usually of the 199 type, with filaments in series and powered by a rectifier system, there is a wealth of practical experience in servicing them, gained during the last two seasons. The largest sellers in this class have been the Radiola super-heterodyne outfits used in connection with the 104 loud speaker and an a.c. rectifier power unit; the Garod, and the Zenith. By consulting not only manufacturers but the service heads of responsible dealer organizations, it has been possible to learn what the service problems in connection with the sets are. The author is particularly indebted to the R. T. M. Service and to Mr. H. T. Cervantes of Haynes Griffin Radio Service for much of the information which follows, based on their experience with thousands of these sets in the New York area.

The procedure for locating trouble, the significance of symptoms, and the remedies, are described with a view to aiding the set owner in determining whether his set requires the services of an expert service man or whether a simple adjustment will put it back in service. Breakdowns with a.c. sets generally impose a strain on the rest of the outfit and, consequently, a certain amount of knowledge of possible difficulties may avoid more serious damage.

When the set goes dead, either shut off the power until the service man takes charge, or else immediately determine whether the rectifier tubes light and, if the set has them, note also if the ballast and the regulator tubes glow. If these tubes appear to be functioning, reduce the filament voltages by means of the filament rheostat. Sets with filament rectifiers do not, of course, give visual indication of their condition and inspection is of no avail. The usual procedure, with such rectifiers, is to test with a rectifier tube known to be good.

Next check the condition of the radio, detector, and audio tubes of the set. This is easy, if you can plug in phones in the detector and audio stages. A signal in the phones indicates that all the tubes supplying them, including radio-frequency and detector stages, and sometimes the first audio stage, are in good working order, as is the power supply for all but the final output tube.

In absence of this convenient test, examine the tubes in the radio receiver. If necessary, darken the room to do so because tubes of the dry-cell type do not generally light very brightly. With some series filament receivers, all the tubes go out when one filament fails. With others, a resistor is used in parallel with each filament as a protective measure and it will pass enough current to light the remaining tubes in the receiver when one or two filaments are burned out.

If you do not locate the tube out of order by inspection, substitute a good tube for each one in the receiver, one at a time, remembering, of course, the first instruction to keep the filament rheostats low.

In the case of sets without the filament resistors in parallel, an even more serious strain is impressed upon the filter condensers when one radio tube goes out, unless a regulator tube is employed. In some cases, when the filament load is removed from the rectifier system, the voltage builds up greatly, sometimes sufficiently, in fact, to cause the breakdown of filter condensers.

The capable service man who, from a brief inspection of the receiver, decides that one of the radio or audio tubes may be dead, tests the tubes with a tube tester rather than placing his reliance upon the power supply of the set to do so. This avoids undue overload of the rectifier condensers. The manufacturer's instruction book often explains the best course to follow when the receiver goes dead and, understanding the reasons for it, the reader will not leave his power supply turned on if his tube filaments do not light, should the manufacturer advise him not to do so. The best test of radio and audio tubes is to use a tube tester or to replace the entire lot. Otherwise substitute a good tube in each socket, one at a time, leaving the remaining tubes in their sockets.

Assuming that rectifier and ballast tubes light and that radio and audio tubes have been proved good, the next thing to examine is the filament-type rectifier tubes. In most cases, if the rectifier tube or tubes show a blue or purple glow, it means that they have begun to leak. If so, place the set out of service at once, as there is no other repair possible than replacement of the rectifier tubes.

When there are two rectifier tubes, it may happen that the plates of one of them turns bright red while the other remains its normal color. Usually, this is a direct and simple indication that the tube which looks normal has lost its emission and the entire load of the set is being drawn from the other tube, which becomes red as a consequence of this overloading. The remedy is obviously replacement of the rectifier tube which does not overload.

On the other hand, when both rectifier tubes become bright red, it is due to an unusual load upon them, usually a broken-down bypass or filter condenser. Should this occur, the set should be placed out of service at once because this places an extreme overload on the rectifier tubes and the only remedy is replacement of the defective condensers. This is a job for an experienced service technician.

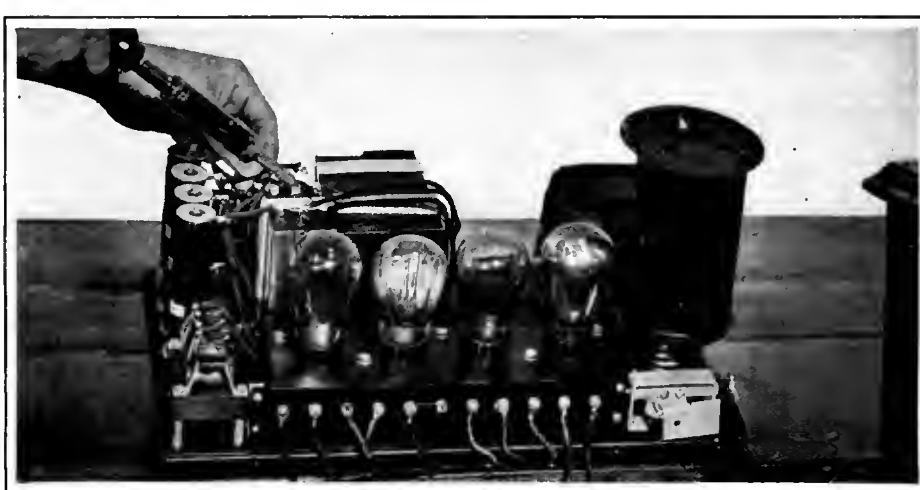
With those sets using regulator tubes, the simplest check which a service man is usually in a position to apply at once is the substitution of a good regulator tube to check the condition of the tube in service. When the regulator tube does not give a colored glow, either violet or pink, it is not receiving its necessary voltage supply, due to the shorting of a bypass condenser, failure of one or both of the rectifier tubes, a failing ballast tube or a radio or audio tube, the elements of which are short-circuited. It is the purpose of the regulator tube to keep the voltage supply constant. A prolonged loud signal or continued strong static may increase the brilliancy of its glow. But, if the antenna is disconnected any flashing of the regulator tube which occurs indicates that it is defective.

This completes the only frequent troubles encountered with a. c. sets. It is needless to go into the usual defects—loose connections, defective plug or flexible cord to power line, lost emission of power tubes, dirty contacts with socket, incorrect adjustment of reproducer, and other difficulties which are not specifically assignable to the a. c. set. They are the kind of difficulties which occur with increasing rareness as the mechanical and electrical design of receiving sets improve.

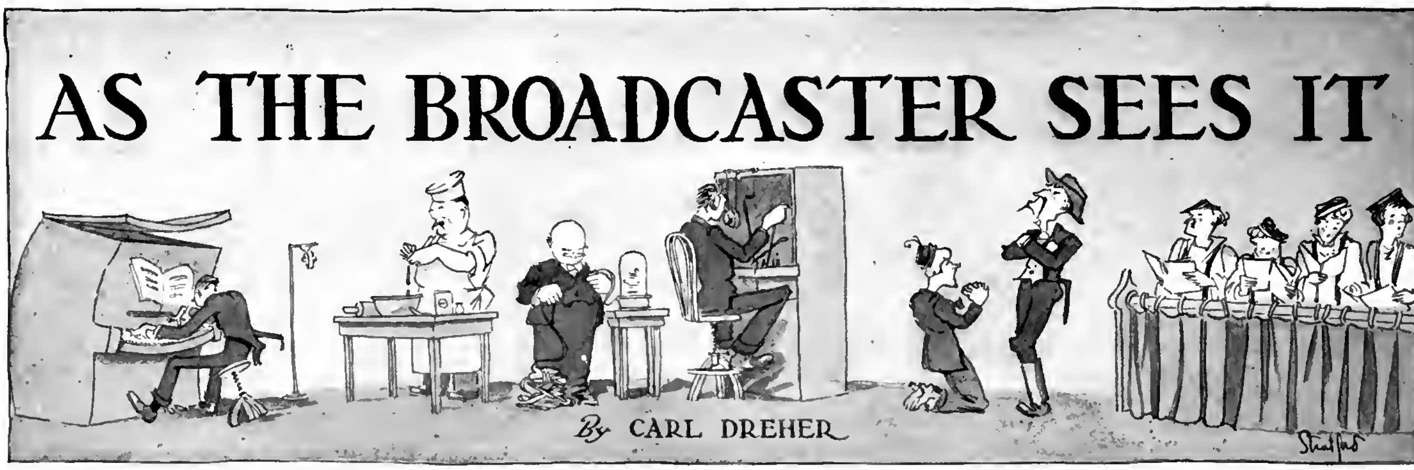
It may be worth while, however, to mention that a sudden increase of hum in the reproducer, which has previously been quiet, may be due to the breaking down of a bypass condenser, a change in the load conditions of the power line, or reversed line connections. The latter is sometimes correctable by pulling out the plug, giving it half a turn, and re-inserting it. The power-line noise may require the attention of the power company as, quite frequently, it is the result of using an appliance in the immediate vicinity which sets up power surges in the line. These can be cured by installing an interference preventor at the device.

From the foregoing, it is obvious that there is nothing unusual or startling about the service requirements of a.c. sets. They introduce new problems but, once these problems have become familiar, they will not cause any serious modifications in radio servicing. The radio trade is learning that it must take its service responsibilities seriously while the consumer is recognizing that service is something which he should pay for, just as he does when he has his watch or automobile repaired. Free service has worked as much harm for the consumer as it has for the industry itself, because dealers giving extensive free service ultimately fail in business. And there can be no redress when the dealer has gone out of business. Amateur servicing with power sets, also, may result in more serious damage, just as does inexpert tinkering with an automobile. Just why there is hesitancy in admitting these simple facts is a little hard to understand, since, with a little consideration, anyone will understand that free service, inexpert service, and promises of perfect reliability do not promote satisfaction to the radio user.

It is premature to set up rules for the selection of a. c. sets at this stage because the relative merits of the various a. c. systems have not yet been fully proved by user experience. One of the safest guides is to consider the engineering reputation and stability of the manufacturer and the service reputation of the dealer from whom the set is bought. A manufacturer who has a reputation worth losing will not skimp by using a cheaper filter condenser in the hope that it will not break down prematurely, nor will a dealer of established standing in his community jeopardize his standing by taking on a line without adequate test and engineering examination. The day of the a. c. set is here. It means simplified radio and adequate power, essential to beauty of reproduction. It means a broader market for radio receivers, with the inevitable consequences of larger production and more radio for the money.



MAKING TESTS ON AN A. C. UNIT
The two-microfarad condensers on the RCA 104 loud speaker power unit are here undergoing tests for possible defects



Going to Jail for Radio in Germany

IN THE United States, a good many, broadcast listeners are in jail, but not for listening to the programs. They went to prison first and listened to the radio afterward, broadcasting being one of the inducements offered in all up-to-date penitentiaries. In Germany, however, radio has been the direct instrumentality whereby one gentleman went behind the bars. It appears that he was a *Schwarzhoerer*, which means, literally, a black listener, i.e., one who neglects to pay a fee and secure a license for his receiving set, as required by German law. The first time this recalcitrant BCL was caught he was fined and his set confiscated. The second time the authorities, with due process of law, clapped him into the jug for three weeks. If they catch him a third time presumably he will be tried by a court martial of studio managers and shot some Greenwich Mean Time morning.

As a practicing broadcaster, I regard this incident as a bad precedent, and am relieved that it occurred in a foreign country. For, if a broadcast listener may be sent up for a little radio bootlegging in this style, it is only a matter of time when the broadcasters themselves will spend their week-ends behind stone walls with spikes and sentry boxes on top. A program impresario permitting one of his flock of baritones to sing "Rolling Down to Rio" will be sent away for six months. The singer himself will merely receive a black eye at the hands of one of the catchpolls, for delicate psychological tests have proved that all baritones are subject to an irresistible impulse to warble this tune. When one of the water-cooled tubes lies down in the middle of a program, interrupting the festivities for a minute or so, the engineer of the station will be set to breaking rock for one year. When the transmitter deviates from the assigned frequency, the jolly technician will be separated from his wife and children one year for each kilocycle high or low and if another station has been heterodyned the owner thereof will be permitted to extract the offending engineers' teeth. This may seem a cruel, unusual, and hence unconstitutional punishment, but it is a sound maxim of law that a statute may be constitutional in one age and unconstitutional under later circumstances, and some judge may reverse the process and decide that, as broadcasting was not known to the Founding Fathers, new and appropriate punishments may properly be devised for erring broadcasters. On this principle, announcers who read telegrams of appreciation to the radio audience will be forced to eat a pound of coarsely ground Celotex. Announcers who read their own poetry over the air will be thrown to the tigers in the nearest zoo, thus relieving the tax-payers in two ways.

Some of these penalties, I admit, appeal to me, and I have derived pleasure in contriving them. But, as I said, I disapprove the principle, since I am a broadcaster myself, and might be one of the first to be dragged to the hoosegow. I therefore appeal for moderation in this instance, and shall telegraph to my Congressman requesting that our government make representations to the Reich on behalf of the imprisoned *Schwarzhoerer*.

Radio's "Aristocracy of Brains"

I OFTEN reflect on the melancholy fact that the men who really made radio, the Marriotts, Alexandersons, Fessendens, Hogans and the rest, are not as well known as the more popular announcers of fifty-watt stations. Compared to the coruscating luminaries of the networks, like MacNamee and Cross, the engineers do not shine at all. For this there are, of course, sufficient reasons, psychological and sociological; one might as well lament that Dr. G. W. Crile is not as well known a man as Babe Ruth. I shall not waste my tears in this cause, yet I cannot refrain, coming down to cases, from pointing an accusing finger at our contemporary and friend, *Popular Radio*, which on Page 402 of its April, 1927, number, prints a picture with the caption, "A Group of Radio's 'Aristocracy of Brains.' The description which follows is reprinted verbatim:

Dr. Ralph Bohn (in front of the desk) is receiving the Liebman Memorial Prize of the Institute of Radio Engineers from Mr. Donald McNicol, former President of the Institute. Dr. Bohn himself is the new president. At Mr. McNicol's left is Mr. John V. N. Hogan, Contributing Editor of *Popular Radio*. Next to him is Mr. R. H. Mariott. Behind Dr. Bohn are Professor Michael I. Pupin, of Columbia University, Mr. L. E. Whittemore, and Mr. E. F. W. Alexanderson, well-known inventor and radio engineer of the General Electric Company.

Children, what is wrong with this description? In the first place, the President of the Institute of Radio Engineers is Dr. Ralph *Bown*. The prize is awarded each year in memory of Colonel Morris N. *Liebmann*. Mr. Hogan's middle initials are *V. L.* Robert Henry *Marriott*, the first President of the Institute, spells his name with two "r's." Finally, the gentleman in the picture just behind Professor Pupin looks suspiciously like Dr. J. H. Dellinger, and not at all like Mr. Whittemore. The total of errors appears to be five. I call loudly for a more flattering vigilance in such matters on the part of Messrs. Kendall Banning and Laurence M. Cockaday. They run altogether too good a magazine to permit such a high concentration of mistakes to the cubic centimeter of printer's ink to pass unnoticed, especially in reference to the Brahmins of the radio art.

Memoirs of a Radio Engineer. *XX*

MY FIRST assignment at the Aldene factory was in the test shop. This was a good-sized room in the old stone building, which later became merely an annex to the modern factory structure erected to fill the wartime requirements of the Army and Navy. Along one wall there was a switchboard controlling the supply of a.c. and d.c. to various outlets. For the rest the room was crowded with quenched spark transmitters of all sizes from one-quarter to five kilowatts, miscellaneous apparatus in various states of disarray, work tables, meters, and a few men: W. H. Howard, the Chief of Test; Baldwin Guild, now practicing patent law with Pennie, Davis, Marvin, and Edmonds; my present colleague O. B. Hanson; a tall gentleman named Lieb; a more medium-dimensioned gentleman named West, and myself. I may have omitted someone, but I think this comprised the list in May, 1917.

The engineering staff of the Marconi Company had the privilege of using the facilities of the test room for experiments when they could get in. By experiments I do not mean research on electron velocities or anything else at all recondite, but merely such incidental tests and measurements as always accompany the design of apparatus. This work had to be sandwiched in between the routine test functions of the department. Inasmuch as I was known to possess some engineering training, I was assigned temporarily as a sort of assistant to engineers who required work to be done in the test room. My first job was handed to me laconically by Mr. Woodhull, one of the transmitter engineers. A five-kva transformer was trundled into the test shop and dumped off. "Measure the iron losses," said Mr. Woodhull, and disappeared.

I gazed at the transformer. It contained plenty of iron in the form of a shell core, and no doubt there were losses. I could identify the primary leads, which were to be fed at 110 volts a.c., and the secondary terminals, which were expected to deliver juice at 10,000 volts or so to the quenched spark gap of the five-kilowatt transmitter. I had never measured the iron losses of a transformer, but I had some vague recollection, from

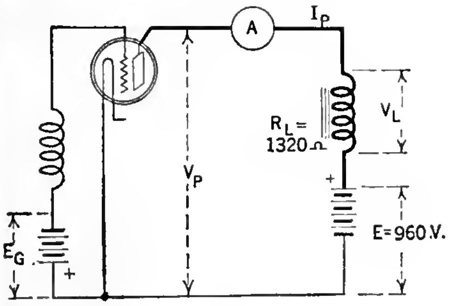


FIG. 1

my studies, that the procedure was to put rated voltage across the primary, leave the secondary open, and measure the power input with a wattmeter under this no-load condition. So I looked around for a wattmeter. The only one I could find had a full scale deflection of 7.5 kw., so I hooked it up and threw the switch. Nothing happened. I disconnected the wattmeter and tested it on another set which was under load. There was nothing obviously wrong with the instrument; it read several kilowatts. I put it back in my circuit and tried again, still without results. After an hour or so Woodhull came back and wanted to know what the iron losses of his transformer were. With much embarrassment I confessed that I did not know, and showed him my predicament. He looked over the circuit, and then glanced at the wattmeter. The scale made him laugh. "The iron losses are only of the order of a hundred watts," he told me. "You can't read that value on this scale. Get a 0.5-kw meter out of the storeroom and try again." Following these directions, I measured the iron losses of the 5-kva transformer at 70 watts, if I remember the figure correctly. Then we went ahead with some other tests involving loads.

This incident illustrates what the engineering student just out of school is up against. He usually has only a vague idea of magnitudes. I had studied under first-rate teachers and my preparation in some directions, was not at all bad. But there were numerous other fields in which I really did not know whether the answer would come out in millimeters or meters, or watts or kilowatts. If that wattmeter had swung up to a reading of a kilowatt or two for the iron losses of a small transformer, I should not have been surprised. A bonehead idea? Certainly, at that place and time. But what is a good engineer? One who has, in the course of practice, got rid of a few thousand of such bonehead ideas. He gets paid largely for the relatively accurate judgment of physical magnitudes (always checked by measurement) and economic results (always checked by the balance sheet) which he has been able to put in their place.

(To Be Continued)

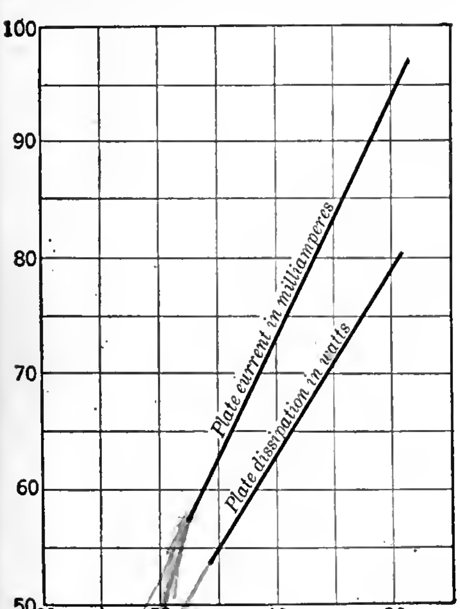


FIG. 2

Technical Problems for Broadcasters. *IV*

The plate feed of a fifty-watt (oscillator rating) tube used as a reactance-coupled amplifier in a broadcast transmitter is shown in Fig. 1. Plate potential is supplied by a storage battery with an output voltage E of 960 volts, the internal resistance being negligible. The reactor in the plate circuit has 50 henrys inductance and the d.c. resistance R_L is 1320 ohms. The resistance drop across it is designated by V_L, and this will necessarily depend on the mean current plate current I_P which is indicated by a milliammeter A in the plate circuit. This plate current varies with the negative grid bias E_G according to the upper characteristic curve of Fig. 2. The problem is, Given a safe plate dissipation of 70 watts for the tube in question, what is the minimum allowable negative grid bias under the conditions shown?

Solution

We are told that 960 volts is the steady output potential of the storage battery under all conditions, since its internal resistance may be neglected. Hence, in order to find the actual voltage V_P on the plate of the tube, all that is required is to find the voltage drop along the reactor for various plate currents, and subtract these values from 960. The plate dissipation W_P of an amplifier of the type shown is the product of the mean plate current and voltage, as indicated by d. c. instruments in the circuit. We may therefore draw up the following table:

E_G Volts	I_P Milli-Amperes	V_L Volts	V_P Volts	W_P Watts
30	94	124	836	78.5
35	83	105	855	71.0
40	72.5	95.5	864.5	62.5
45	62	81.5	878.5	54.4

The first two columns are obtained from the plate current-grid voltage characteristic. The V_L column follows when the value of plate current in each case is multiplied into 1320, the d.c. resistance in ohms of the reactor, giving the direct voltage drop across the winding. Subtracted individually from 960 volts, these values yield the actual plate potentials corresponding to the various grid bias figures. The plate dissipation is then calculated in each instance as the product of the V_P and I_P. As it happens, the plate dissipation results are numerically of about the same order as the plate currents in milliamperes, so that they may be plotted in the form of the lower curve of Fig. 2. (This is an accident, resulting from the fact that the plate potentials are near 1000 volts, but of course an independent characteristic could be drawn in any case.) From this curve we note that 70 watts dissipation corresponds to 35.5 volts negative grid bias. The answer to the problem is, therefore, that 35.5 volts is the minimum allowable bias to be used with the tube in question if the plate is not to be overheated.

Abstract of Technical Article. *VI*

"Making the Most of the Line—A Statement Referring to the Utilization of Frequency Bands in Communication Engineering," by Dr. Frank B. Jewett. Presented before Philadelphia Section of the American Institute of Electrical Engineers on Oct. 17, 1923. Reprinted May, 1924 by Western Electric Company, Inc. (Bell Telephone Laboratories, Inc.).

Although telephone wires used in connection with broadcast transmission are in general not utilized for other communication services during program periods, technical broadcasters will find it instructive to learn something about the multiplication of channels on expensive long distance circuits by the use of separate frequency bands for different purposes. Doctor Jewett, who is himself responsible for much of this development, has outlined the main features in this paper.

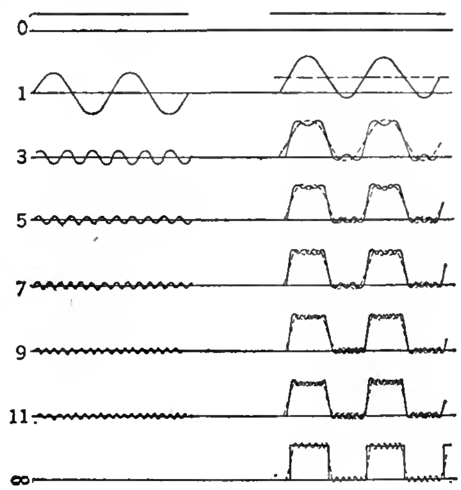


FIG. 3

The first point which concerns us is the analysis of a square-topped wave, reproduced here as Fig. 3. Such a wave is produced in a direct current telegraph system which has neither capacity nor inductance, as the circuit is made and broken by a key. It may be established mathematically and graphically that such a square-topped wave is composed of a continuous direct current and a number of sine wave alternating currents, comprising a fundamental frequency corresponding to the keying frequency, and, theoretically, an infinite number of odd harmonics. Fig. 3 shows this d.c., and the a.c. components up to the eleventh harmonic, with the resultant wave form in each case, and the ideal rectangular shape which is secured when all the harmonics are preserved. Fig. 4 is a diagram showing the same components in their relative amplitudes. If the current at the receiver is to be a strict reproduction of that at the keying end, frequencies considerably higher than the keying frequency must be transmitted. With hand sending it may be necessary to pass over the line frequencies as high as 40 cycles, to preserve the wave shape. With a multiplex printer the range is preferably extended to 100 cycles per second. Even in telegraphy, we note, accurate reproduction (what we call "good quality" in broadcasting) requires widening the frequency band.

Instead of keying a direct current for telegraph

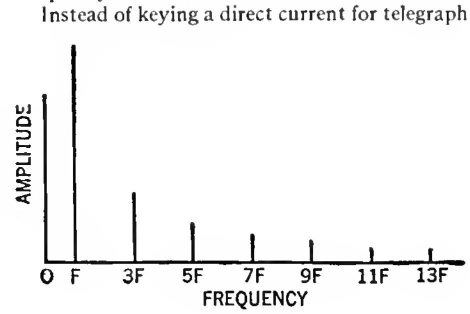


FIG. 4

communication, we may make and break an alternating current carrier. The resulting wave is shown in Fig. 5, the carrier being assumed to obey a sine law, and the line to be without inductance or capacity. This wave may be resolved into a fundamental and harmonics, as shown in Fig. 6. The difference between Fig. 4 and Fig. 6 is that in the former (d.c.) case the harmonics are grouped in ascending order on the positive side of the hoizontal axis, starting with the frequency O, which is the direct current component, while with an a.c. carrier the harmonics are grouped on either side of the carrier frequency. In the latter method we employ a process of modulation and remodulation (now more commonly called demodulation). The process of modulation consists in taking a group of currents which have a certain relation to each other, mixing them with a carrier and thus translating them to a more convenient frequency band, while not disturbing the relation between them, and then, in demodulation, getting back the original group at its original frequencies. This is what we do in radio telephony as well as in the carrier telegraph illustration here used. Fig. 6, it will be noted, shows a carrier with both sidebands. For the transmission of intelligence only one of the sidebands need be retained, a locally generated carrier being substituted for the transmitting carrier, at the receiver, for the purpose of demodulation.

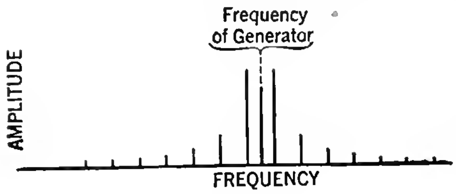


FIG. 6

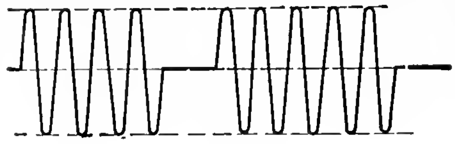


FIG. 5

In low frequency telephony a complex combination of frequencies corresponding to the sounds of speech and music must be transmitted, with fair fidelity in the case of commercial toll circuits and with considerable fidelity for broadcast purposes. In high frequency telephony, whether by radio or line carrier current, the same process of modulation and demodulation is carried out, but the representative chart of current components shown in Fig. 7 indicates the infinite number of harmonic mixtures and proportions. This particular combination corresponds to the sound of long *o* modulated by the human voice, and is relatively lacking in high overtones.

In transmitting a number of signal waves over a common circuit it is necessary to generate and separate various kinds of currents. The devices used in the latter process fall generally into two classes:

1. Elements such as transformers, condensers, and choke coils, which discriminate between alternating and direct currents.
2. Filters.

The use of (1) is familiar in urban telephone systems of the central energy type. Low frequency (usually 16-cycle) alternating current is employed to ring subscribers' bells, direct current is supplied from a common battery for the transmitters, and alternating currents of voice frequency pass between the subscribers and operators. Direct current is supplied only when the receiver is off the hook, being controlled by the hook switch. The operator's ringing key controls the low frequency a.c. used for signalling. The voice currents pass from one trunk circuit to another through repeating coils, but d.c. is confined to subscribers' loops by the same agency. (Audio amplifiers, and such devices as output transformers for loud speakers, utilize inductances and capacities for similar purposes.) A.c.-d.c. separation is also required in joint use of telephone and direct current telegraph services on one line. Fig. 8 shows one such arrangement, blocking condensers being used to keep the d.c. telegraph currents out of the telephone set, and chokes to keep the voice currents away from the relays and sounders. A series connection of chokes and a parallel connection of condensers (by-pass) is a protection against a.c. while a parallel choke and series condenser arrangement discriminates against d.c.

(To be Continued in the November Issue.)

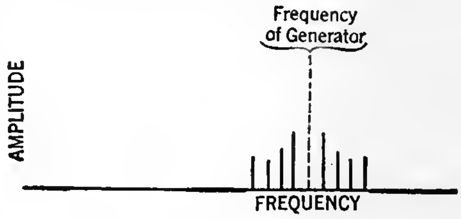


FIG. 7

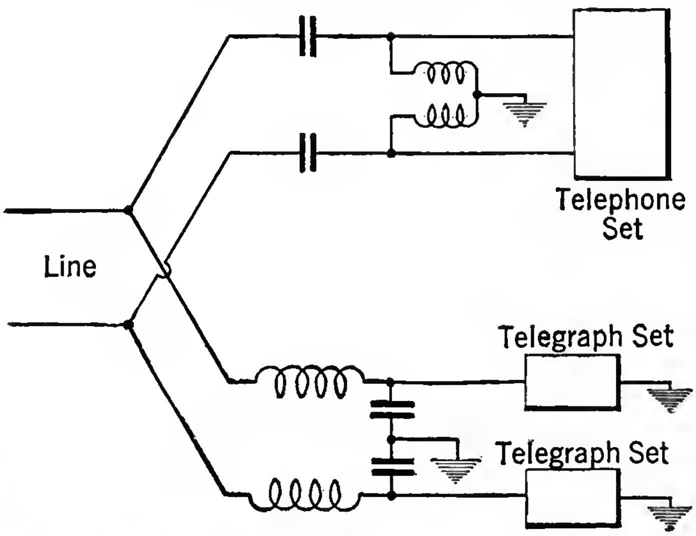
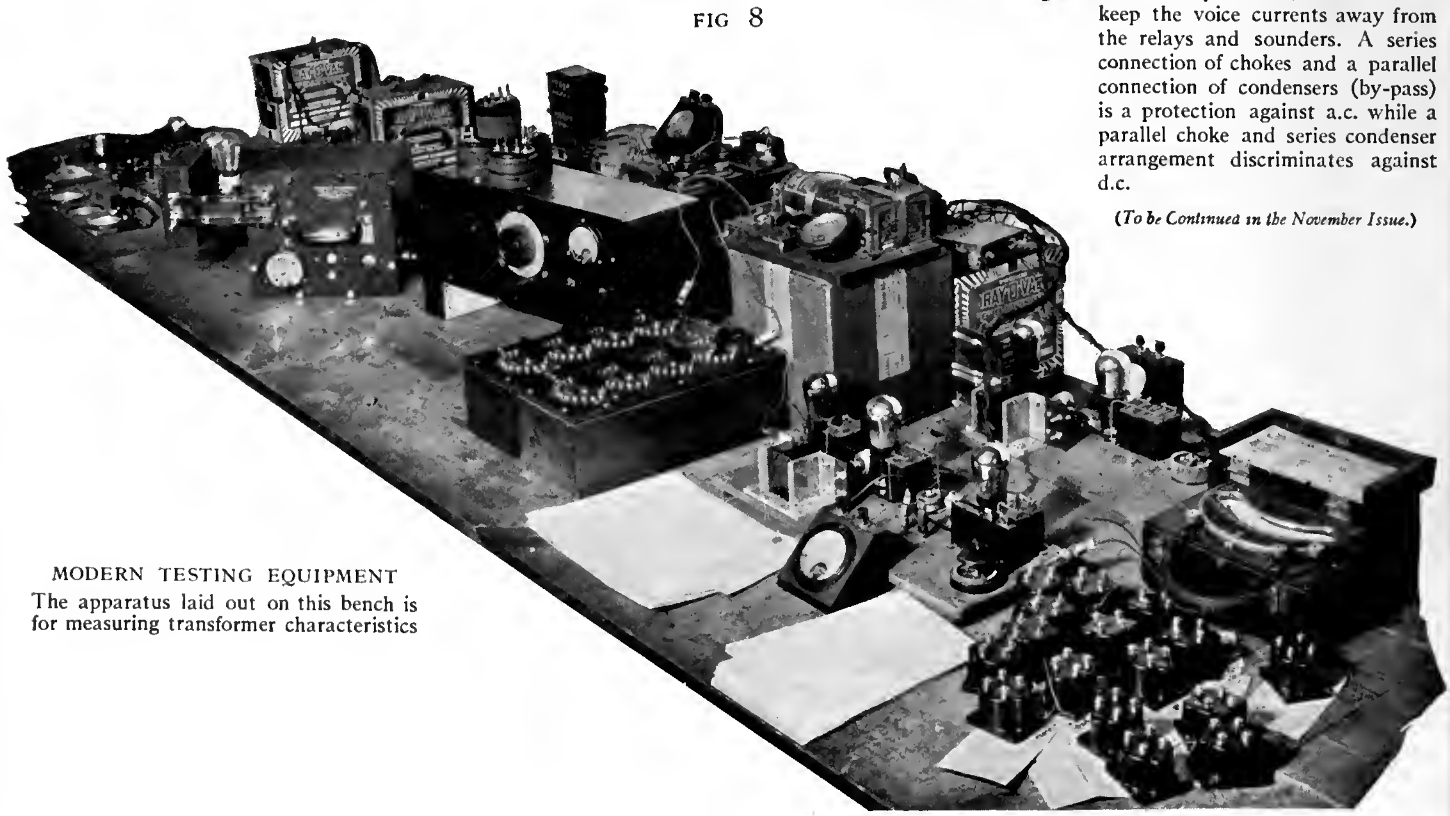


FIG 8



MODERN TESTING EQUIPMENT
The apparatus laid out on this bench is for measuring transformer characteristics

Home-Constructing Transformers and Chokes for Power-Supply Devices

The Second of Two Articles Intended to Obviate Tricky Mathematical Calculations when Building These Units—The Design of Choke Coils, and the Actual Construction of Both Chokes and Transformers, Is Discussed

By HOMER S. DAVIS

CHOKE coils are used in radio work chiefly to introduce opposition to the flow of alternating current, while at the same time allowing direct current to pass easily. In general, the lower the frequency of the alternating current, the more the inductance required. At radio frequencies, air-core chokes may provide sufficient opposition, but at audio frequencies and for smoothing out the ripple in power-supply units, an iron core is provided to make possible a greater inductance in a more compact unit, since the magnetic flux will flow through iron more easily than through air.

A different situation exists in the core of the choke coil than in the transformer core. In the latter, the magnetic flux due to the alternating current has the core all to itself, while in the case of the choke it has to share the core with the flux due to the direct current. To make certain that the direct current flux does not saturate the core, an air gap must be placed somewhere in the core. This greatly complicates the design, and a reasonable length of gap is difficult to maintain. Too great a gap will reduce the inductance and therefore require a larger choke for the same amount of inductance, while too small a gap will increase the harmonics, thus impairing the filtering action. It is generally agreed that a good value to use is one that uses up about ninety per cent. of the magnetizing force. For an ordinary silicon steel core this means a gap about 0.005 inches long for each inch of core length. The actual value to give best results can be determined only by trial with the other apparatus with which the choke coil is to work. Only the core type of construction will be considered in this article, as was done in the case of the transformer, design data for which were given in last month's article.

The inductance of the choke coil is proportional to the cross section area of the core, to the square of the number of turns of wire, and inversely to the length of the air gap. This is expressed mathematically as:

$$L = 3.2\frac{AN^2}{G10^8} \qquad (1)$$

where L is the inductance in henries, A the net area of the core cross section in square inches, N the number of turns, and G the equivalent air gap in inches. The equivalent air gap is defined as the total reluctance of the core, including the actual air gap, reduced to an air gap of the same cross section which will replace it. The value of equivalent air gap to use in designing the choke is uncertain. It is best figured from the formula:

$$G = 3.2\frac{NI}{B} \qquad (2)$$

in which N is the number of turns of wire, I the current in amperes, and B the flux density in lines per square inch. The value of I being predetermined, adjust the number of turns so as to give a flux density of not more than about 50,000 lines per square inch, with a reasonable value of G. This is relatively easy with small currents, but with the larger currents it is very difficult to maintain reasonable flux density. The value of G increases with the size of the choke, starting with about 0.03 inches as a minimum.

To avoid the mathematical difficulties of using the above formulas, calculation charts have been devised to replace them, formula No. 1 being represented by Chart II and formula No. 2 by Chart I.

The first things to begin with in designing a choke coil are the inductance and the current capacity. A reasonable length of air gap is then decided upon, and a flux density of about 50,000 lines per square inch assumed to start with. The number of turns can then be found from formula No. 2 or Chart I, after which the size of core may be figured from formula No. 1 or Chart II. Here it may be found that either the amount of copper or the size of the core is excessive from the standpoint of economical and compact design, in which case it may be necessary to try again with a larger air gap or a smaller flux density, or both. Several trials are often necessary before a reasonable design is arrived at. Then with these vital factors settled, the next step is to choose the size of wire to handle the current, just as was done with the transformer.

Here again it is convenient to lay out a full-size drawing of the choke coil, to see just how its proportions will work out. As with the transformer, a compact arrangement should be striven for. Enameled wire is best for the choke, as the voltage difference per turn is small and thicker insulation would make the choke unnecessarily bulky. Allow for about $\frac{1}{16}''$ of insulation between the winding and the core. Insulating papers between layers are seldom used with choke coils. If the layout looks unwieldy with all the winding on one side of the core, it may be split into two coils on opposite legs. Although this requires less wire per turn, about 10 per cent. more turns should be added to each coil to make up for the effect of leakage of flux between them. With the drawing completed, the length around the center line of the core may be measured and the theoretical length of air gap computed on the basis of 0.005 inches per inch of core length, and compared with the value used in the design, to make sure that the latter was not assumed too small. The amounts of wire and core material may be estimated in the same manner as with the transformer. The resistance of the choke coil is an important factor, and, knowing the total length of wire and looking up its resistance per thousand feet in the wire table, on page 277 of the August article, it may be readily estimated. If the resistance proves greater than desirable, use a larger size of wire.

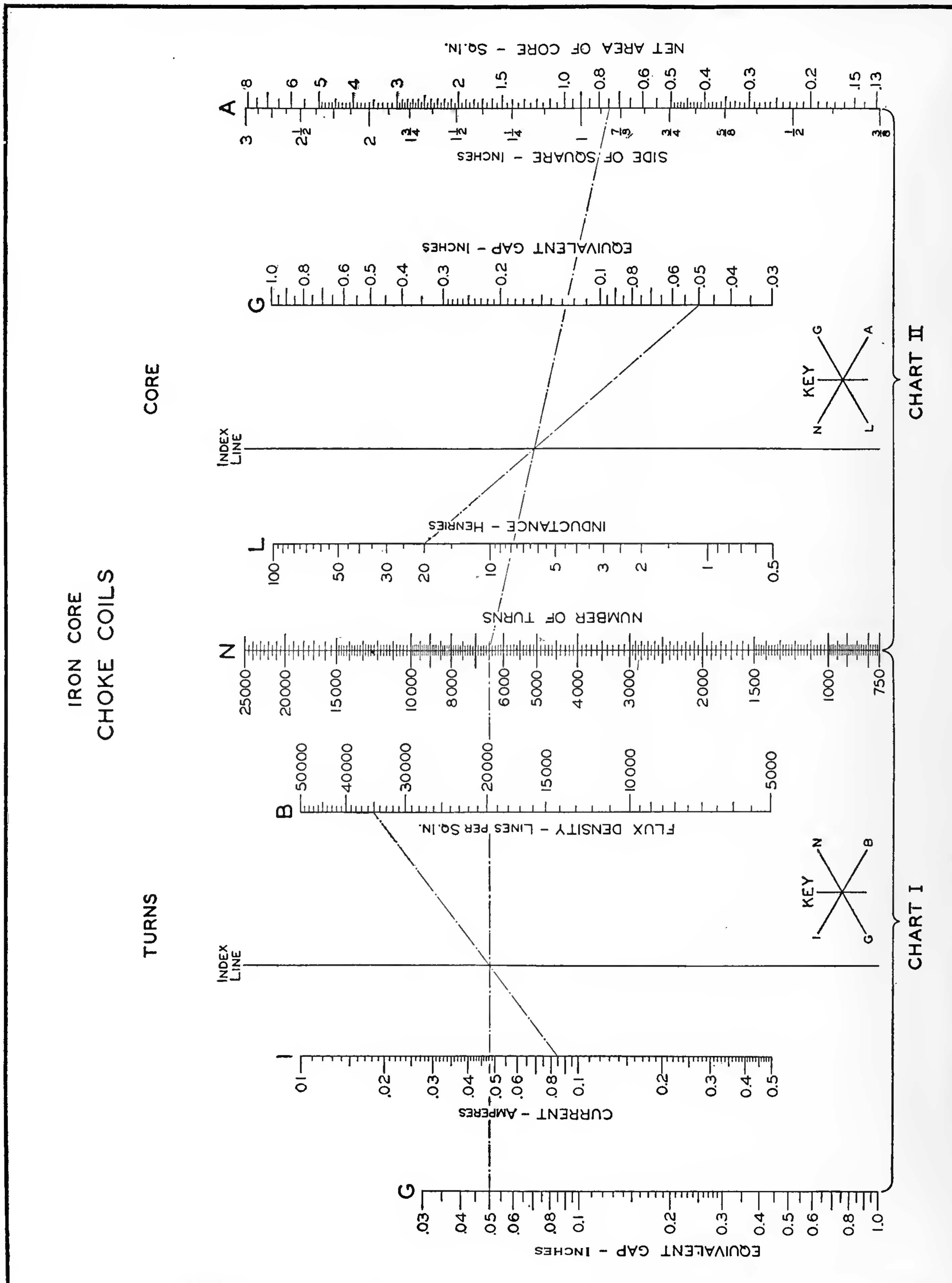
The solution of a typical example should clear up any doubtful points remaining. Suppose a 20-henry choke coil is desired, capable of carrying 85 milliamperes of direct current. Where a choke is connected directly to the output of a rectifier without previous filtering, the maximum value of the rectified alternating current may be as high as 1.57 times the value of the direct current. Since both the alternating and direct currents contribute to the flux in the core, and only the direct current component has been used in the formulas, it is customary to allow for the alternating current component by modifying the value of flux density substituted in the formulas. About 35,000 lines per square inch will be satisfactory. Assume an equivalent air gap of about 0.05 inches. The number of turns of wire to wind on the coil may be found from Chart I. The key at the bottom of the chart shows which scales to connect together. Accordingly, draw a straight line from 0.085 on the current scale to 35,000 on the flux density scale. Through the point at which this line crosses the index line, draw a second line from 0.05 on the equivalent gap scale until it meets the turns scale, at 6500 turns in this case. Next, the size of core to use is obtained from Chart II. Draw a line from 20 on the inductance scale to 0.05 on the equivalent gap scale. Through the point at which this line intersects the index line, draw a second line from 6500 on the turns scale until it meets the core area scale. This point indicates a net area of 0.74 square inches, which is approximately equivalent to a core $\frac{7}{8}''$ square.

As mentioned before, the design is not so straightforward for the larger currents. It is difficult to arrive at a compact, economical design, and frequently it is necessary to make several trials. Sometimes a faulty design will not be evident from the plain figures, but will show up when the full-size drawing is made. The only remedy is to try again.

Having settled on the number of turns and area of the core, the next step is the determination of the wire size. This is done in exactly the same manner as with the transformer. Then comes the full-size layout, estimation of materials, and resistance calculation. If the resistance proves excessive for the particular use to which the coil is to be put, choose a larger size of wire and make a new layout. The design is then complete.

CONSTRUCTION

THE preparation of the core of the transformer or choke coil should be undertaken first. Several sources of the material are open to the constructor. Oftentimes a junked pole transformer may be obtained for a small sum from the shops of the local power company or from a junk yard, the core of which may be removed, cleaned with kerosene or alcohol, and cut down to the required size. For use in a B socket power-supply device, the core of a toy


IRON CORE
CHOKE COILS
CORE
TURNS
INDEX LINE
INDEX LINE
NET AREA OF CORE - SQ. IN.
SIDE OF SQUARE - INCHES
EQUIVALENT GAP - INCHES
INDUCTANCE - HENRIES
NUMBER OF TURNS
FLUX DENSITY - LINES PER SQ. IN.
CURRENT - AMPERES
EQUIVALENT GAP - INCHES
KEY
KEY
CHART I
CHART II

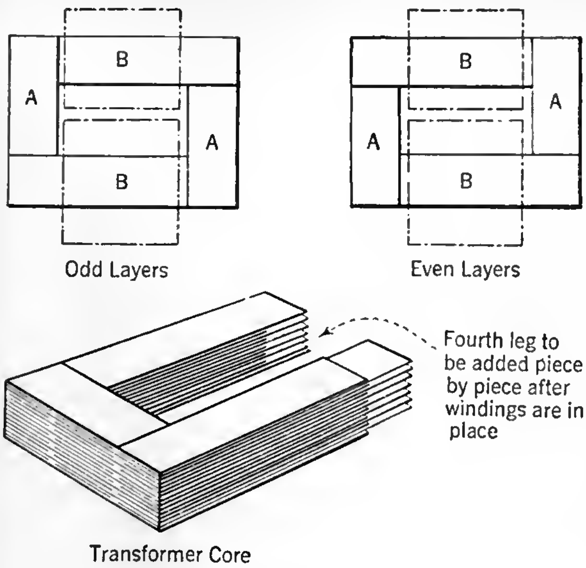


FIG. 1

transformer will often be found to be about the right size without cutting. Ordinary stovepipe iron may be cut to size and used, but it will increase the losses, resulting in excessive heating and waste of power unless a much larger core is used. The use of regular transformer steel is recommended wherever possible. Motor or armature repair shops sometimes handle it. Supply houses that cater to transmitting amateurs often stock it and will cut it to any desired size. Their advertisements may be found in current amateur periodicals or their addresses obtained from a neighboring "ham." This source lacking, purchase the best available grade of soft sheet iron or steel from a local tin shop. It should be not more than 0.014" thick. It is best to cut the material to size with squaring shears, or to have a tinsmith do it, as accurate work is essential. Unless the pieces are square and of uniform size, poor joints at the corners will be inevitable and the resulting small air gaps will increase the core losses due to reduction of effective area. All rough edges should be removed and the pieces should lie flat.

If an old core is used, the construction of the transformer will of course depend upon whatever conditions are encountered. But assuming that the raw material is available, several types of core arrangement are possible. The one shown in Fig. 1, using interleaving joints, is most convenient for transformers. Two different sizes of pieces are required, shown as A and B, with enough of each to stack twice as thick as the completed core when tightly clamped. Another way of building up the core is indicated in Fig. 2, but this type is not practical unless the pieces of the core are very accurately cut and closely butted together. This construction may be used for choke coils, however, since an air gap is required somewhere in the core, its location being immaterial as long as the requisite total length is provided. Fig. 3 illustrates a modified construction for chokes which has the advantage of being easier to clamp. In this case the pieces are cut to four different sizes, with enough of each to make up the full thickness of the core.

Some sort of insulation between the laminations should be provided, to reduce the core losses due to eddy currents. Commercial transformer steel usually comes with an oxide coating for this purpose. Ordinary rust is often sufficient when the oxide coating is not present, but it is better to apply a thin coat of shellac to one side of each piece, allowing it to dry thoroughly before assembling.

If the interleaving type of construction is used, the building up of the core may be expedited by providing some sort of square corner as a guide, such as a cigar box with two adjacent sides removed. Only three sides of the core should be assembled at first, alternating the layers as shown in Fig. 1; the fourth side is to be put in piece by piece after the coils have been slipped into place. The partially completed core is carefully removed to a vise and clamped, and the legs that receive the coils bound tightly with a layer of tape, or with heavy string, which may be later unwound as the coils are pushed onto the core. The joints should be carefully trued up, making sure that the pieces butt together well. A wooden mallet, or a rawhide or lead hammer may be used for this purpose.

Preparing the coils is not difficult if done properly. They should be evenly wound in layers, not only to make for compactness, but to prevent the possibility of two turns of widely different voltages coming together. Coils of small enameled wire should have a layer of paper between each layer of wire, to keep the winding even and to improve the insulation. If special insulating papers are not available, tracing paper such as used by draftsmen, will serve the purpose nicely; ordinary wrapping paper can also be used. These papers may be omitted with the larger sizes of enameled wire, since they are easier to wind evenly and the voltage difference between layers is less. They may be dispensed with entirely if cotton-covered wire is used.

Windings of cotton-covered wire may be made moisture proof and more rigid by applying a thin coat of shellac to each layer as wound, and baking the finished coil to dry it out. Enameled wire cannot be treated in this way, however, as the shellac may soften the enamel. Small coils of enameled wire may be made rigid by dipping them in melted wax, such as a mixture of beeswax and rosin. Ordinary paraffin is not suitable, as it may soften if the transformer runs at all warm. Large coils may be painted with insulating varnish or black asphaltum paint.

The windings may either be made self-supporting or wound on a fibre spool which is slipped over the core. The former is the more common method. A square wooden mandrel the same size as the core cross section is first prepared, cut to the same length that the winding is to be, and sanded smooth. For the larger core sizes it may have to be built up of several thicknesses of wood glued together. Flanges a quarter of an inch thick are then screwed to each end, as shown in Fig. 4; these are later to be removed in order that the winding may be slipped off.

Some means of rotating the winding form must be provided. A convenient arrangement is to drive a spike in the center of one end of the mandrel, grind or file off the head, and secure the end of the spike in the chuck of a hand or breast drill which is clamped horizontally in a vise. A lathe may also be used. A small geared emery wheel is excellent for the purpose. Another common method is to fasten the mandrel to a wooden disc which is clamped or wired to the flywheel of a sewing machine. If a geared emery wheel or hand drill is used, the number of turns of wire may be computed by determining the turns ratio between the crank and the spindle, and then counting the turns of the crank. Another way is

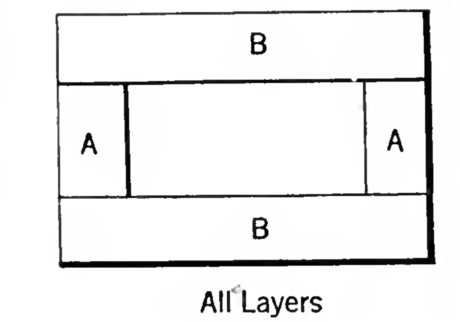


FIG. 2

to insert the spindle of a revolution counter into a hole in the free end of the mandrel, as shown in Fig. 4.

As the coils are to be taped when finished, wind a layer of heavy string around the mandrel and fasten the ends. This is to be unraveled after the coils are wound, enabling them to be slipped off easily and allowing room for the tape. A layer or two of fibre is then cut to size and squarely

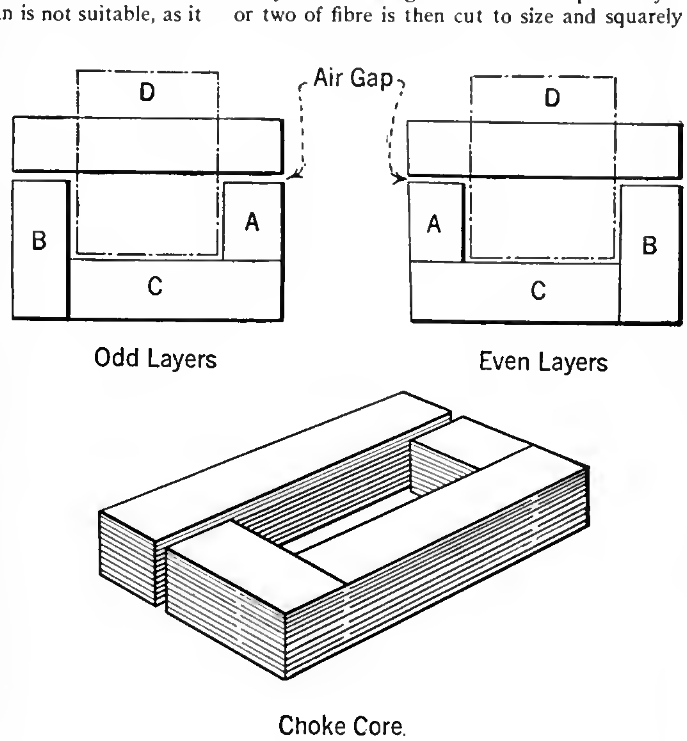


FIG. 3

bent around the string-covered mandrel and glued in place. On high-voltage windings, above about 500 volts, add a few layers of empire cloth, which may be obtained at motor repair shops.

WINDING THE COIL

THE coil is now ready to be wound. Pass the free end of the wire through a small hole drilled in the flange, leaving enough wire to provide a lead to the panel. If fine wire is used, the lead and the first few turns should be of insulated flexible wire, to avoid any possibility of the lead breaking off. The fine wire is then soldered to this, carefully cleaned of any excess flux, and the joint covered with a bit of tape. The rest of this first layer is then wound. If the wire is cotton-covered, this layer, and each succeeding layer as wound, may be given a thin coat of shellac as a binder, or insulating papers may be used as described above, for enameled wire. The wire should be wound as tightly as its strength will permit. It may be necessary here to wear a glove on the guiding hand, or to pass the wire over a piece of cloth held in the hand. Guiding the wire will be made easier if the hand is held as far away from the coil as is convenient. The turns should be kept close together and not allowed to overlap, and extreme care should be exerted to avoid any possibility of shorted turns. A shorted turn acts as an independent short-circuited secondary and will burn out as soon as the transformer is connected to the line. Where taps are brought out, the turns per layer should be so arranged, if possible, that the taps will come at the end of a layer. Be especially watchful here for shorted turns. In finishing the winding, pass the end of the wire through another small hole in the flange and fasten the last few turns with a bit of sealing wax. With fine wire the last few turns and the lead should be of flexible wire just as at the start. If another winding is to be placed over the first, they should be separated by several layers of friction tape or empire cloth.

Where a split secondary is used, the two coils may be wound side by side, each covering half the mandrel, rather than one on top of the other, to insure their having symmetrical characteristics. An end flange may be removed while a fibre separator is slipped in place, and one side filled tightly with cloth strips while the other is being wound, to prevent the separator being crowded over. A split or center-tapped filament winding of only a few turns may be wound by means of a pair of wires, each comprising half of the total number of turns, the end of one wire being connected externally to the beginning of the other so as to put them in series. The connection between the two is used as the center tap.

The finished winding may be removed from the form by taking off one of the flanges and pulling out the layer of string, after which the coil can be slipped off. It may then be taped, as in Fig. 5, using ordinary friction tape and advancing half the width with each turn. High-voltage coils should be covered with empire cloth tape. The tape should not be allowed to bunch at the inside corners, or trouble will be experienced in inserting the core. The coils should not be taped too heavily, or they will not cool well.

Small coils of enameled wire may be conveniently made by winding them on spools made of pieces of fibre glued together. After being wound the wire may be covered with a layer or two of heavy paper or one layer of friction tape.

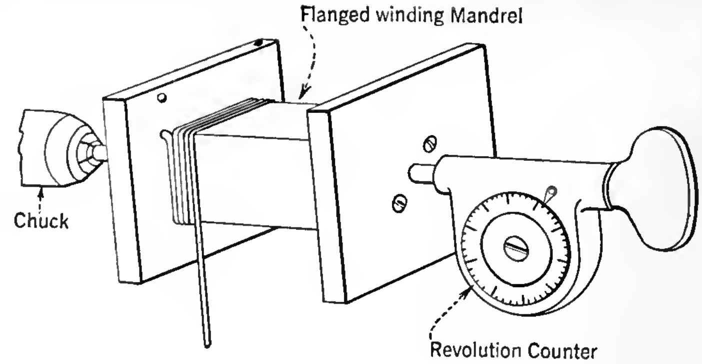


FIG. 4

The finished coils, after painting or moisture-proofing, may now be placed on the core, unwinding the string on each leg as its coil is pushed on. The fourth leg of the core is then put in, piece by piece, hammering the corners up tightly. If the winding fits too loosely, extra core pieces may be forced in, taking care not to damage the insulation of the coil, or small wooden wedges may be driven between the coil and the core.

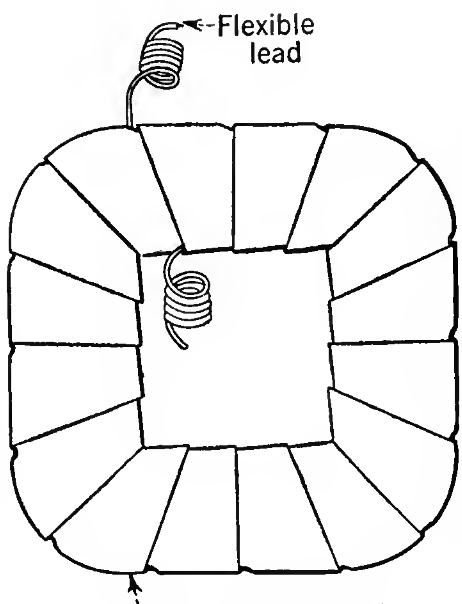


FIG. 5

The whole assembly should be made rigid, to reduce any audible hum when the transformer is in use.

Methods of mounting the transformer or choke coil are shown in Fig. 6. Angle iron, strap iron, or square lengths of wood may be used for clamping the core. Another method is to drill a hole in each corner of the core for a small bolt, but the diameter of the hole should not exceed one-fifth of the width of the core leg, otherwise the effective area of the core will be reduced. A panel of bakelite or hard rubber may be provided to hold the terminals, which may be ordinary binding posts or soldering clips. The leads may be brought up to the back of the panel and soldered to the terminals. They should be kept well separated from each other and insulated with "spaghetti" or similar tubing. Flexible insulated hook-up wire makes good leads. The terminals of the transformer should be plainly and permanently labeled with their voltages.

The transformer should be tested before being connected to any other apparatus. First connect the primary to the line without any load on the secondary, to detect any shorted turns, which will show up as excessive heating or as an actual burn-out. If after several hours the transformer is only slightly warm, it is probably all right. The terminal voltages may be checked with an a. c. voltmeter, if desired.

After the choke coil is completed the air gap must be adjusted to the proper value. This can only be done experimentally, by connecting the choke to its associated apparatus and changing the gap until the best filtering action is obtained. The gap should then be filled with cardboard or a cloth pad and the core permanently clamped, to prevent the gap being gradually closed by the magnetic pull between the two parts of the core. The inductance of the choke cannot be measured directly. If the necessary meters are available, it may be found as follows. Connect the choke in series with a battery and measure the voltage across the coil and the current in amperes through it. Its resistance may then be calculated from Ohm's Law:

$$R = \frac{V}{I}$$

Then connect it across a source of a. c. voltage of known frequency, such as the 110-volt line, and again measure the current and voltage. The impedance is then:

$$Z = \frac{V}{I}$$

The inductance, L, may then be calculated from the formula:

$$Z = \sqrt{R^2 + (2\pi fL)^2}$$

Or its equivalent:

$$L = \sqrt{\frac{Z^2 - R^2}{(2\pi f)^2}}$$

The writer wishes to acknowledge his indebtedness to Prof. F. S. Dellenbaugh, Jr., of the Massachusetts Institute of Technology, for the design formulas applying to the choke coil.

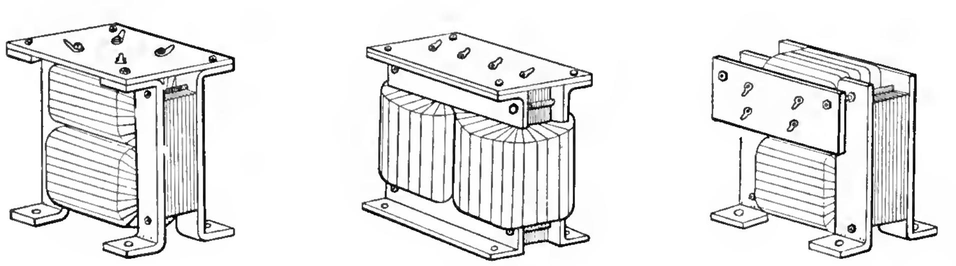
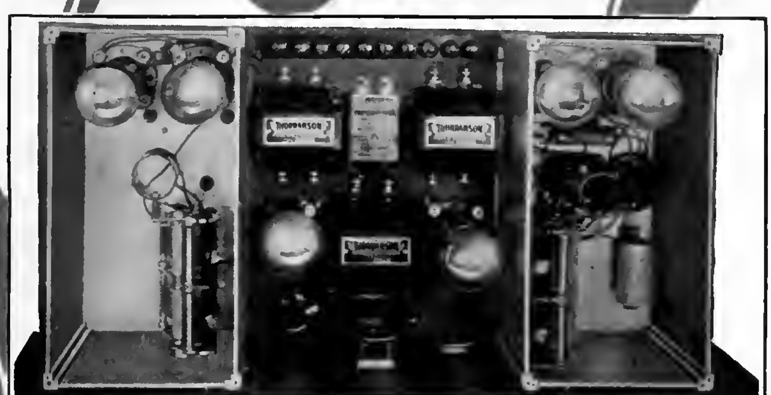


FIG. 6

Employing the New RGS *"Octa-Monic" Principle*

Not a Super-Heterodyne
Not Tuned Radio Frequency
Not Regenerative
But—

New!



The "OCTA-MONIC" RGS

All models of the R. G. S. "OCTA-MONIC" will be on display at the Radio World's Fair, New Madison Square Garden, between the 19th & 24th of September inclusive at the booth of the R. G. S. Mfg. Co., Inc.

BUILT FOR MODERN BROADCAST CONDITIONS

THESE TOOLS ONLY

Employing the New "RGS" "Octa-Monic" Principle

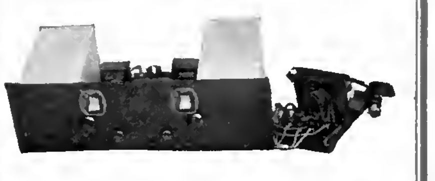
The New and R·G·S

One of the Outstanding Contributions

A. C. Tube Models

R. G. S. "Octa-Monic"
A-C Tube Kit

including detailed instructions and graphic blue-prints; all necessary apparatus, power (A-C Tube) transformer, four-way line voltage switch, carefully tested and selected heavy duty wire, lamp socket connections and cable etc., etc., ready to build, ***$114.60***



R. G. S. "Octa-Monic"
A-C Tube Chassis

Completely assembled according to latest laboratory methods, with instructions and blue-prints for installation, ready to plug-in your lamp socket and operate, ***$129.60***

R. G. S. "Octa-Monic"
A-C Tube Receiver

housed in an attractive, partitioned, walnut table cabinet, ***$149.60***

NOTE: *In A-C Tube Models of the R. G. S. "Octa-Monic", the performance is practically as startlingly satisfactory as the Battery models. Volume and selectivity are about the same; the Tonal Quality is slightly better on strong local stations but on distant stations or stations of weak signal strength, a slight hum is noticeable.*

To all intents and purposes, elaborate experiments have proved all A-C models of the new and revolutionary R. G. S. "Octa-Monic" quite satisfactory.

Price Notice

Above prices do not include Cunningham A-C and Power Tubes nor the "B" Battery Eliminator. All A-C models will operate on any good eliminator. This, therefore permits the use of your own "B" Battery Eliminator. It goes without saying, of course, that B Batteries will also perform perfectly satisfactorily.

The fundamentally new R. G. S. "Octa-Monic" Receiver developed by David Grimes is one of the four great radio developments of the past 10 years. The R. G. S. "Octa-Monic" principles are fully as important and represent as basic a contribution to the Radio Art as did any of the discoveries of DeForest, Armstrong, Alexanderson, etc., etc.

These new and revolutionary principles of tuning, or the radio frequency end of the R. G. S. "Octa-Monic", produce results not only superior *but*, these principles of tuning place this Receiver far in advance of any receiver developed to date. The R. G. S. "Octa-Monic" is fundamental and is as radically new as was the Super-Heterodyne.

These highly efficient principles employed in the new R. G. S. "Octa-Monic" cover not only the tuning or radio frequency end of this receiver but they cover the amplification end as well. The R. G. S. "Octa-Monic" amplifier (Power tube in the last stage,) gives, unquestionably, as perfect reproduction as it is possible to buy, regardless of cost.

The R. G. S. "Octa-Monic" comes to you more heavily endorsed by able authorities than any other receiver ever presented to the Radio Public. The editor of one of the most important radio publications in America said that it was the only receiver he had ever seen in his career as an editor to which the terms "new and revolutionary" could be applied in good faith.

Selectivity superior to the super-heterodyne without cutting side bands. Selectivity enough to eliminate the heterodyne squeals of local stations, operating on a higher octave; selectivity that is equal over the whole dial without being at all critical at any point; selectivity enough to separate with ease the local jumble of Metropolitan (New York City, Chicago, San Francisco, etc.) stations; selectivity enough to give five (5) degrees of silence between stations WEAF and WNYC in a location 200 yards away from WNYC.

Selectivity positive enough to make use of vernier control unnecessary.

Sensitivity or Distance-Getting Ability. Can work right down to static level. This insures trans-continental or trans-oceanic reception on favorable occasions.

Volume sufficient to fill a hall that will seat 3500.

Tonal Quality that is as nearly perfect as development in the Radio Art will permit.

Straight Line Audio Amplification.

Stability Margin of 800 ohms. The average receiver has a stability margin of from 6 to 20 ohms. This high stability margin of the R. G. S. "Octa-Monic" eliminates any possibilities of howling from poor batteries or "motor-boating" from eliminators. Batteries registering as low as 10 volts will deliver a clear tone, free from howling, in this receiver.

Straight Line Radio Amplification insuring reception at all broadcast wavelengths.

Straight Line Volume Control that makes distorting of tone impossible.

Automatic Wavetrap for prevention of heterodyning and whistling resulting from stations operating on one-half wave-length or on first octave beat.

Automatic Filament Control.

Employs 135 Volts or 180 Volts. Draws 22 mils.

Each R. G. S. "Octa-Monic" is carefully tested with scientific apparatus and under actual broadcasting conditions before it leaves the laboratories; while every piece of apparatus is just as thoroughly tested before it is built into this receiver.

The R. G. S. "Octa-Monic" is a closely co-ordinated Receiver built of quality apparatus. Careful tests are the basis for the choice of each piece of apparatus, tests that not only determine the merits of each individual part, but more importantly its relation to the whole receiver.

Standard Cunningham tubes (5CX 301-A's and 1CX 371, Power tube in last stage) and Western Electric Cone are recommended for best results.

The R. G. S. "Octa-Monic" is highly attractive in appearance. It is built on five-ply, specially shellaced sub-panel (20½ x 9½) to which is mounted beautifully designed panel, walnut finished, 7 x 21. The panel and dials are trimmed in gold.

The R. G. S. "Octa-Monic" is unusually simple to construct. The instructions and blueprints are more comprehensive and complete than any issued to date. They are very easy to follow and come, attractively bound, with your R. G. S. "Octa-Monic," which is one of the simplest receivers

DEALERS: ***Write for Complete Merchandizing Plans***

BUILT FOR MODERN (THESE TOOLS ONLY) BROADCAST CONDITIONS

Employing the New (RGS) *"Octa-Monic" Principle*

Revolutionary "OCTA-MONIC"*

of Ten Years of Radio Development

to operate. There are but two dials, the nearest possible approach to tuning efficiency, and you will find that stations actually "click" or "tumble-in" for you as you slowly rotate your dials.

The customary need of wooden screw-drivers or involved balancing devices is entirely removed in the R. G. S. "Octa-Monic." Major or minor adjustments are unnecessary. The R. G. S. "Octa-Monic" is free from ordinary service. Tuning condensers are the only moving parts, and as a consequence, there are no fussy mechanisms, either mechanical or electrical, to get out of order.

The R. G. S. "Octa-Monic" operates satisfactorily on either a good "B" battery eliminator or batteries without "motor-boating" or howling.

The R. G. S. "Octa-Monic" is so designed that it will fit any good cabinet or console. Write for cabinet and console literature.

Orders cannot be accepted for individual pieces of apparatus or blueprints.

The R. G. S. "Octa-Monic" is sold as follows: 1. R. G. S. "Octa-Monic" kit, of parts including all required apparatus, transformers, rheostats, drilled and engraved aluminum panel, etc. even the necessary Acme Celatsite wire is enclosed in the attractive container, complete instructions and blueprints, ready to build, **$79.60** 2. R. G. S. "Octa-Monic" chassis, completely assembled according to latest laboratory methods with complete thorough operational instructions, ready to operate, **$89.60,** 3. R. G. S. "Octa-Monic" Receiver housed in an attractive, well-designed, walnut table cabinet, **$104.60,** 4. R. G. S. "Octa-Monic" Tuning kit, including all necessary apparatus and complete blue-prints and instructions on how to build the radio frequency end of this Receiver and on how to book-up to your favorite amplifier, **$59.60** 5. R. G. S. "Octa-Monic" Tuning Chassis, completely assembled according to latest laboratory methods with complete instructions and ready to wire to your amplifier, **$66.60.**

All models of the R. G. S. "Octa-Monic" have been adapted to the Cunningham A-C and Power Tubes (Four (4) CX 326, one (1) C 327, and one (1) CX 371. The "B" Battery Eliminator and the Cunningham Tubes are not included in the following prices. This eliminates an unnecessary expenditure on your part because the A-C Tube models of the R. G. S. "Octa-Monic" have been designed to operate satisfactorily with any good "B" Eliminator. It is recommended if your "B" Eliminator has no "C" battery tap, that you use the regular 40 volts of C battery.

The A-C Tube models are sold as follows (1) The R. G. S. "Octa-Monic" A-C Tube kit, including all necessary apparatus with complete and thorough blue-prints, and instructions, ready to build, **$114.60** (2) The R. G. S. "Octa-Monic" A-C Tube Chassis, completely assembled according to latest laboratory methods, with thorough operational blue-prints and instructions, ready to plug-in your light socket and operate, **$129.60** (3) The R. G. S. "Octa-Monic" A-C Tube Receiver housed in an attractive, well-designed, walnut table cabinet, **$149.60**

The R. G. S. "Four" employing the Inverse Duplex System (1) R. G. S. "Four" Kit, all parts, complete instructions, $74.40. (2) Chassis, assembled according to latest laboratory methods, $84.40.

All prices slightly higher west of Denver. Canadian and Export prices on request.

Go to your dealer to-day and insist on a demonstration. If he hasn't stocked the R. G. S. "Octa-Monic" yet, tear off and mail to us the attached coupon with the required information. Every effort will be made to arrange a demonstration for you.

Arrange for that demonstration now because you have a real radio thrill waiting for you. In the R. G. S. "Octa-Monic" you will hear radio at its best. And when you hear the R. G. S. "Octa-Monic" you will know why it is: ***"The Synonym of Performance"***

All models of the R. G. S. "Octa-Monic" and the R. G. S. "Four" are fully protected by Grimes Patents issued and pending.

**Trade Mark Registered.*

DEALERS: ***Write for Complete Merchandizing Plans***

R-G-S Manfg. Co., Inc.

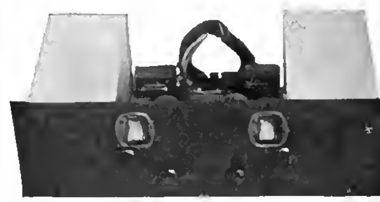
of the

Grimes Radio Engineering Company, Inc.
Staten Island New York

Battery or "B" Eliminator Models

R. G. S. "Octa-Monic" Kit

*of parts including all required apparatus, transformers, rheostat, drilled and engraved panel, etc., etc., even the necessary Acme Celatsite wire is enclosed in the attractive container; complete and thorough instructions and blue-prints, ready to build, **$79.60.***



R. G. S. "Octa-Monic" Chasis

*completely assembled according to latest laboratory methods, ready to operate, **$89.60***

R. G. S. "Octa-Monic" Receiver

*housed in an attractive, well-designed, walnut table cabinet, **$104.60***

R. G. S. "Octa-Monic" Tuning Kit

*including all necessary apparatus and complete blue-prints and instructions on how to build the radio frequency end of this receiver and on how to hook up to your favorite amplifier, **$59.60***

R. G. S. "Octa-Monic" Tuning Chasis

*completely assembled according to latest laboratory methods with complete instructions and ready to wire to your amplifier, **$66.60***

R. G. S. MANFG. CO., Inc.
Staten Island, New York

Gentlemen:
I want to hear your R. G. S. "Octa-Monic." Please arrange with my dealer, whose address I have printed below, for a demonstration. I am much interested in this receiver but this request for a demonstration and literature, you understand, entails no obligation on my part.

My Name..
Street...
City or State ....
My Dealer's Name ....
His Address..

BUILT FOR MODERN (THESE TOOLS ONLY) BROADCAST CONDITIONS

Tireless Performance

These gulls fly and fly until we wonder *how* such stamina can be contained in so frail an object.

Just so with CeCo Tubes. A strong combination of frail materials. Glass for a covering; hair-like wires for filament; fine spun metal for grid.

But so carefully engineered, so cleverly assembled so skillfully exhausted, so thoroughly tested that their durability is astounding to the radio operator and fan who judges CeCo performance by ordinary standards.

You expect *MORE* of CeCo Tubes—and *get* more.

A Type for Every Radio Need

General Purpose Tubes, Special Purpose Tubes, Power Tubes, Filament Type Rectifiers, Gas Filled Rectifiers and A. C. Tubes.

Ask your radio dealer for complete data sheet of CeCo Tubes.

C. E. MANUFACTURING CO., Inc., Providence, R. I.

Write for Data Sheet giving characteristics of all CeCo Tubes

Announcing Our New

Gas Filled Rectifier

(NO FILAMENT)

TYPE D-G

Maximum Volts—300 *Maximum Cur.*—85 *M-A*

Long Life without decrease in output is assured if these values are not exceeded.

Easy Filtration. Less strain on Filter condensers and smoother output with less Hum or Ripple.

These tubes are tested in a Standard rectifying circuit using well designed parts. The unit is connected to a ripple test position, and tube checked both by phones and observed on an oscillograph, insuring a perfect tube which will give excellent results in *well designed and constructed units.*

PRICE $5.00

Makes a Good "B" Eliminator—BETTER

Restored Enchantment

This is the Eveready Layerbilt that gives you Battery Power for the longest time and the least money.

THERE is no doubt of it—radio is better with Battery Power. And never was radio so worthy of the perfection of reception that batteries, and batteries alone, make possible. Today more than ever you need what batteries give—pure DC, Direct Current, electricity that flows smoothly, quietly, noiselessly. When such is the current that operates your receiver, you are unconscious of its mechanism, for you do not hear it humming, buzzing, crackling. The enchantment of the program is complete.

Batteries themselves have improved, as has radio. Today they are so perfect, and so long-lasting, as to be equal to the demands of the modern receiver. Power your set with the Eveready Layerbilt "B" Battery No. 486. This is the battery whose unique, exclusive construction makes it last longer than any other Eveready. Could more be said? In most homes a set of Layerbilts lasts an entire season. This is the battery that brings you Battery Power with all its advantages, conferring benefits and enjoyments that are really tremendous when compared with the small cost and effort involved in replacements at long intervals. For the best in radio, use the Eveready Layerbilt.

EVEREADY
Radio Batteries
-they last longer

Radio is better with Battery Power

At a turn of the dial a radio program comes to you. It is clear. It is true. It is natural. You thank the powers of nature that have once more brought quiet to the distant reaches of the radio-swept air. You are grateful to the broadcasters whose programs were never so enjoyable, so enchanting. You call down blessings upon the authority that has allotted to each station its proper place. And, if you are radio-wise, you will be thankful that you bought a new set of "B" batteries to make the most out of radio's newest and most glorious season.

NATIONAL CARBON CO., INC. UCC New York—San Francisco

Unit of Union Carbide and Carbon Corporation

Tuesday night is Eveready Hour Night—8 P. M., Eastern Standard Time

WEAF—*New York*	WGR—*Buffalo*	WGN—*Chicago*	WRC—*Washington*
WJAR—*Providence*	WCAE—*Pittsburgh*	WOC—*Davenport*	WGY—*Schenectady*
WEEI—*Boston*	WSAI—*Cincinnati*	WCCO { *Minneapolis* / *St. Paul* }	WHAS—*Louisville*
WDAF—*Kansas City*	WTAM—*Cleveland*		WSB—*Atlanta*
WFI—*Philadelphia*	WWJ—*Detroit*	KSD—*St. Louis*	WSM—*Nashville*
	WMC—*Memphis*		

Pacific Coast Stations—9 P. M., Pacific Standard Time

KPO—KGO—*San Francisco*	KFI—*Los Angeles*
KFOA—KOMO—*Seattle*	KGW—*Portland*

Have you heard the new Victor record by the Eveready Hour Group—orchestra and singers—in Middleton's Down South Overture and Dvořák's Goin' Home?

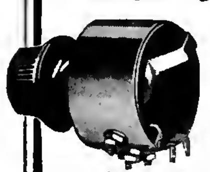
Improved Positive VOLTAGE CONTROL for "B" Eliminators

HEAVY DUTY Centralab Variable Resistor

To carry plenty of power and withstand high voltage this new unit provides outstanding advantages. A single turn of the knob gives full resistance variation. Units are practically heat-proof, and will dissipate up to 20 watts through the entire resistance, without danger of burning out. Resistance remains constant at any knob setting.

Used as improvement over present controls, or add to the "B" eliminator that has no variable voltage. A 50,000 ohm unit attached to high voltage terminal, provides a tap adjustable to any voltage. When replacing present controls, use 100,000 ohms for detector and 50,000 ohms for intermediate voltage. Also 10,000 and 500,000 ohms. Each $2.00

HEAVY DUTY Centralab Potentiometer



Identical with above Resistor, plus a third terminal. Potentiometers provide better voltage regulation for "B" Eliminators than the two-terminal type and are economical because no fixed resistors are needed. Have ample current carrying capacity for any "B" power circuit. Try this improved regulation on your Eliminator. Resistances up to 10,000 ohms all wire wound. 2,000, 3,000, 10,000, 25,000, 50,000, 100,000 ohms, $2.00.

WIRE WOUND Centralab Fixed Resistor

Built for the heavy current of A & B power circuits. The wire is wound over asbestos, fixed with heat-proof cement. Ample area. Flat and thin, making them easy to mount. Resistance values for all ABC Power Circuits.

At your dealer's or C. O. D. Send for the new Centralab A and B power circuit Literature.

CENTRAL RADIO LABORATORIES
22 Keefe Ave. Milwaukee, Wis.

Centralab

The *Radio Broadcast* LABORATORY INFORMATION SHEETS

THE RADIO BROADCAST Laboratory Information Sheets are a regular feature of this magazine and have appeared since our June, 1926, issue. They cover a wide range of information of value to the experimenter and to the technical radio man. It is not our purpose always to include new information but to present concise and accurate facts in the most convenient form. The sheets are arranged so that they may be cut from the magazine and preserved for constant reference, and we suggest that each sheet be cut out with a razor blade and pasted on 4" x 6" filing cards, or in a notebook. The cards should be arranged in numerical order. An index appears twice a year dealing with the sheets published during that year. The first index appeared on sheets Nos. 47 and 48, in November, 1926. In July, an index to all sheets appearing since that time was printed.

The June, October, November, and December, 1926, issues are out of print. A complete set of Sheets, Nos. 1 to 88, can be secured from the Circulation Department, Doubleday, Page & Company, Garden City, New York, for $1.00. Some readers have asked what provision is made to rectify possible errors in these Sheets. In the unfortunate event that any such errors do appear, a new Laboratory Sheet with the old number will appear.

—THE EDITOR.

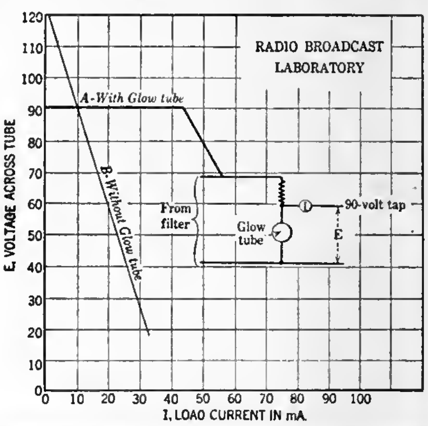
No. 129 RADIO BROADCAST Laboratory Information Sheet October, 1927

The Type 874 Glow Tube

HOW IT FUNCTIONS

THE type 874 tube is a special voltage regulator designed for use in B power units to maintain the voltages, supplied by the unit, constant. An ordinary B power unit operated without a glow tube has a comparatively poor regulation, *i.e.*, the voltage changes considerably with changes in the amount of current being drawn from the unit. It would obviously be of decided advantage if this voltage could be made to remain practically constant at all loads. The power unit could then be used with any receiver irrespective of the amount of current being drawn by it (within reason) with the knowledge that the actual voltages designated on the binding posts of the B device were being supplied. How the glow tube functions to maintain the voltage constant may be understood by reference to the curve A. This curve is plotted by measuring the voltage across the glow tube with various load currents and it should be noted that the voltage across the tube is practically 90 at all loads up to more than 40 mA. In ordinary operation, when there is no current being drawn from the 90-volt tap, the glow tube current is about 45 milliamperes. Then, if current is drawn for a receiver from the 90-volt tap, which would ordinarily cause the voltage to go down, the current through the glow tube automatically decreases, providing for the current required by the set. The voltage thereby is maintained at exactly 90.

Curve B illustrates the curve of output voltage that might be obtained from a B power unit not using a glow tube. At no load the voltage is 123, while at a load of 10 mA. the voltage drops to 90. If, however, the receiver requires 20 milliamperes, the actual voltage available would be only 60 volts.



No. 130 RADIO BROADCAST Laboratory Information Sheet October, 1927

Data on Honeycomb Coils

No. of Turns	Inductance, at 800 Cycles, in Millihenries	Natural Wavelength, Meters	Distributed Capacity in Mmfd.	Wavelength Range, Meters 0.0005-Mfd. Condenser	0.001-Mfd. Condenser
25	.039	65	30	120 to 245	120 to 355
35	.0717	92	33	160 to 335	160 to 480
50	.149	128	31	220 to 485	220 to 690
75	.325	172	26	340 to 715	340 to 1020
100	.555	218	24	430 to 930	430 to 1330
150	1.30	282	17	680 to 1410	680 to 2060
200	2.31	358	16	900 to 1880	900 to 2700
249	3.67	442	15	1100 to 2370	1000 to 3410
300	5.35	535	17	1400 to 2870	1400 to 4120
400	9.62	656	13	1800 to 3830	1800 to 5500
500	15.5	836	13	2300 to 4870	2300 to 2000
600	21.6	1045	14	2800 to 5700	2800 to 8200
750	34.2	1300	14	3500 to 7200	3500 to 10400
1000	61	1700	13	4700 to 9600	4700 to 13800
1250	102.5	2010	11	6000 to 12500	6000 to 18000
1500	155	2710	13	7500 to 15400	7500 to 22100

Balkite has pioneered-
but not at public expense

Balkite "A" *Contains no battery.* The same as Balkite "AB" below, but for the "A" circuit only. Not a battery and charger but a perfected light socket "A" power supply. One of the most remarkable developments in the entire radio field. Price $32.50.

Balkite "B" *Has the longest life in radio.* The accepted tried and proved light socket "B" power supply. 300,000 units in use show that it lasts longer than any device in radio. Three models: "B"-W, 67-90 volts, $22.50; "B"-135,* 135 volts, $32.50; "B"-180, 180 volts, $39.50. Balkite now costs no more than the ordinary "B" eliminator.

Balkite Chargers

Standard for "A" batteries. Noiseless. Can be used during reception. Prices drastically reduced. Model "J,"* rates 2.5 and .5 amperes, for both rapid and trickle charging, $17.50. Model "N"* Trickle Charger, rate .5 and .8 amperes, $9.50. Model "K" Trickle Charger, $7.50.

**Special models for 25-40 cycles at slightly higher prices.*

Prices are slightly higher West of the Rockies and in Canada.

The great improvements in radio power have been made by Balkite.

First noiseless battery charging. Then successful light socket "B" power. Then trickle charging. And today, most important of all, Balkite "AB," a complete unit containing no battery in any form, supplying both "A" and "B" power directly from the light socket, and operating only while set is in use.

This pioneering has been important. Yet alone it would never have made Balkite one of the best known names in radio. Balkite is today the established leader because of Balkite performance in the hands of its owners. Because with 2,000,000* units in the field Balkite has a record of long life and freedom from trouble seldom equalled in any industry. Because the first Balkite "B," purchased 5 years ago, is still in use and will be for years to come. Because to your radio dealer Balkite is a synonym for quality. Because the electrolytic rectification developed and used by Balkite is so reliable that today it is standard on the signal systems of most American as well as European and Oriental railroads. Because Balkite is permanent equipment. Balkite has pioneered — but not at the expense of the public.

Today, whatever type of set you own, whatever type of power equipment you want, whatever you want to pay for it, Balkite has it. And production is so enormous that prices are astonishingly low.

Your dealer will recommend the Balkite equipment you need for your set.

BALKITE "AB"

Contains no battery. A complete unit, replacing both "A" and "B" batteries and supplying "A" and "B" current directly from the light socket. Contains no battery in any form. Operates only while the set is in use. Two models: "AB" 6-135,* 135 volts "B" current, $59.50: "AB" 6-180, 180 volts, $67.50.

FANSTEEL PRODUCTS COMPANY, Inc.
North Chicago, Illinois

FANSTEEL
Balkite
Radio Power Units

Bradleyunit-A

PERFECT FIXED RESISTOR

Unaffected by temperature, moisture or atmospheric changes. Does not age or change in resistance.

A solid-molded fixed resistor, baked under high pressure, and accurately calibrated. Can be soldered without affecting accuracy.

Two Remarkable Radio Resistors

Bradleyunit-A is an outstanding success! It is a fixed resistor for radio circuits of all kinds, and has a capacity of 2 watts. It is rugged and can be soldered easily, without affecting the rating of the unit.

Bradleyohm-E is widely used by manufacturers of B-Eliminators for plate voltage control. Its remarkably wide, noiseless range, accomplished with two columns of graphite discs, accounts for its tremendous popularity.

Use Allen-Bradley resistors in your own hook-ups for superlative results. Follow the example of prominent radio manufacturers. They know!

Bradleyohm-E is available in several ranges and ratings. Sold in distinctive checkered cartons. Ask your dealer for Bradleyohm-E

Allen-Bradley Co.

ELECTRIC CONTROLLING APPARATUS

278 Greenfield Ave. (A-B) Milwaukee, Wis.

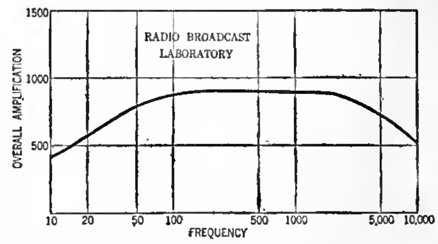
No. 131 RADIO BROADCAST Laboratory Information Sheet October, 1927

Resistance-Coupled Amplifier

DATA ON CONSTANTS

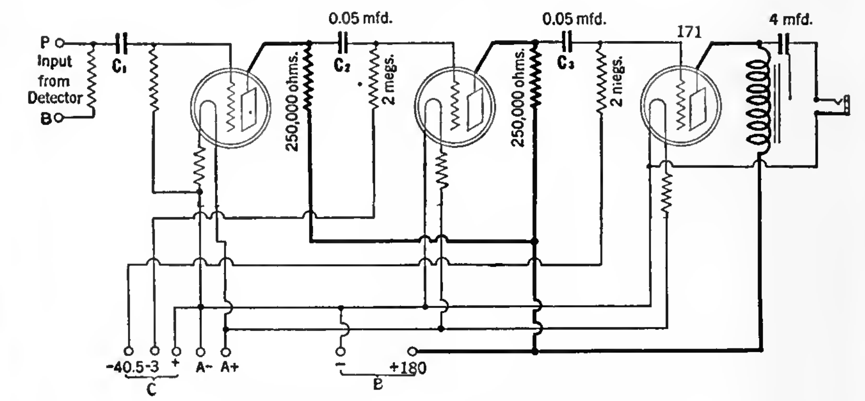
ON LABORATORY Sheet No. 132 is given a circuit diagram of a resistance-coupled amplifier using the new type 240 high-mu tube (Cunningham type 340). To obtain satisfactory operation from such an amplifier it is essential that several points be given careful consideration. In the first place it is essential that excessive C bias is not used on any of the high-mu tubes. The following values should be used in combination with the voltage shown in the circuit diagram to prevent overloading: 1 volt on the first stage, 3 volts on the second stage, and 40.5 volts on the 171 power tube. The second consideration of great importance in the construction of such an amplifier is that the coupling condensers, C_1, C_2, and C_3, be of the best quality that can be obtained. Even a small amount of leakage across the condenser, due to faulty insulation, will permit some of the plate potential to leak through it to the grid of the next tube and this will not only cause distortion but very frequently will make the amplifier absolutely inoperative. Use only the best of mica condensers.

It is, of course, also essential that the plate and grid resistance be noiseless in operation but it is not necessary that they be exactly of the values given in the circuit. A variation of ten or twenty per cent. in these values is quite unimportant. The plate supply for the amplifier may either be a well constructed B power unit or batteries. No trouble whatsoever should be experienced when operating the unit from new batteries, but it is possible that "motor-boating" troubles will develop when the amplifier is used with some B power units. The overall gain is comparatively high and difficulties of this sort become more pronounced as the amplification is increased. Large bypass condensers across the output of the power unit will frequently be necessary in order to prevent the occurrence of "motor-boating." The frequency characteristic of the complete amplifier is shown by the accompanying curve.



No. 132 RADIO BROADCAST Laboratory Information Sheet October, 1927

Resistance-Coupled Amplifier Circuit



Data concerning resistance-coupled amplifiers appear on Laboratory Sheet No. 131

No. 133 RADIO BROADCAST Laboratory Information Sheet October, 1927

Care of Power Supply Units

FREQUENT CHECKING NECESSARY

MANY modern radio receiver installations employ a B power unit for the plate voltage, and a storage battery in conjunction with a trickle charger for the filament supply, the entire combination being controlled by means of an automatic relay. If well manufactured units are used throughout, such an installation should require practically no attention other than the addition of water to the storage battery and the trickle charger, if the latter is of the electrolytic type.

In order to make certain that the entire power plant is functioning satisfactorily, it is a good idea to make some simple tests every six months or so. Little can go wrong with the B power unit without it becoming noticeable in the operation of the receiver. If the rectifier tube deteriorates the volume produced by the receiver will be lowered and also the quality will be impaired. A total failure of the power unit will, of course, mean that it will be impossible to hear anything at all on the receiver.

The simplest check to make on the A power unit in order to make certain that it is functioning satisfactorily is to take a hydrometer reading of the storage battery. If the battery reads "fully charged" it is possible that the trickle charging rate is excessive and it will be a good idea to somewhat reduce the rate and then make frequent tests with the hydrometer to determine how the battery is standing up. If the total charge in the battery now gradually decreases it will be best to increase the rate of trickle charge again. If, on the other hand, the battery continues to remain in a fully charged condition, we have a good indication that the previous rate of trickle charge was too high and that very probably the battery was being continually over charged, which is very harmful. If a hydrometer reading of the battery indicates that the battery is very low the trickle charge rate should be increased so that the battery is brought up to practically full charge and then the rate should be adjusted so as to maintain the battery in this condition. The contacts in the relay controlling the installation should be inspected every so often. There is a certain amount of sparking at the contacts which tends to pit them and it might be necessary to smooth them with a piece of emery cloth. Badly pitted contacts in the relay might at times prevent the unit from closing the trickle charger circuit and consequently the battery will not always be charged while the receiver is not being operated.

LINCOLN

Only $1 Down Brings You Either of These Guaranteed Eliminators

ELECTRIFY ANY RADIO

Super-Power "A" Eliminator

Here is a constant, unvarying, smooth, humless current at 6 volts for any radio receiver using 201-A and power tubes. **Uncertain storage batteries** with their changing power, **chargers** and other bothers are **done away with.** This eliminator completely replaces "A" batteries. In addition your set gets perfect current at all times—it is always ready to do its best. Stations come in easily and quickly.

Not a Battery-Charger Combination

This Super-power **"A" Eliminator** consists of a large capacity rectifier which changes the alternating house-lighting current into direct current. Then a highly efficient heavy duty filter system of extremely high capacity changes the pulsating direct current from the rectifier into smooth, even current for lighting the filaments in the radio tubes. Anyone can install this Super-power **"A" Eliminator** in a few minutes. Just attach it to your set and plug it into an electric light socket. Your set is instantly supplied with the correct amount of hum-free current, used only when set is in use. You are assured of good current whenever you want it. This **"A" Eliminator** works perfectly whether used once or thousands of times a year. It has no moving parts to wear out. Operates from light socket 110-120 volts, 50-60 cycle A.C., output 6 volts direct current for all sets up to 12 tubes with power tubes. **There are no batteries to be charged.** It is fool-proof in operation. Once attached it is permanent—**you can forget you ever heard about "A" batteries.**

Test It for 30 Days Before You Buy

Just fill out the coupon below and mail it to us with a dollar bill. We will send you this **"A" Eliminator** to test. It must deliver satisfaction before you buy. After 30 days trial pay only $5.00 a month until you have paid $31.50. Only our great buying power enables us to make this liberal offer and to also sell this Super-power **"A" Eliminator** for easily ¼ less than is ordinarily asked. Take advantage of this offer today. Remember if you are disappointed in any way we will refund your dollar and pay return postage. You run no risk. Order now.

Super-Power "B" Eliminator

Do away with "B" batteries—their annoyance—and the constant expense of always getting new ones. The great **"B" Eliminator** offered here replaces them permanently. Just attach this eliminator to your set—plug it into an electric light socket—and a steady flow of power is delivered to your set. Hum, noise, distortion and all other disturbances are gone. Built with heavy duty chokes, transformers and the finest of condensers in the filter system, it is 100% efficient at all times—the most modern and flexible **"B" Eliminator** in the world. **Used with any good "A" Eliminator it completely electrifies your set.**

Complete With Raytheon Tube

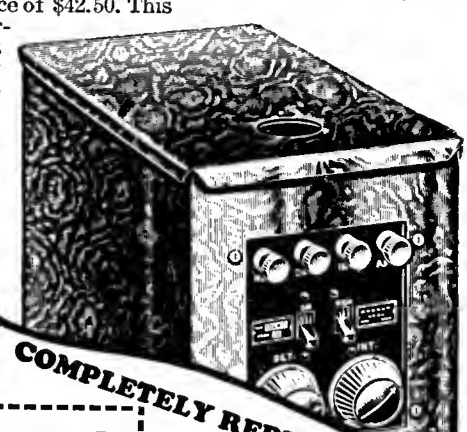
This Super-power **"B" Eliminator** can be used with any set up to 12 tubes. It comes complete with full wave rectifying 85 mil. Raytheon tube, making possible the delivery of great current at a high voltage. This Raytheon tube has indefinite life as it has no filament to burn out. Delivers up to 180 volts.

The case is beautifully finished in olive green Duco with black panel etched in gold. Equipped with rubber-covered cord and socket plug. High voltage taps and variable adjustments enable the use of new power tubes. Operates from 110-120 A.C., 50-60 cycle current. Has tap for intermediate voltage on which 67½ to 90 volts may be obtained. The detector tap will supply 22½ to 67½ volts. Variable adjuster will deliver any desired detector voltage. On and off switch and high and low voltage switch are integral parts of the eliminator. No additional switches or cords are necessary.

Only $1.00

We make the same liberal offer on both the **"B"** and the **"A" Eliminator.** Fill out the coupon and mail it to us with a dollar indicating which eliminator you wish. If both are desired send $2.00. Each eliminator must then make good while you test it for 30 days before you pay another cent. After test the balance is due in easy installments. This **"B" Eliminator** ordinarily sells for as high as the cash price of $42.50. This is your opportunity to get it for only $29.50 payable in easy installments.

Complete instructions with each unit for wiring to set.



AT REDUCED PRICES

NO BATTERY—NO CHARGER
NO BULBS
NO HUM
NOTHING TO WEAR OUT OR REPLACE

COMPLETELY REPLACES "B" BATTERIES
EASY TO ATTACH
Plug Into Electric Light Socket

Mail This Coupon NOW!

ELLIOTT RADIO CORPORATION, DEPT. 172
709 West Lake Street, Chicago, Illinois

Attached find $1.00 for which you agree to send me ( ) **"A" Eliminator** at $31.50, ( ) **"B" Eliminator** at $29.50. (Send $2.00 if both are desired, as described in your ad.) Full particulars will be sent me by return mail and my money refunded if I do not accept your offer.

Name ______________________

Address ______________________

City ______________ *State* ______________

More *for your money in this* $28.50 Sterling "B" Power Unit

$28.50 is an amazingly low price for this "B" Power Unit. Yet, in spite of price, Sterling quality is maintained throughout.

For efficiency, long life, in fact for *permanent* operation, only the genuine Raytheon BH rectifier is used. For convenience there's an "on" and "off" switch.

Current regulation? It's perfect! Amplifier and detector voltages are variable. An additional primary control regulates all voltages to suit large or small sets.

No wonder the Sterling R-81 is found today on thousands of 3 to 8 tube sets, giving constant, dependable light socket service. Ask your dealer for a demonstration of the Sterling R-81.

THE STERLING MFG. CO.
2831-53 Prospect Ave. • Cleveland, Ohio

DESIGNED FOR USE WITH Raytheon TYPE BH LONG LIFE RECTIFYING TUBE

The Sterling Mfg. Co.'s 21-year reputation stands behind every dealer who sells the Sterling line.

Perfect current Regulation for your set
Genuine Raytheon BH Equipped

No. 134 | RADIO BROADCAST Laboratory Information Sheet | October, 1927

Loud Speaker Horns

THE EXPONENTIAL TYPE

A CORRECTLY designed horn makes a very good type of loud speaker. The best horn is one which radiates most uniformly over the required range of frequency and it has been proved mathematically that the exponentially shaped horn conforms closely to this requirement. A horn is of the exponential type when its cross section area doubles at equal intervals along its length. For example, a horn would be of the exponential type if at the orifice it had an area of ¼ square inches and an area of ½ square inches, 1 square inch, and 2 square inches, at distances of 1, 2, and 3 feet respectively from the orifice. The rate of expansion determines the lowest frequency of which the horn will be a good sound producer. A horn which doubles in area every foot will reproduce down to about 64 cycles, and a horn which expands twice as rapidly will only reproduce well down to 128 cycles.

A properly designed horn should be free from noticeable resonance, and to prevent this the mouth of the horn should be made large enough to transmit the sounds coming from it without any great amount of back pressure. In the design of loud speaker horns it has been found that, if the mouth is made comparable to ¼ of the wavelength corresponding to the low frequency cut-off point of the horn, the resonance in the horn will be negligible. The wavelength in feet is determined by dividing the velocity of sound in feet per second, which is 1120, by the frequency. For example, a horn whose cut-off frequency is to be 32 cycles, corresponding to a wavelength of 39 feet, should have a mouth of 39 divided by 4, or 9¾ feet. These facts indicate definitely that a horn, to be a good one, must be large. Small horns, whether they are or are not exponential, cannot radiate the low frequencies.

The horn makes it possible for a comparatively small diaphragm to get a good grip on the air and thereby produce a large volume of sound. The small diaphragm and the large horn may be replaced by a large diaphragm, as is done in a cone type loud speaker.

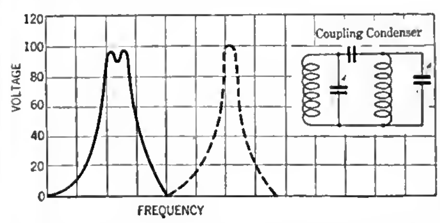
The material of which the horn is made is important. Although a horn may be well designed, and constructed to the correct size, total length and expansion per unit length, it may still fail to give really good results because of resonant effects in the material used in the construction. The material used should have no marked resonant frequency unless it is very low, where it might help to increase the low note radiation.

No. 135 | RADIO BROADCAST Laboratory Information Sheet | October, 1927

Closely Coupled Circuits

RESONANCE CURVES

IF TWO circuits are coupled together by a condenser, as shown in the sketch, and they are both adjusted so that they are tuned to slightly different frequencies, we will find that a resonance curve of



the combination has the form shown by the solid curve. The resonance curve of either separate circuit alone would have the form indicated by the dotted curve. It is evident from the resultant curve that the combination of these two circuits produces a resultant characteristic curve which is quite broad and flat on the top in comparison with the quite sharp peak of either circuit alone. This double peaked effect is a characteristic of closely coupled circuits and has been used to some extent in radio receivers.

An ordinary resonance circuit consisting of a single coil and condenser has a comparatively sharp resonance curve and therefore frequencies slightly above or below the resonant frequency are not amplified as well as the latter and, therefore, the tuned circuit tends to cut down the amplification of the side bands of the incoming wave and this causes some loss of high frequencies. If a receiver is made up, however, with two coupled circuits, such as we have indicated, this cutting of the side bands will not take place because the flat top of the resonance curve can be made sufficiently broad so as to give equal amplification over a band 10,000 cycles wide and therefore practically equal amplification can be obtained at all frequencies 5000 cycles above or below the carrier frequency. The circuit has not been used in actual practice to any great extent because of the difficult tuning required and because of the careful adjustments necessary.

No. 136 | RADIO BROADCAST Laboratory Information Sheet | October, 1927

Carrier Telephony

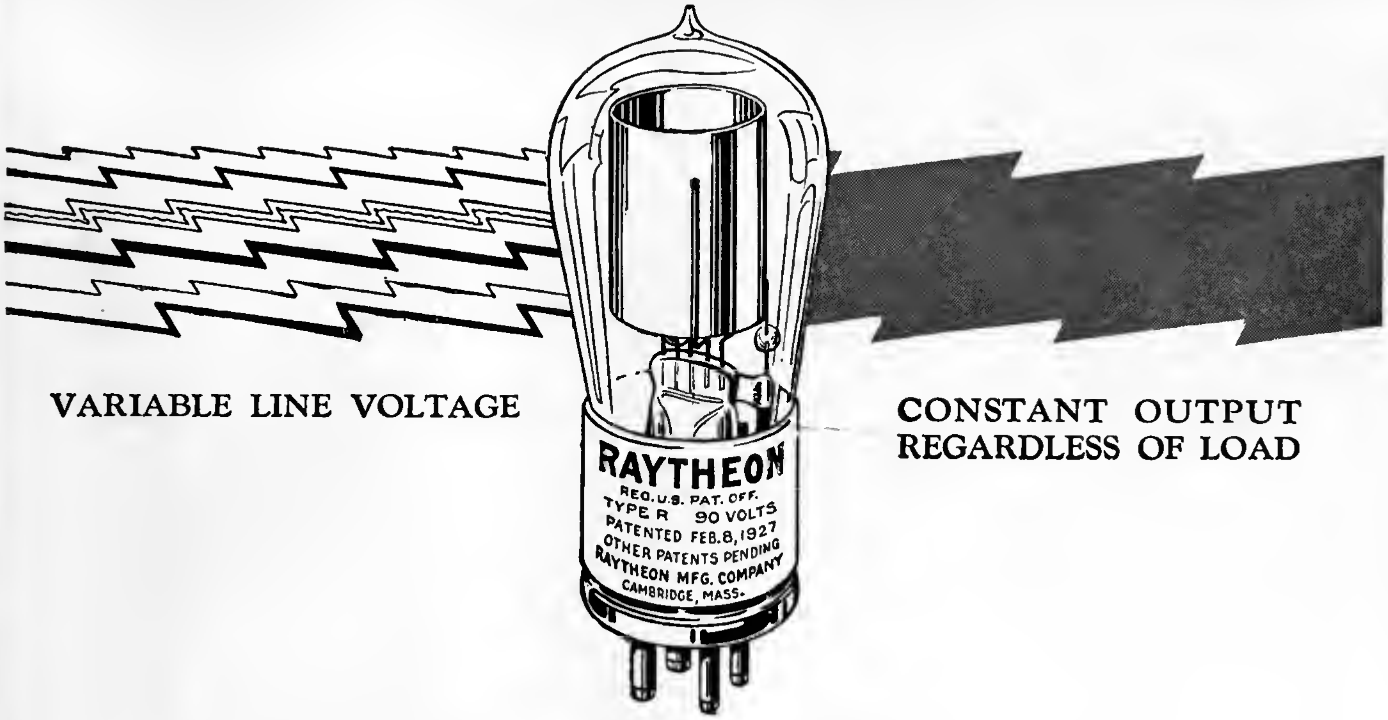
THEORY AND USES

THE use of power lines for the dissemination of intelligence is becoming increasingly common throughout the country. Large power companies have in many cases installed radio equipment for inter-communication between various power plants; these radio-frequency signals are transmitted over the power lines rather than through the air, and, in this way less interference is encountered. The system has also been used in some communities in order to make it possible to receive musical programs at home by connecting a suitable device directly to the power socket.

For commercial use, this system has certain advantages, such as lack of interference, which make its use valuable, but it is unlikely that the system will ever replace broadcasting. The number of different stations that can be "tuned-in" by a subscriber using the system is naturally limited, and this is a definite disadvantage.

The system actually differs very little from that of ordinary broadcasting, the major difference being that the power of the transmitter, instead of being radiated into the air by means of an antenna, is coupled directly to the power line. The coupling between the transmitter and the power line is generally made through high-voltage coupling condensers and special filter and protective circuits. At the receiving end an ordinary radio receiver can be used to detect the signals. It also must, of course, be coupled in some way to the transmission line. The system is generally operated in duplex so that transmitting or receiving can be accomplished at any of the various terminals of the system.

In carrier telephony it has generally been found best to use carrier frequencies somewhat above 50,000 cycles. For comparatively low radio frequencies, around 10,000 cycles, there is considerable loss in the various power transformers in the line, and at frequencies intermediate between about 10,000 and 50,000 cycles there will very likely be sharp resonance peaks causing excessive loss at particular frequencies. Above 50,000 cycles an ordinary transmission line is fairly satisfactory as a transmitting medium.



Raytheon Voltage Regulator Tube

EXPERIENCE gained in seven years of exhaustive research, experiments and tests, have enabled the Raytheon Research Laboratories to produce a new and fundamentally improved Voltage Regulator Tube of marked characteristics.

Raytheon—Type R, when incorporated in the proper B Power circuits, maintains constant voltage on the 90 and lower voltage taps and greatly improves the voltage regulation on the 180 and 135 volt taps, *regardless of variations in either the line voltage or load current.* The variable voltage controls can be thus eliminated and the construction of the unit simplified.

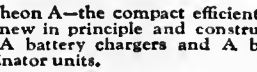
Furthermore, this new tube has a very pronounced effect in eliminating the last vestige of ripple from the output, and when connected to an amplifier will completely eliminate "motor-boating".

A new feature—*the starting anode*—incorporated in type R, maintains constantly a state of ionization in the tube to prevent any "going out" regardless of the load fluctuation.

Raytheon—Type R, can be used in any power unit circuit now on the market employing a glow tube with greatly improved results. Diagrams of an approved Type R tube installation, in connection with the heavy duty Raytheon BH tube, can be had from the Raytheon Research Laboratories upon request.

Raytheon, Type R, 90 volts, 60 milliamperes—Price $4.00

Raytheon BH—a 125 milliampere rectifying tube, because of its constant heavy duty output, is especially designed for use in conjunction with the Raytheon Type R Regulator Tube in light socket power units.



Raytheon A—the compact efficient rectifier, new in principle and construction. For A battery chargers and A battery eliminator units.

Raytheon BA—a 350 milliampere rectifying tube for complete battery elimination. Watch for the new ABC power units employing this rectifier.

RAYTHEON MANUFACTURING COMPANY
CAMBRIDGE, MASS.

Raytheon

THE HEART OF RELIABLE RADIO POWER

New Transformers for A. C. Power Supply

The AmerTran Power Transformer Type PF-281, $25.00 each

AS IN audio transformers, AmerTran products stand first in the power transformer field. They are up-to-date in design, well made and dependable.

Type PF-281, illustrated above, becomes virtually an A-B-C eliminator when used with AC tubes and the proper filter circuit for DC voltages of from 425 to 650 volts, plate current 110 milliamperes. This unit is designed for use with the new UX-281 rectifying tube, and has a 750 volt plate winding which enables it to be used with a UX-281 or 216-B rectifying tube. In addition, there are filament heating windings for the new AC tubes. Therefore, this single unit will convert AC house current into filament and plate current, and grid bias potential. Used with types 709 and 854 AmerChokes in the filter circuit, a receiver may be constructed to operate entirely from the house lighting circuit.

Type H-67 Heater Transformer is a new unit recommended for use with the RCA UX-226 raw AC amplifier tubes and the UY-227 detector tube. It also has a third filament winding capable of handling two UX-171 tubes. In connection with the new AC tubes, type H-67 becomes the power source for the filament and is therefore a real "A" battery eliminator. This transformer sells for $12.00.

Write for Booklet, "Improving the Audio Amplifier," and data on Power Supply Units.

AMERICAN TRANSFORMER CO.
178 Emmet Street Newark, N. J.

We also make Audio Transformers Choke Coils and Resistors.

Transformer Builders for Over Twenty-Six Years

Manufacturers' Booklets

A Varied List of Books Pertaining to Radio and Allied Subjects Obtainable Free With the Accompanying Coupon

READERS may obtain any of the booklets listed below by using the coupon printed on page 396 Order by number only.

1. FILAMENT CONTROL—Problems of filament supply, voltage regulation, and effect on various circuits. RADIALL COMPANY.
2. HARD RUBBER PANELS—Characteristics and properties of hard rubber as used in radio, with suggestions on how to "work" it. B. F. GOODRICH RUBBER COMPANY.
3. TRANSFORMERS—A booklet giving data on input and output transformers. PACENT ELECTRIC COMPANY.
4. RESISTANCE-COUPLED AMPLIFIERS—A general discussion of resistance coupling with curves and circuit diagrams. COLE RADIO MANUFACTURING COMPANY.
5. CARBORUNDUM IN RADIO—A book giving pertinent data on the crystal as used for detection, with hook-ups, and a section giving information on the use of resistors. THE CARBORUNDUM COMPANY.
6. B-ELIMINATOR CONSTRUCTION—Constructional data on how to build. AMERICAN ELECTRIC COMPANY.
7. TRANSFORMER AND CHOKE-COUPLED AMPLIFICATION—Circuit diagrams and discussion. ALL-AMERICAN RADIO CORPORATION.
8. RESISTANCE UNITS—A data sheet of resistance units and their application. WARD-LEONARD ELECTRIC COMPANY.
9. VOLUME CONTROL—A leaflet showing circuits for distortionless control of volume. CENTRAL RADIO LABORATORIES.
10. VARIABLE RESISTANCE—As used in various circuits. CENTRAL RADIO LABORATORIES.
11. RESISTANCE COUPLING—Resistors and their application to audio amplification, with circuit diagrams. DEJUR PRODUCTS COMPANY.
12. DISTORTION AND WHAT CAUSES IT—Hook-ups of resistance-coupled amplifiers with standard circuits. ALLEN-BRADLEY COMPANY.
15. B-ELIMINATOR AND POWER AMPLIFIER—Instructions for assembly and operation using Raytheon tube. GENERAL RADIO COMPANY.
15a. B-ELIMINATOR AND POWER AMPLIFIER—Instructions for assembly and operation using an R. C. A. rectifier. GENERAL RADIO COMPANY.
16. VARIABLE CONDENSERS—A description of the functions and characteristics of variable condensers with curves and specifications for their application to complete receivers. ALLEN D. CARDWELL MANUFACTURING COMPANY.
17. BAKELITE—A description of various uses of bakelite in radio, its manufacture, and its properties. BAKELITE CORPORATION.
19. POWER SUPPLY—A discussion on power supply with particular reference to lamp-socket operation. Theory and constructional data for building power supply devices. ACME APPARATUS COMPANY.
20. AUDIO AMPLIFICATION—A booklet containing data on audio amplification together with hints for the constructor. ALL AMERICAN RADIO CORPORATION.
21. HIGH-FREQUENCY DRIVER AND SHORT-WAVE WAVEMETER—Constructional data and application. BURGESS BATTERY COMPANY.
46. AUDIO-FREQUENCY CHOKES—A pamphlet showing positions in the circuit where audio-frequency chokes may be used. SAMSON ELECTRIC COMPANY.
47. RADIO-FREQUENCY CHOKES—Circuit diagrams illustrating the use of chokes to keep out radio-frequency currents from definite points. SAMSON ELECTRIC COMPANY.
48. TRANSFORMER AND IMPEDANCE DATA—Tables giving the mechanical and electrical characteristics of transformers and impedances, together with a short description of their use in the circuit. SAMSON ELECTRIC COMPANY.
49. BYPASS CONDENSERS—A description of the manufacture of bypass and filter condensers. LESLIE F. MUTER COMPANY.
50. AUDIO MANUAL—Fifty questions which are often asked regarding audio amplification, and their answers. AMERTRAN SALES COMPANY, INCORPORATED.
51. SHORT-WAVE RECEIVER—Constructional data on a receiver which, by the substitution of various coils, may be made to tune from a frequency of 16,660 kc. (18 meters) to 1999 kc. (150 meters). SILVER-MARSHALL, INCORPORATED.
52. AUDIO QUALITY—A booklet dealing with audio-frequency amplification of various kinds and the application to well-known circuits. SILVER-MARSHALL, INCORPORATED.
56. VARIABLE CONDENSERS—A bulletin giving an analysis of various condensers together with their characteristics. GENERAL RADIO COMPANY.
57. FILTER DATA—Facts about the filtering of direct current supplied by means of motor-generator outfits used with transmitters. ELECTRIC SPECIALTY COMPANY.
59. RESISTANCE COUPLING—A booklet giving some general information on the subject of radio and the application of resistors to a circuit. DAVEN RADIO CORPORATION.
60. RESISTORS—A pamphlet giving some technical data on resistors which are capable of dissipating considerable energy; also data on the ordinary resistors used in resistance-coupled amplification. THE CRESCENT RADIO SUPPLY COMPANY.
62. RADIO-FREQUENCY AMPLIFICATION—Constructional details of a five-tube receiver using a special design of radio-frequency transformer. CAMFIELD RADIO MFG. COMPANY.
63. FIVE-TUBE RECEIVER—Constructional data on building a receiver. AERO PRODUCTS, INCORPORATED.
64. AMPLIFICATION WITHOUT DISTORTION—Data and curves illustrating the use of various methods of amplification. ACME APPARATUS COMPANY.
66. SUPER-HETERODYNE—Constructional details of a seven-tube set. G. C. EVANS COMPANY.
70. IMPROVING THE AUDIO AMPLIFIER—Data on the characteristics of audio transformers, with a circuit diagram showing where chokes, resistors, and condensers can be used. AMERICAN TRANSFORMER COMPANY.
72. PLATE SUPPLY SYSTEM—A wiring diagram and layout plan for a plate supply system to be used with a power amplifier. Complete directions for wiring are given. AMERTRAN SALES COMPANY.
80. FIVE-TUBE RECEIVER—Data are given for the construction of a five-tube tuned radio-frequency receiver. Complete instructions, list of parts, circuit diagram, and template are given. ALL-AMERICAN RADIO CORPORATION.
81. BETTER TUNING—A booklet giving much general information on the subject of radio reception with specific illustrations. Primarily for the non-technical home constructor. BREMER-TULLY MANUFACTURING COMPANY.
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83. SOCKET POWER DEVICE—A list of parts, diagrams, and templates for the construction and assembly of socket power devices. JEFFERSON ELECTRIC MANUFACTURING COMPANY.
84. FIVE-TUBE EQUAMATIC—Panel layout, circuit diagrams, and instructions for building a five-tube receiver, together with data on the operation of tuned radio-frequency transformers of special design. KARAS ELECTRIC COMPANY.
85. FILTER—Data on a high-capacity electrolytic condenser used in filter circuits in connection with A socket power supply units, are given in a pamphlet. THE ABOX COMPANY.
86. SHORT-WAVE RECEIVER—A booklet containing data on a short-wave receiver as constructed for experimental purposes. THE ALLEN D. CARDWELL MANUFACTURING CORPORATION.
88. SUPER-HETERODYNE CONSTRUCTION—A booklet giving full instructions, together with a blue print and necessary data, for building an eight-tube receiver. THE GEORGE W. WALKER COMPANY.
89. SHORT-WAVE TRANSMITTER—Data and blue prints are given on the construction of a short-wave transmitter, together with operating instructions, methods of keying, and other pertinent data. RADIO ENGINEERING LABORATORIES.
90. IMPEDANCE AMPLIFICATION—The theory and practice of a special type of dual-impedance audio amplification are given. ALDEN MANUFACTURING COMPANY.
93. B-SOCKET POWER—A booklet giving constructional details of a socket-power device using either the BH or 313 type rectifier. NATIONAL COMPANY, INCORPORATED.
94. POWER AMPLIFIER—Constructional data and wiring diagrams of a power amplifier combined with a B-supply unit are given. NATIONAL COMPANY, INCORPORATED.
100. A, B, AND C SOCKET-POWER SUPPLY—A booklet giving data on the construction and operation of a socket-power supply using the new high-current rectifier tube. THE Q. R. S. MUSIC COMPANY.
101. USING CHOKES—A folder with circuit diagrams of the more popular circuits showing where choke coils may be placed to produce better results. SAMSON ELECTRIC COMPANY.

ACCESSORIES

22. A PRIMER OF ELECTRICITY—Fundamentals of electricity with special reference to the application of dry cells to radio and other uses. Constructional data on buzzers, automatic switches, alarms, etc. NATIONAL CARBON COMPANY.
23. AUTOMATIC RELAY CONNECTIONS—A data sheet showing how a relay may be used to control A and B circuits. YAXLEY MANUFACTURING COMPANY.
25. ELECTROLYTIC RECTIFIER—Technical data on a new type of rectifier with operating curves. KODEL RADIO CORPORATION.
26. DRY CELLS FOR TRANSMITTERS—Actual tests given, well illustrated with curves showing exactly what may be expected of this type of B power. BURGESS BATTERY COMPANY.
27. DRY-CELL BATTERY CAPACITIES FOR RADIO TRANSMITTERS—Characteristic curves and data on discharge tests. BURGESS BATTERY COMPANY.
28. B BATTERY LIFE—Battery life curves with general curves on tube characteristics. BURGESS BATTERY COMPANY.
29. HOW TO MAKE YOUR SET WORK BETTER—A non-technical discussion of general radio subjects with hints on how reception may be bettered by using the right tubes. UNITED RADIO AND ELECTRIC CORPORATION.
30. TUBE CHARACTERISTICS—A data sheet giving constants of tubes. C. E. MANUFACTURING COMPANY.
31. FUNCTIONS OF THE LOUD SPEAKER—A short, non-technical general article on loud speakers. AMPLION CORPORATION OF AMERICA.
32. METERS FOR RADIO—A catalogue of meters used in radio, with connecting diagrams. BURTON-ROGERS COMPANY.
33. SWITCHBOARD AND PORTABLE METERS—A booklet giving dimensions, specifications, and shunts used with various meters. BURTON-ROGERS COMPANY.
34. COST OF B BATTERIES—An interesting discussion of the relative merits of various sources of B supply, HARTFORD BATTERY MANUFACTURING COMPANY.
35. STORAGE BATTERY OPERATION—An illustrated booklet on the care and operation of the storage battery. GENERAL LEAD BATTERIES COMPANY.
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37. CHOOSING THE RIGHT RADIO BATTERY—Advice on what dry cell battery to use; their application to radio, with wiring diagrams. NATIONAL CARBON COMPANY.
53. TUBE REACTIVATOR—Information on the care of vacuum tubes, with notes on how and when they should be reactivated. THE STERLING MANUFACTURING COMPANY.
54. ARRESTERS—Mechanical details and principles of the vacuum type of arrester. NATIONAL ELECTRIC SPECIALTY COMPANY.
55. CAPACITY CONNECTOR—Description of a new device for connecting up the various parts of a receiving set, and at the same time providing bypass condensers between the leads. KURZ-KASCH COMPANY.

(Continued on page 396)

VITROHM RESISTORS and RHEOSTATS

cover every resistance requirement in current supply unit circuits

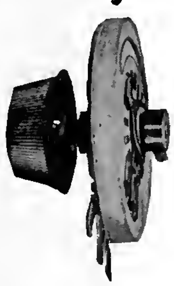
CHOOSE to build the power circuit you will this year and there is a *dependable* Vitrohm Resistor and Rheostat exactly engineered to meet your requirements.

Resistance is the heart of power circuits. Assure yourself of quiet, permanent, and unfailing service by insisting upon Vitrohms for radio. Each of the 95 Vitrohm Radio Resistors and Rheostats is guaranteed unconditionally for continuous duty in any circuit where it operates within its watts-dissipation rating. And Vitrohms have the highest watts-dissipation rating without resistance change of all resistance units.

The Adjustat

The Adjustat is a new Vitrohm Rheostat designed for use in radio current supply unit circuits.

Each Adjustat has 15 steps of resistance and is arranged for potentiometer connection. Its compact size, 2¾ inches in diameter, permits the use of several Adjustats in circuits where adjustable resistance is desirable.



Like all Vitrohm Products, the resistive element, wire having a low temperature coefficient of resistivity, is embedded and permanently protected by a fuse-on coating of vitreous enamel.

11 Types are available as listed below. The Adjustat is priced at $3.00.

507-79, 1 ohm, 4 amp.—507-71, 2 ohms, 3 amp.—507-72, 6 ohms, 1.5 amp.—507-73, 20 ohms, 1.0 amp.—507-74, 30 ohms, 0.75 amp.—507-80, 50 ohms, 650 m.a.—507-81, 600 ohms, 180 m.a.—507-75, 1000 ohms, 125 m.a.—507-76, 2250 ohms, 90 m.a.—507-77, 10,000 ohms, 40 m.a.—507-78, 25,000 ohms, 10 m.a.

Raytheon and QRS ABC Units

Three new Vitrohm Radio Products are immediately available for use in the Raytheon 350 m. a. and QRS 400 m. a. ABC Current Supply Units. Vitrohm Resistor 507-62, priced at $7.50, is tapped for all voltages needed in the QRS Circuits.

Vitrohm Resistor 507-70, priced at $7.50, is officially approved by the Raytheon Laboratories for use with their rectifier. (Illustrated.)

Vitrohm Rheostat 507-59, priced at $5.50, is designed for series primary control in both circuits.

Vitrohm Grid Leaks for Transmitting Circuits

Vitrohm Transmitting Grid Leaks are now available for the R.C.A. UX 852 and De Forest P and H transmitting tubes.

Ward Leonard has developed a complete standard line of transmitting grid leaks and rheostats covering all circuits up to and including those of 1,000 watts input. If you are interested in this and other radio apparatus, write for Radio Bulletin 507 (1927–1928). It will be sent without charge.

Ward Leonard Electric Company

31-41 SOUTH STREET MOUNT VERNON, N. Y.

resistor specialists for more than 35 years

Build Bigger Values into Your Radio Set with YAXLEY

YAXLEY APPROVED RADIO PRODUCTS

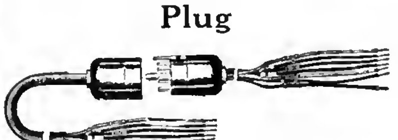
APPROVED RADIO PRODUCTS

Modernize your radio set construction with these two great Yaxley contributions to convenience, efficiency and good appearance;

Automatic Power Control

A new and better power control that cuts in the B eliminator and cuts out the trickle charger when the set is switched on. Cuts out the B eliminator and cuts in the trickle charger when the set is switched off, automatically, unfailingly. No. 444—Series Type. With the exclusively Yaxley feature that keeps the voltage drop less than two-tenths (2-10) volts when used with sets having a current draw equivalent to four 199 type tubes up to eleven 201 type tubes $5.00

Cable Connector Plug



Preserve the neat appearance of your set by centering all battery wires in one neat, compact cable. Safe, simple and sure. Plug is of handsome Bakelite construction. Contact springs of phosphor bronze. Positive contact.

No. 660—Cable Connector Plug, Complete........................ $3.00

No. 670—Cable Connector Plug for Binding Post Connections, Complete $3.50

At your dealer's. If he cannot supply you, send his name with your order to

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CHICAGO, ILL.

68. Chemical Rectifier—Details of assembly, with wiring diagrams, showing how to use a chemical rectifier for charging batteries. Cleveland Engineering Laboratories Company.

69. Vacuum Tubes—A booklet giving the characteristics of the various tube types with a short description of where they may be used in the circuit. Radio Corporation of America.

77. Tubes—A booklet for the beginner who is interested in vacuum tubes. A non-technical consideration of the various elements in the tube as well as their position in the receiver. Cleartron Vacuum Tube Company.

87. Tube Tester—A complete description of how to build and how to operate a tube tester. Burton-Rogers Company.

91. Vacuum Tubes—A booklet giving the characteristics and uses of various types of tubes. This booklet may be obtained in English, Spanish, or Portuguese. DeForest Radio Company.

92. Resistors for A. C. Operated Receivers—A booklet giving circuit suggestions for building a. c. operated receivers, together with a diagram of the circuit used with the new 400-mill ampere r ctifier tube. Carter Radio Company.

97. High-Resistance Voltmeters—A folder giving information on how to use a high-resistance voltmet r, special consideration being g'ven the voltage measurement of socket-power d-vices. Westinghouse Electric & Manufacturing Company.

102. Radio Power Bulletins—Circuit diagrams, theory constants, and trouble-shooting hints for units employing th BH or B rectifi-r tubes. Raytheon Manufacturing Company.

103. A. C. Tubes—The design and operating character istics of a new a. c. tube. Five circuit diagrams show how to convert well-known circuits. Sovreign Electric & Manufacturing Company.

Miscellaneous

38. Log Sheet—A list of broadcasting stations with columns for marking down dial settings. U. S. L. Radio, Incorporated.

41. Baby Radio Transmitter of 9XH-9EK—Description and circuit diagrams of dry-cell operated transmitter. Burgess Battery Company.

42. Arctic Radio Equipment—Description and circuit details of short-wave receiver and transmitter used in Arctic exploration. Burgess Battery Company.

43. Short-Wave Receiver of 9XH-9EK—Complete directions for assembly and operation of the receiver. Burgess Battery Company.

44. Aluminum for Radio—A booklet containing much radio information with hook-ups of basic circuits, with inductance-capacity tables and other pertinent data. Aluminum Company of America.

45. Shielding—A discussion of the application of shielding in radio circuits with special data on aluminum shields. Aluminum Company of America.

58. How to Select a Receiver—A commonsense booklet describing what a radio set is, and what you should expect from it, in language that any one can understand. Day-Fan Electric Company.

67. Weather for Radio—A very interesting booklet on the relationship between weather and radio reception, with maps and data on forecasting the probable results. Taylor Instrument Companies.

73. Radio Simplified—A non-technical booklet giving pertinent data on various radio subjects. Of especial interest to the beginner and set owner. Crosley Radio Corporation.

74. The Experimenter—A monthly publication which gives technical facts, valuable tables, and pertinent information on various radio subjects. Interesting to the experimenter and to the technical radio man. General Radio Company.

75. For the Listener—General suggestions for the selecting, and the care of radio receivers. Valley Electric Company.

76. Radio Instruments—A description of various meters used in radio and electrical circuits together with a short discussion of their uses. Jewell Electrical Instrument Company.

78. Electrical Troubles—A pamphlet describing the use of electrical testing instruments in automotive work combined with a description of the cadmium test for storage batteries. Of interest to the owner of storage batteries. Burton Rogers Company.

95. Resistance Data—Successive bulletins regarding the use of resistors in various parts of the rad'o circuit. International Resistance Company.

96. Vacuum Tube Testing—A booklet giving pertinent data on how to test vacuum tubes with special reference to a tube testing unit. Jewell Electrical Instrument Company.

98. Copper Shielding—A booklet giving information on the use of shielding in radio receivers, with notes and diagrams showing how it may be app:ied practi:ally. Of special interest to the home constructor. The Copper and Brass Research Association.

99. Radio Convenience Outlets—A folder giving diagrams and sp.cifications for :nstalling loud speakers in various locations at some distanc: from the receiving set. Yaxley Manufacturing Company.

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What Kit Shall I Buy?

The list of kits herewith is printed as an extension of the scope of the Service Department of Radio Broadcast. *It is our purpose to list here the technical data about kits on which information is available. In some cases, the kit can be purchased from your dealer complete; in others, the descriptive booklet is supplied for a small charge and the parts can be purchased as the buyer likes. The Service Department will not undertake to handle cash remittances for parts, but when the coupon on page 398 is filled out, all the information requested will be forwarded.*

201. SC Four-Tube Receiver—Single control. One stage of tuned radio frequency, regenerative detector, and two stages of transformer-coupled audio amplification. Regeneration cont rol is accomplished by means of a variable resistor across the tickler coil. Standard parts; cost approximately $58.85.

202. SC-II Five-Tube Receiver—Two stages of tuned radio frequency, detector, and two tages of transformer-coupled audio. Two tuning controls. Volume control consists of potentiometer grid bias on r.f. tubes. Standard parts cost approximately $60.35.

203. "HI-Q" Kit—A five-tube tuned radio-frequency set having two radio stages, a detector, and two transformer-coupled audio stages. A special method of coupling in the r.f. stages tends to make the amplification more nearly equal over the entire band. Price $63.05 without cabinet.

204. R. G. S. Kit—A four-tube inverse reflex circuit, having the equivalent of two tuned radio-frequency stages, detector, and three audio stages. Two controls. Price $69.70 without cabinet.

205. Pierce Airo Kit—A six-tube single-dial receiver; two stages of radio-frequency amplification, detector, and three stages of resistance-coupled audio. Volume control accomplished by variation of filament brilliancy of r.f. tubes or by adjusting compensating condensers. Complete chassis assembled but not wired costs $42.50.

206. H & H-T. r. f. Assembly—A five-tube set; three tuning dials, two steps of radio frequency, detector, and 2 transformer-coupled audio stages. Complete except for baseboard, panel, screws, wires, and accessories. Price $35.00.

207. Premier Five-Tube Ensemble—Two stages of tuned radio frequency, detector, and two steps of transformer coupled audio. Three dials. Parts assembled but not wired. Price complete, except for cabinet, $35.00.

208. "Quadraformer VI"—A six-tube set with two tuning controls. Two stages of tuned radio frequency using specially designed shielded coils, a detector, one stage of transformer-coupled audio, and two stages of resistance-coupled audio. Gain control by means of tapped primaries on the r.f. transformers. Essential kit consists of three shielded double-range "Quadraformer" coils, a selectivity control, and an "Ampitrol," price $17.50. Complete parts $70.15.

209. Gen-Ral Five-Tube Set—Two stages of tuned radio frequency, detector, and two transformer-coupled audio stages. Volume is controlled by a resistor in the plate circuit of the r.f. tubes. Uses a special r.f. coil ("Duo-Former") with figure eight winding. Parts mounted but not wired, price $37.50.

210. Bremer-Tully Power-Six—A six-tube, dual-control set; three stages of neutralized tuned radio frequency, detector, and two transformer-coupled audio stages. Resistances in the grid circuit together with a phase shifting arrangement are used to prevent oscillation. Volume control accomplished by variation of B potential on r.f. tube. Essential kit consists of four r.f. transformers, two dual condensers, three small condensers, three choke coils, one 500,000-ohm resistor, three 1500-ohm resistors, and a set of color charts and diagrams. Price $41.50.

211. Bruno Drum Control Receivers—How to apply a drum tuning unit to such circuits as the three-tube regenerative receiver, four-tube Browning-Drake, five-tube Diamond-of-the-Air, and the "Grand" 6.

212. Infradyne Amplifier—A three-tube intermediate-frequency amplifier for the super-heterodyne and other special receivers, tuned to 3490 kc. (86 meters). Price $25.00.

213. Radio Broadcast "Lab" Receiver—A four-tube dual-control receiver with one stage of Rice neutralized tuned-radio frequency, regenerative detector (capacity controlled), and two stages of transformer-coupled audio. Approximate price, $78.15.

214. LC-27—A five-tube set with two stages of tuned-radio frequency, a detector, and two stages of transformer-coupled audio. Special coils and special means of neutralizing are employed. Output device. Price $85.20 without cabinet.

215. Loftin-White—A five-tube set with two stages of radio frequency, especially designed to give equal amplification at all frequencies, a detector, and two stages of transformer-coupled audio. Two controls. Output device. Price $85.10.

216. K.H.-27—A six-tube receiver with two stages of neutralized tuned radio frequency, a detector, three stages of choke-coupled audio, and an output device. Two controls. Price $86.00 without cabinet.

217. Aero Short-Wave Kit—Three plug-in coils designed to operate with a regenerative detector circuit and having a frequency range of from 19,990 to 2306 kc. (15 to 130 meters). Coils and plug only, price $12.50.

218. Diamond-of-the-Air—A five-tube set having one stage of tuned-radio frequency, a regenerative detector, one stage of transformer-coupled audio, and two stages of resistance-coupled audio. Volume control through regeneration. Two tuning dials.

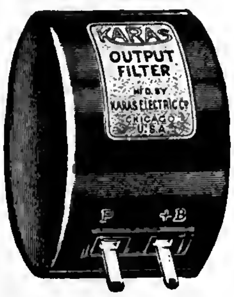
219. Norden-Hauck Super 10—Ten tubes; five stages of tuned radio frequency, detector, and four stages of choke- and transformer-coupled audio frequency. Two controls. Price $291.40.

USE KARAS PARTS FOR THE FINEST POSSIBLE RESULTS

in building your 2-Dial Karas Equamatic or in building any other high grade receiver

KARAS PRODUCTS

The NEW Karas Type 28 Audio Transformer Price, $8.00



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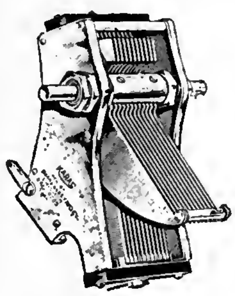


The NEW Karas S.F.L. Condenser with Removable Shaft, Price: .00025 mfd., $5; .00037 mfd. $5.25; .0005 mfd. $5.50

YOU must, of course, use Karas Parts when you build your NEW Karas 2-Dial Equamatic Receiver—the powerful 5-tube completely balanced and perfectly neutralized radio frequency circuit with which Karas scores again in another sensational success for 1927-28. This new receiver was designed by Karas engineers to operate at maximum efficiency with Karas parts—and will only do so when these parts are used exactly as specified. But ALL Karas parts are adapted for use in scores of other popular circuits—are specified in the leading successes of 1927-28 by many leading radio publications—and to get the maximum of efficiency—the finest possible results—you should be sure to use Karas parts when building ANY receiver. There is not a circuit in popular use which cannot be vastly improved thruugh the use of these parts in place of less efficient ones.

Karas Engineering is Known All Over the World

All over the world, wherever radio has penetrated, Karas parts are known for their precise, careful engineering. The reputation of the entire Karas line has been built upon sound radio engineering practice, allied with precision manufacturing methods, insuring positively and certainly that each Karas part will do exactly what we claim it will do. Other manufacturers do not bother to work within limits of accuracy as close as those established in the Karas factories. Yet we know of no other way to build radio apparatus and have it exactly right. Our standards are high, but they are essential to best results in radio performance. Sound engineering practice, scientific study of every problem presented, and the finding of the correct solution, are Karas essentials upon which we have built the remarkable reputation Karas Products enjoy. For example, in our new Type 28 Transformers we use hermetically spun-sealed steel clad cases in which the impregnated windings are sealed. Moisture cannot enter this case, nor can the insulating compound ever get out. Thus the delicate windings are forever protected from injury. In our new S. F. L. Condensers we work within such close limits that the shafts of any Karas Condenser may be instantly removed and interchanged with the shaft of any other Karas Condenser of the same type. In the Karas Micrometric Vernier Dial we obtain a 63 to 1 gear ratio and you obtain 1|1000th of an inch tuning as a result. You will discover for yourself many other examples of Karas engineering as you use Karas parts in building your sets.

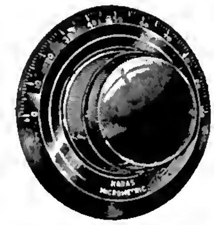
Use these Karas Parts for the 2-Dial Equamatic

You will wish to build a Karas 2-Dial Equamatic right away when you know how marvelously simple it is to operate—how powerful and sweet-toned it is—and what selectivity and volume it possesses. There is nothing else to equal it in a 5-tube receiver—many 6 and 7 tube sets cannot rival the 2-Dial Equamatic.

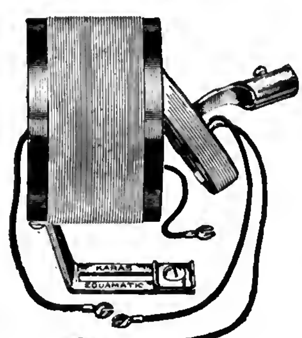
This new Karas receiver is extremely easy to build. Our Complete, detailed instructions make every step very clear and very easy to follow. You can build this receiver in a few hours and thus have one of the finest, most selective radio frequency sets you have ever owned. To build this receiver you will need, in addition to certain standard parts easily obtainable anywhere, the following Karas parts which your dealer has in stock for you:

3 Karas Equamatic R.F. Transformers, each $4	$12.00
3 Karas Equamatic Type 17 Removable Shaft S. F. L. Variable Condensers, each $5.25	15.75
2 Karas Micrometric Vernier Dials, each $3.50	7.00
2 Karas Type 28 Impregnated Audio Transformers, each $8.00	16.00
1 Karas Output Filter	8.00
3 Karas Subpanel Brackets, set of 3	.70
1 Karas 2-Dial Control System, complete with three extra shafts and all necessary assembly hardware for set	3.00

Mail the coupon to-day for complete list of parts, and full information about this receiver. Then order the necessary Karas and other parts from your dealer so you can build this set without delay. You will be delighted with it—will find it a receiver of tremendous power, volume and tone, and the most satisfactory receiver you ever built. Be sure to mail coupon to us to-day.



Karas Micrometric Vernier Dials, Price $3.50



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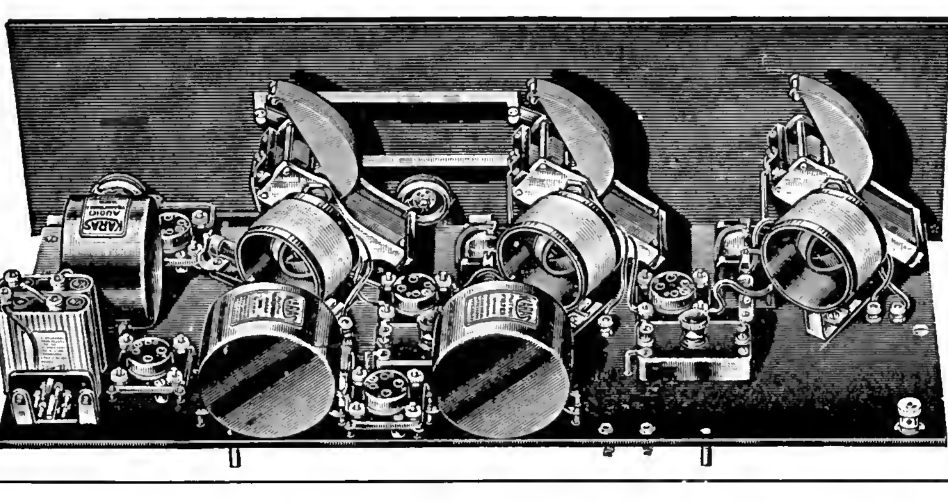

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Please send me complete data on the new 2-Dial Karas Equamatic Receiver, and also data on the Knickerbocker 4, as well as information about the new Karas parts.

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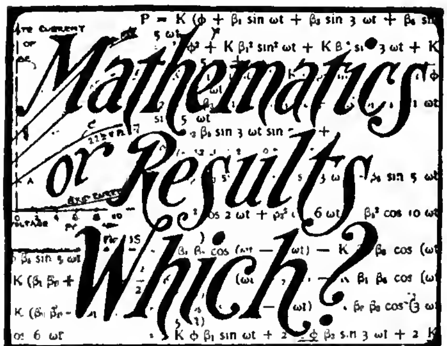

YOU can't get away from "variables" in the radio power unit. Line voltage fluctuations, changes in receiver tubes, differences in rectifier tubes, lowered rectifier output with age, unequal drain for different yet inter-related circuits—well, there are many "variables" present and for which you must compensate with suitable resistance values.

Of course, if you are an expert mathematician and engineer, preferring to work the slide rule than to enjoy radio programs, then by all means get the fun out of figuring the necessary resistance values. And don't forget to change the resistors from time to time to compensate for the changing conditions.

But if you are just the average radio enthusiast, seeking the best results with the least troubles, then use variable resistors to take care of all "variables." And when you say variable resistor—that means.

CLAROSTAT

CAUTION! Clarostat is being imitated Look for the name stamped on the shell!

GET THE FACTS!

Ask your local dealer regarding Clarostats and how you can apply them in that new or old radio power unit. Better still, send a quarter for our big 32-page book "The Gateway to Better Radio," which contains a vast fund of information on radio in general.

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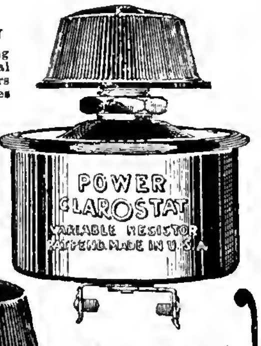
The POWER CLAROSTAT
A husky for handling real power. In several turns of knob, it covers wide range. Handles up to 40 watts. In three ranges—0 to 10 ohms, 25-500 ohms, 200-100,000 ohms. **Price $3.50.**



The STANDARD CLAROSTAT
The ideal B-voltage tap control, providing the precise voltage for each circuit and for any type of tube. Universal resistance range of from practically 0 to 5,000,000 ohms, with a current carrying capacity of 20 watts. Noiseless, nonpacking, foolproof and indestructible within its working capacity. **Price $2.25**

WHAT KIT SHALL I BUY? *(Continued)*

220. BROWNING-DRAKE—Five tubes; one stage tuned radio frequency (Rice neutralization), regenerative detector (tickler control), three stages of audio (special combination of resistance- and impedance-coupled audio). Two controls

221. LR4 ULTRAOYNE—Nine-tube super-heterodyne; one stage of tuned radio frequency, one modulator, one oscillator, three intermediate-frequency stages, detector, and two transformer-coupled audio stages.

222. GREIFF MULTIPLEX—Four tubes (equivalent to six tubes); one stage of tuned radio frequency, one stage of transformer-coupled radio frequency, crystal detector, two stages of transformer-coupled audio, and one stage of impedance-coupled audio. Two controls. Price complete parts, $50.00.

223. PHONOGRAPH AMPLIFIER—A five-tube amplifier device having an oscillator, a detector, one stage of transformer-coupled audio, and two stages of impedance-coupled audio. The phonograph signal is made to modulate the oscillator in much the same manner as an incoming signal from an antenna.

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Garden City, New York.
Please send me information about the following kits indicated by number:

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RB1027

A KEY TO RECENT RADIO ARTICLES

By E. G. SHALKHAUSER

THIS is the twenty-third installment of references to articles which have appeared recently in various radio periodicals. Each separate reference should be cut out and pasted on 4" x 6" cards for filing, or pasted in a scrap book either alphabetically or numerically. An outline of the Dewey Decimal System (employed here) appeared last in the January RADIO BROADCAST.

R344.4. SHORT-WAVE GENERATORS. TRANSMITTER,
QST. April, 1927. Pp. 15-16. *Short-Wave.*
"A 15-Meter Commercial Station-2 XS."
The General Electric station 2 XS, operating on 15 meters, built for the purpose of transmitting to Buenos Aires 365 days in the year, regardless of weather conditions, is described. The set is rated at 7 kw. and radiates its energy from a horizontal doublet with reflector.

R134. DETECTOR ACTION DETECTOR ACTION.
QST. April, 1927. Pp. 17-18.
"Which Is the Detector Tube?" L. W. Hatry.
The difference in operation of detectors and amplifiers in standard radio circuits is discussed. Whether a tube functions as a detector as an amplifier, or both, depends upon various factors in the circuit, such as grid return, connection of grid leak, etc.

R330. ELECTRON TUBES. ELECTRON TUBES.
QST. April, 1927. Pp. 26-30. *UX-240.*
"CX-340—UX-240," R. S. Kruse.
In making a comparison between the UX-201-A and the new UX-240 amplifier tube, the writer presents the details upon which good amplification depends, namely: (1) The amplification constant of the tube; (2) the plate impedance of the tube; (3) the impedance of the transformer. The UX-240 is said to be excellent for c. w. and for resistance-coupled broadcast sets. As a detector, this new tube is said to eliminate considerable interference because of its peak characteristics.

R251.2. THERMO-ELEMENT. THERMO-COUPLE
QST. April, 1927. Pp. 31-32. DEVICE.
"A Sensitive Thermo-Couple," B. J. Chromy.
A very inexpensive and useful thermo-couple, made of tellurium and platinum wire, is described. The method of constructing the device and calibrating its range, together with a wiring diagram and experimental data, are given.

R 375.3. ELECTROLYTIC RECTIFIERS. RECTIFIERS,
QST. April, 1927. Pp. 34-38. *Dry Electrolytic.*
"Developments in Dry Electrolytic Rectifiers," R. S. Kruse.
A new type of rectifier, using a combination of copper, magnesium, and composition discs (the last mentioned consisting of zinc selenide and copper selenide, among other things), has been perfected for A battery chargers up to 3 amperes output, and also for A battery substitutes, as stated. Complete details concerning mechanical and electrical characteristics of this new type of dry rectifier are given.

R007.1. UNITED STATES LAWS AND REGULATIONS. LAWS,
QST. April, 1927. Pp. 39-44. *Radio Act, 1927.*
"The New Radio Law,"
The complete text of the new Radio Law, as enacted by Congress in February, 1927, is printed for the benefit of the readers of *QST.*

R113.5. METEOROLOGICAL. METEOROLOGY,
QST. April, 1927. Pp. 45-46. *Distance Calculations.*
"How Far Is It?" C. C. Knight.
A method whereby distances on the earth's surface from place to place may be determined with accuracy, is outlined in terms of spherical trignometric formulas. As stated, the plan is very simple and the average person may obtain very good results using these formulas. Distance on flat maps are very inaccurate ordinarily, since it is difficult to make allowances for the curvature of the earth.

R261. ELECTRON-TUBE VOLTMETERS. VOLTMETER,
QST. April, 1927, Pp. 47-53. *Electron-Tube*
"The Most Useful Meter," R. F. Shea.
A comparison made between ordinary types of meters used in radio measurements and the vacuum-tube voltmeter shows how far superior the latter is when making accurate tests for small current and voltage values: Five types of commercial vacuum-tube voltmeters, their apparatus, and circuit arrangement, and their operation, are outlined in detail. The following are some of the many measurements that can be made with this handy instrument: (1) Obtaining gain through a radio-frequency or audio-frequency amplifier; (2) Checking the wave form of an oscillator; (3) Measuring high impedance; (4) Employing it as a wavemeter of high precision.

R381. CONDENSERS. CONDENSERS,
QST. April, 1927. Pp. 55-57. *Electrolytic.*
"Electrolytic Filter Condensers," L. F. Lenck.
The operation of electrolytic filter condensers, employing aluminum "pie-plates" and ammonium phosphate in their make-up in smoothing out the rectified a. c., is outlined. The method of forming plates and precautions to take in getting good results are discussed in detail.

R344.4. SHORT-WAVE GENERATORS. TRANSMITTER,
RADIO BROADCAST. April, 1927. Pp. 570-573. *Short-Wave.*
"A 20—40—80—Meter Transmitter," K. Henney.
Supplementing data given in the April, 1926, and Nov. 1926, RADIO BROADCAST, on the construction and operation of a short-wave transmitter, additional information is presented concerning a similar set which operates from the power mains, using two 216-B rectifiers and two UX-210 oscillators. The circuit is of the well-known Hartley pattern. Considerable information on details of construction is presented so that any one interested in transmitters may set up the outfit. Data on DeForest transmitter tubes are also given.

R351. SIMPLE OSCILLATORS. OSCILLATOR,
QST. March, 1927. Pp. 23-27. *Calibrator.*
"Quartz Crystal Calibrators," A. Crossley.
Two circuits, in which the quartz crystal may be used to set up continuous oscillations, are discussed. These employ either a crystal placed between plate and grid or between grid and filament of a vacuum tube, the latter method being preferred, With large inductance and small capacity in the phase adjusting circuit of the plate, many harmonics are said to be obtainable. The crystal calibrator, as described, may be used to measure accurately inductances, capacities, frequency meters, transmitters, etc.

R536. MINING. MINING AND RADIO.
Radio. Feb., 1927. Pp. 28-ff.
"Experiments in Radio Prospecting, "J. G. Alverson.
The author gives some of his findings regarding the propagation of radio waves through the crust of the earth, showing how the wave-front of the electromagnetic wave changes with a change in rock, earth, and minerals. Data are presented of many observations made with a small transmitter operating on a wavelength of 1000 meters (300 kc.) and using an ordinary type receiver.

R343.5. SUPER-HETERODYNE SETS. SUPER-HETERODYNE,
Radio. Feb., 1927. Pp. 25-ff. *Best 1927 Model.*
"The 1927 Model of Best's Super-Heterodyne," G. M. Best.
The improved model of Best's super-heterodyne receiver is outlined for the set builder. The set consists of nine tubes, with two tuning dials, and is completely shielded.

R084. MAPS AND CHARTS. CHART,
Radio. Feb., 1927. Pp. 140-141. *L, C, f Data.*
"Chart for Radio Circuit Calculations," E. L. Hall.
A graphic chart, showing the relation between frequency, inductance, and capacitance for values as used in radio circuits, is drawn for purposes of rapid calculation. The accuracy of results obtainable may be within several per cent. of the mathematical calculation, as stated. The range may be extended beyond those actually shown by a simple process.

R350. GENERATING APPARATUS;
TRANSMITTING SETS. TRANSMITTER,
QST. March, 1927. Pp. 33-37. *Flexible.*
"A Flexible Transmitter," F. J. Marco.
A transmitter is described which uses the Armstrong tuned-grid tuned-plate circuit. It is said to be capable of a quick change to either the 20-, the 40-, or the 80-meter band (1500-, 750-, or 3750-kc. band) by means of plug-in coils. Tubes giving an output power up to 7.5 watts may be used with the apparatus. Complete circuit diagrams, methods of tuning, and operation data are given.

The Majestic

Most popular "B" Power Unit for radio sets in the world

The Super "B," illustrated above is only $29.50, complete with Majestic Super-Power B-Rectifier Tube.

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The NEW Moorish design Pacent Cabinet Cone in two-tone antique finish mahogany $35.00

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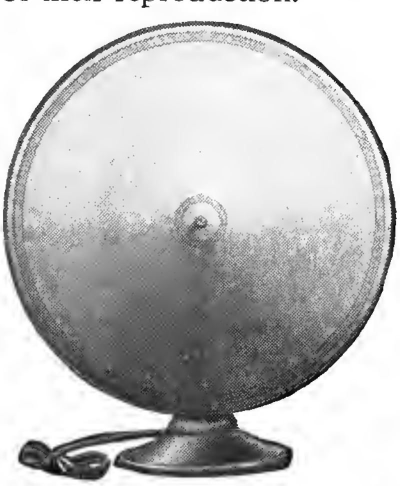
THESE three *new* Pacent products bring a new and keener enjoyment of radio by the true fidelity and realism of their reproduction.



The new 17-inch Pacent Balanced Cone establishes a new standard in cone speaker performance $22.50

The Pacent PHONOVOX (electric pickup) attached to your phonograph and radio, reproduces records with the tone quality rivaling the electric phonograph . . . $12.50

Ask your dealer for a demonstration or write us if dealer doesn't handle.

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RADIO CORPORATION

156 W. 16th Street, New York City

R113.5. METEOROLOGICAL. METEOROLOGY.
Proc. I. R. E. Feb., 1927, Pp. 83–97.
"The Correlation of Radio Reception with Solar Activity and Terrestrial Magnetism," G. W. Pickard.

Atmospheric changes and the resulting magnetic storms affecting radio reception are discussed. Atmospheric changes are said to be due to radiations and emissions from the sun. The author compares observed radio reception data, obtained over a continuous period, with meteorological data, and finds a close correlation of sunspot disturbances and radio reception on the upper broadcast wave spectra. Graphs drawn from observed data obtained from station WBBM show that, when average results are compared with magnetic storms, both variations appear to be more or less in phase.

R201. GENERAL METHODS AND APPARATUS. MEASUREMENTS, *Receiver.*
Proc. I. R. E. Feb., 1927. Pp. 99–111.
"Importance of Laboratory Measurements in the Design of Radio Receivers," W. A. MacDonald.

A series of thirteen fundamental tests are outlined for determining individual and overall characteristics of commercial receivers. A series of graphs gives the results obtained from a typical circuit and depicts to what degree a high precision standard may be used.

R134. DETECTOR ACTION. DETECTOR, *Action.*
Proc. I. R. E. Feb., 1927. Pp. 113–153.
"A Theoretical and Experimental Investigation of Detection for Small Signals," E. L. Chaffee and G. H. Browning.

Data are given on the detecting properties of diode and triode valves as used in radio circuits. The mathematical presentation is expressed in terms of the circuit impedances and the first and second partial differential coefficients of the static characteristic curves of the device, taken at the points on the curves determined by the steady polarizing voltages. It is then assumed that the impressed signal is so small that for any given steady voltages these coefficients can be assumed constant within the range of the variation due to the signal voltage.

R430. INTERFERENCE ELIMINATION. INTERFERENCE, *Elimination.*
QST. March, 1927. Pp. 9–14.
"Cures for 'Power Leaks,'" R. S. Kruse.

The article states that power leaks and other sources of high-frequency interference may be eliminated by proper filtering. The "Tobe," the "Dayfan," and other interference eliminating devices are described.

R142.3. INDUCTIVE COUPLED CIRCUITS. TRANSFORMERS, *Tuned R.F.*
QST. March, 1927. Pp. 20–22.
"The Theory of a Tuned R. F. Transformer," G. H. Browning and F. H. Drake.

A mathematical presentation, supplemented by experimental curves of tuned radio-frequency transformers, is given. The results show that the secondary inductance should be made as large as possible, the losses made very small, and the primary-secondary capacity kept as low as possible, in order to obtain maximum efficiency.

R140. RADIO CIRCUITS. MASTER-OSC. AND POWER-AMP. CIRCUITS.
QST. March, 1927. Pp. 38-ff.
"How Our Tube Circuits Work. Part 4," R. S. Kruse.

In this fourth of a series of articles on radio circuits the writer takes up the many phases of oscillator circuits with and without amplifier hook-ups. A variety of subjects dealing with this type of circuit are taken up, as for instance: "Wobbulation," its causes and remedy; steadiness of wave with and without the use of a crystal; the characteristics of the Armstrong circuit; single- and multi-stage amplifiers and their use as wave-changers in order to prevent troublesome feedbacks.

R900. MISCELLANEOUS. FUTURE OF RADIO.
Popular Radio. March, 1927. Pp. 229-ff.
"Radio in 1950 A. D.," Dr. Lee DeForest.

The author enumerates some of the future possibilities found in the stored-up energy of waves as utilized for radio transmission and reception. The newly discovered cosmic ray, having a wavelength of 0.0004 angstrom units, and traveling at a much greater speed than light waves, as stated by Millikan, is said to have many possibilities.

R342.7. AUDIO-FREQUENCY AMPLIFIERS. AMPLIFIERS, *Audio-Frequency.*
Popular Radio. March, 1927. Pp. 253-ff.
"Audio Amplifiers," E. L. Bowles.

The underlying principles covering audio-frequency reproduction and amplification are outlined in an elementary discussion. Causes and effects of distortion, at either the transmitting or receiving end, may be corrected, it is said, by proper design and construction of the apparatus.

R201.5. SHIELDING AND GROUNDING. SHIELDING.
Radio News. Feb., 1927. Pp. 988-ff.
"Shielding in Radio Receivers," M. L. Hartmann and J. R. Meagher.

A brief and elementary discussion on the theory of shielding of radio receivers is given. Some of the benefits of shielding are said to be increased amplification, increased selectivity, better neutralization, and decreased body-capacity effects.

R375. 3 ELECTROLYTIC RECTIFIERS. RECTIFIERS, *Chemical.*
The Transmitter. Dec. 1927., Pp. 10-ff.
"Practical Chemical Rectifiers," C. R. Stedman.

In constructing a practical chemical rectifier, the writer suggests that pure aluminum should be used. Both the lead and aluminum plates, however, should be of the same size. The solution recommended is either bicarbonate of soda or ammonium phosphate. Constructional details and wiring diagrams are given.

R342.7. AUDIO-FREQUENCY AMPLIFIERS. AMPLIFIERS, *Audio-Frequency.*
Radio World. Feb., 19, 1927. Pp. 5.
"More Volume from Lower Ratio in Audio Transformers, a Frequent Condition," K. B. Humphrey.

In analyzing the importance of proper relation of audio transformer winding ratios to tube resistance, it is stated that consideration should be given the various factors involved from an engineering standpoint when selection is made. Usually, it is said, more volume and less distortion is obtained from properly constructed low-ratio transformers than those of high ratio.

R582. TRANSMISSION OF PHOTOGRAPHS. PHOTOGRAPH TRANSMISSION.
Radio World. Feb., 26, 1927. Pp. 4–5.
"First Television Hookups Elucidate Alexanderson and Baird Plans," H. Wall.

The Alexanderson and the Baird systems of television are shown in schematic diagram. The two systems are compared and the advantages and disadvantages outlined.

R113.4. IONIZATION; HEAVISIDE LAYER. HEAVISIDE LAYER.
Radio World. Feb., 26, 1927. Pp. 8.
"Radio Ceiling Again Verified."

Experiments conducted by the Carnegie Institute regarding the existence and probable nature of the Kenelly-Heaviside layer have established that such a layer actually exists at an altitude varying between 50 and 130 miles. Whether the radio waves are reflected or refracted from this upper layer is not definitely known. Fading may be explained on the assumption that interfering waves neutralize each other.

R020. TEXTBOOKS. TEXTBOOKS. *Radio.*
The New York *Sun.* Radio Section. Nov. 6, 1926.
"An Expert's 3-Foot Shelf of Radio Books," S. R. Winter.

The following is a list of textbooks and published material selected by Doctor Dellinger, of the Bureau of Standards, for the radio man:

1. "Signalling Through Space Without Wires,"—H. Hertz.
2. "The Principles of Electric Wave Telegraphy and Telephony,"—J. A. Fleming.
3. "Electric Waves,"—H. Hertz.
4. "The Principles Underlying Radio Communication," —Bureau of Standards.
5. "Radio Instruments and Measurements,"—Circular 74, Bureau of Standards.
6. "Robinson's Manual of Radio Telegraphy,"—United States Navy.
7. "How to Become a Wireless Operator,"—Chas. B. Haywaro.
8. "Direction and Position Finding,"—R. Keen, of Sheffield, England.
9. "I. C. S. Handbook for Radio Operators,"—International Correspondence Schools.
10. "Radio Telephony for Amateurs,"—S. Ballantine.
11. "Radio for Everybody,"—A. C. Lescarboura.
12. "Radio for All,"—H. Gernsback.
13. "Elements of the Mathematical Theory of Electricity and Magnetism,"—J. J. Thompson.
14. "Handbook of Technical Instruction for Wireless Telegraphists,"—C. Hawkhead and H. M. Dowsett.
15. "Wireless Telegraphy and Telephony,"—H. M. Dowsett.
16. "The Thermionic Vacuum Tube and Its Application," H. J. Von der Bijl.
17. "The Radio Amateur's Handbook,"—F. E. Handy.
18. "Yearbook of Wireless Telegraphy,"—Wireless Press, Ltd. (Published annually).
19. "Electromagnetic Oscillations in Oscillators and Radio Telegraphy,"—J. Zenneck.
20. "Wireless Telegraphy and Telephony"—Chas. R. Gibson.
21. "Radio Laws and Regulations of the United States," —U. S. Department of Commerce.
22. "The Realities of Modern Science,"—John Mills.
23. "Electric Oscillations and Electric Waves,"—G. W. Pierce.
24. "Principles of Radio Communication,"—J. H. Morecroft.
25. "Principles of Radio Transmission and Reception with Antenna and Coil Aerials,"—Bureau of Standards.
26. "Methods of Measurement of Properties of Electrical Insulating Materials,"—Bureau of Standards.
27. "Handbook of Safety Rules for Radio Installations," —Bureau of Standards.
28. "Wireless Telegraphy and Telephony,"—W. H. Eccles.
29. "Thermionic Tubes in Radio Telegraphy,"—John Scott-Taggart.
30. "Radio Broadcast's Knockout Receiver,"—Doubleday, Page and Company.
31. "How to Build Your Radio Receiver,"—Popular Radio Publishing Company.
32. "The Radio Service Bulletin,"—United States Department of Commerce. (Monthly).
33. "Introduction to Line Radio Communication,"—Signal Corps Pamphlet.
34. "Modern Radio Operation,"—J. O. Smith.
35. "The C. W. Manual,"—J. B. Dow.
36. "Radio for Amateurs,"—A. H. Verrill.
37. "Circular No. 24,"—Bureau of Standards.
38. "Copper Wire Tables,"—Bureau of Standards.
39. "The Radio Direction Finder and Its Application to Navigation,"—Bureau of Standards.
40. "Formulas and Tables for the Calculation of Mutual and Self-Inductance,"—Bureau of Standards.
41. "The Outline of Radio,"—J. V. L. Hogan.
42. "Qualitative Experiments in Radio Transmission," —Bureau of Standards.

R134.8. REFLEX ACTION. REFLEX ACTION.
QST. Feb., 1927. Pp. 21-27.
"Developments in Tuned Inverse Duplex," David Grimes. Part 2.

In this second of two articles, the Inverse Duplex System of amplification in the radio and audio circuits, developed for duplexing, are discussed. For the audio stage, a transformer-resistance-transformer arrangement is said to be the most desirable and effective. In order to obtain equal amplification over the entire broadcast band, a radio frequency-audio frequency filter circuit, comprising a choke coil and a large fixed condenser, is connected between stages. Circuit diagrams and panel layouts are shown.

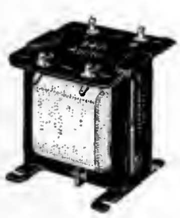
R344.5. ALTERNATING CURRENT SUPPLY. A.C. FOR FILAMENTS.
RADIO BROADCAST. Feb., 1927. Pp. 393-396.
"A.C. As a Filament-Supply Source," B. F. Miessner.

The writer discusses the problems encountered in lighting the filaments of radio vacuum tubes from the regular direct or alternating current obtained from the light socket. Filter systems, devised to eliminate the hum in the a.c. line, which presents many varying characteristics, as shown in graphs, are given. The 112 type tube, as compared to the 199, the 201-A type, and the WX-12 type, is considered the best tube to use for radio-and audio-frequency amplification in a.c. lighted filament circuits.

SM

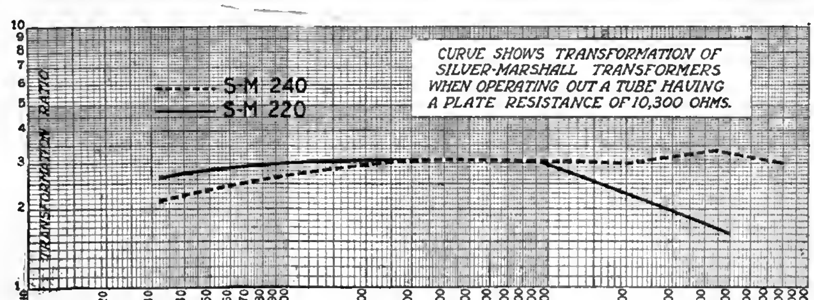
87% At 30 Cycles!

In this standardized black shielding case are housed the famous 220 audio and 221 output transformers, 222 output, 230 push-pull input, 231 push-pull output, 325 filament, 329, 329A and 330 power transformers, 331 Unichoke and 332 condenser bank. And a new super-power full wave ABC supply transformer is on the way —type 328, at $18.00, for one or two 216B or 281 tubes.



Silver-Marshall now offers two smaller size audio transformers for replacement work in old sets, wherever price and size is a consideration. Type 240 audio transformer is equal or superior to the majority of high-grade audio transformers, but does not reproduce frequencies below 80 cycles to the extent that the famous 220 does. Its single stage amplifier curve is shown above—in two stages, the 240's afford practically the same 5000 cycle cut-off as do 220's, althought this is not evident in the single stage curve above. 241 output transformer offers the same low frequency compensation as type 221 and 222. Due to their small size, these transformers will fit in almost any of the older receivers, and once installed, will work wonders in tone quality improvement, for their performance nearly equals that of 220's and 221's. Size 3 7/16" high, 2 1/4" wide, 2 5/8" deep, weight 2 lbs. 4 ozs. each. Price, 240 audio $6.00, 241 output $5.00.

Laurence Cockaday, for the preferred audio amplifier for the LC-28 receiver uses two 240's and a 241 with an S-M power supply!



At 30 cycles, an S-M 220 audio transformer in a standard amplifier circuit gives 87% of the amplification obtained at 1000 cycles, while its curve is substantially flat from 100 to 1000 cycles. Above 2000 cycles, the curve for a single stage falls off gradually, while in a standard two stage amplifier circuit, the curve is substantially flat up to 5000 cycles above which frequency it falls off rapidly to keep static, heterodyne squeals and "set noise" at a minimum.

The above paragraph sums up at once the desirable characteristics of an audio amplifier for realistic recreation of broadcast programs, and the actual performance of S-M audio transformers. It is just this fact that has made 220's the choice of over half of the designers of the new 1927-1928 circuits, for engineers know that the short cut to the finest of quality is to use S-M audios. Experienced fans know this too, as is proven by the fact that 220's have outsold every other transformer in their class by a wide margin for over a year. And S-M audios are signally favored by being used in more broadcasting stations than any other types. WCAE, WBBM, WEBH, KFCR, WTAQ, KGDJ, WLBF, and many others. WCFL, the "Voice of Labor" checks quality of all programs with them. Nathaniel Baldwin, Inc., famous speaker experts, test with 220's and 221's.

Your guarantee of quality is to use S-M 220's and 221's in every circuit you build, and you'll find that over half the popular 1927 and 1928 circuits will give you just this same guarantee of quality. But S-M promises unconditionally that you can improve any set by using 220's and 221's, and backs the promise by the offer of your money back if 220's and 221's don't give you more satisfactory quality than you've ever heard before.

The 220 audio is the biggest value on the market, and its performance measures up to its 4 pound size. It contains more steel and copper than any other transformer—the measure of transformer merit. Price $8.00.

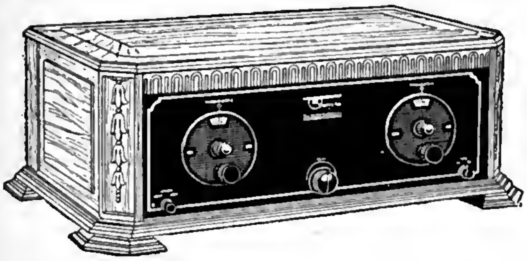
221 output transformer not only protects loud speakers against power tube plate currents, but compensates low frequencies for all loud speakers. Price $7.50, or with cord and tip jacks, No. 222, $8.00.

230 push-pull input and 231 push-pull output transformers are priced at $10.00 each.

The New Shielded Six Is Ready!

The Improved Shielded Six is ready, the very latest model of this excellent receiver which has over a year of successful and satisfying performance to its credit. The Improved model has vastly increased selectivity, greater distance getting ability, and the same fine tone that has made almost every builder say of the original, "That's the finest set I've ever heard!"

This year the Six offers the additional possibilities of push-pull amplification with 210 tubes for the man who wants the utmost. All in all, the Six deserves the reputation as the finest tuned R. F. kit you can buy, equalled only by $200 to $400 factory built sets. Yet it's priced at but $95.00 for the complete kit, or $142.00 assembled, in cabinet, and guaranteed to satisfy you. S-M will be glad to tell owners how last year's model can be converted to the Improved Six, or push-pull 210 amplification installed with simple changes.



We can't tell you the whole story of new S-M developments, so if you'll just fill in the coupon, and mail it with 10c to cover postage, we'll send you free more up-to-the-minute advance radio information than you could buy in a text book.

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Please send me information on new S-M developments, for which I enclose 10c.

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"RADIO BROADCAST'S" DIRECTORY OF MANUFACTURED RECEIVERS

¶ A coupon will be found on page 416. All readers who desire additional information on the receivers listed below need only insert the proper numbers in the coupon, mail it to the Service Department of RADIO BROADCAST, and full details will be sent. New sets are listed in this space each month.

KEY TO TUBE ABBREVIATIONS

99—60-mA. filament (dry cell)
01-A—Storage battery 0.25 amps. filament
12—Power tube (Storage battery)
71—Power tube (Storage battery)
16-B—Half-wave rectifier tube
80—Full-wave, high current rectifier
81—Half-wave, high current rectifier
Hmu—High-Mu tube for resistance-coupled audio
20—Power tube (dry cell)
10—Power Tube (Storage battery)
00-A—Special detector
13—Full-wave rectifier tube
26—Low-voltage high-current a. c. tube
27—Heater type a. c. tube

DIRECT CURRENT RECEIVERS

NO. 424. COLONIAL 26

Six tubes; 2 t. r. f. (01-A), detector (12), 2 transformer audio (01-A and 71). Balanced t. r. f. One to three dials. Volume control: antenna switch and potentiometer across first audio. Watts required: 120. Console size: 34 x 38 x 18 inches. Headphone connections. The filaments are connected in a series parallel arrangement. Price $250 including power unit.

NO. 425. SUPERPOWER

Five tubes: All 01-A tubes. Multiplex circuit. Two dials. Volume control: resistance in r. f. plate. Watts required: 30. Antenna: loop or outside. Cabinet sizes: table, 27 x 10 x 9 inches; console, 28 x 50 x 21. Prices: table, $135 including power unit; console, $390 including power unit and loud speaker.

A. C. OPERATED RECEIVERS

NO. 508. ALL-AMERICAN 77, 88, AND 99

Six tubes; 3 t. r. f. (26), detector (27), 2 transformer audio (26 and 71). Rice neutralized t. r. f. Single drum tuning. Volume control: potentiometer in r. f. plate. Cabinet sizes: No. 77, 21 x 10 x 8 inches; No. 88 Hiboy, 25 x 38 x 18 inches; No. 99 console, 27¼ x 43 x 20 inches. Shielded. Output device. The filaments are supplied by means of three small transformers. The plate supply employs a gas-filled rectifier tube. Voltmeter in a. c. supply line. Prices: No. 77, $150, including power unit; No. 88, $210 including power unit; No. 99, $285 including power unit and loud speaker.

NO. 509. ALL-AMERICAN "DUET"; "SEXTET"

Six tubes; 2 t. r. f. (99), detector (99), 3 transformer audio (99 and 12). Rice neutralized t.r.f. Two dials. Volume control: resistance in r.f. plate. Cabinet sizes: "Duet," 23 x 56 x 16½ inches; "Sextet," 22½ x 13½ x 15½ inches. Shielded. Output device. The 99 filaments are connected in series and supplied with rectified a.c., while 12 is supplied with raw a.c. The plate and filament supply uses gaseous rectifier tubes. Millammeter on power unit. Prices: "Duet," $160 including power unit; "Sextet," $220 including power unit and loud speaker.

NO. 511. ALL-AMERICAN 80, 90, AND 115

Five tubes; 2 t.r.f. (99), detector (99), 2 transformer audio (99 and 12). Rice neutralized t.r.f. Two dials. Volume control: resistance in r.f. plate. Cabinet sizes: No. 80, 23¼ x 12½ x 15 inches; No. 90, 37½ x 12 x 12½ inches; No. 115 Hiboy, 24 x 41 x 15 inches. Coils individually shielded. Output device. See No. 509 for power supply. Prices: No. 80, $135 including power unit; No. 90, $145 including power unit and compartment; No. 115, $170 including power unit, compartment, and loud speaker.

NO. 510. ALL-AMERICAN 7

Seven tubes; 3 t.r.f. (26), 1 untuned r.f. (26), detector (27), 2 transformer audio (26 and 71). Rice neutralized t.r.f. One drum. Volume control: resistance in r.f. plate. Cabinet sizes: "Sovereign" console, 30½ x 60½ x 19 inches; "Lorraine" Hiboy, 25½ x 53¾ x 17½ inches; "Forte" cabinet, 25½ x 13½ x 17½ inches. For filament and plate supply: See No. 508. Prices: "Sovereign" $460; "Lorraine" $360; "Forte" $270. All prices include power unit. First two include loud speaker.

NO. 403. ARGUS 250B

Six tubes; 2 t.r.f. (99), 1 untuned r.f. (99), detector (99), 2 transformer audio (99 and 12). Stabilized with grid resistances. Two dials. Volume control: resistance across 1st audio. Watts required: 100. Cabinet size: 35⅝ x 14⅝ x 10¾ inches. Output device. The 99 filaments are connected in series and supplied with rectified a.c., while the 12 is run on raw a.c. The power unit requires two 16-B rectifier tubes. Milliammeter included in d.c. supply. Price $250.00 including self-contained power unit. Other models: No. 125, $125.00; console model, $375.00.

NO. 401. AMRAD AC9

Six tubes; 3 t.r.f. (99), detector (99), 2 transformer (99 and 12). Neutrodyne. Two dials. Volume control: resistance across 1st audio. Watts consumed: 50. Cabinet size: 27 x 9 x 11¾ inches. The 99 filaments are connected in series and supplied with rectified a.c., while the 12 is run on raw a.c. The power unit, requiring two 16-B rectifiers, is separate and supplies A, B, and C current. Price $142 including power unit.

NO. 402. AMRAD AC5

Five tubes. Same as No. 401 except one less r.f. stage. Price $125 including power unit.

NO. 484. BOSWORTH, B5

Five tubes; 2 t.r.f. (26), detector (99), 2 transformer audio (special a.c. tubes). T.r.f. circuit. Two dials. Volume control: potentiometer. Cabinet size: 23 x 7 x 8 inches. Output device included. Price $175.

NO. 406. CLEARTONE 110

Five tubes; 2 t.r.f., detector, 2 transformer audio. All tubes a. c. heater type. One or two dials. Volume control: resistance in r. f. plate. Watts consumed: 40. Cabinet size varies. The plate supply is built in the receiver and requires one rectifier tube. Filament supply through step down transformers. Prices range from $175 to $375 which includes 5 a.c. tubes and one rectifier tube.

NO. 407. COLONIAL 25

Six tubes; 2 t. r. f. (01-A), detector (99), 2 resistance audio (99). 1 transformer audio (10). Balanced t.r.f. circuit. One or three dials. Volume control: Antenna switch and potentiometer on 1st audio. Watts consumed: 100. Console size: 34 x 38 x 18 inches. Output device. All tube filaments are operated on a. c. except the detector which is supplied with rectified a.c. from the plate supply. The rectifier employs two 16-B tubes. Price $250 including built-in plate and filament supply.

NO. 507. CROSLEY 602 BANDBOX

Six tubes; 3 t.r.f. (26), detector (27), 2 transformer audio (26 and 71). Neutrodyne circuit. One dial. Cabinet size: 17¼ x 5¼ x 7⅝ inches. The heaters for the a.c. tubes and the 71 filament are supplied by windings in B unit transformers available to operate either on 25 or 60 cycles. The plate current is supplied by means of rectifier tube. Price $65 for set alone, power unit $60.

NO. 408. DAY-FAN "DE LUXE"

Six tubes; 3 t.r.f., detector, 2 transformer audio. All 01-A tubes. One dial. Volume control: potentiometer across r.f. tubes. Watts consumed: 300. Console size: 30 x 40 x 20 inches. The filaments are connected in series and supplied with d.c. from a motor-generator set which also supplies B and C current. Output device. Price $350 including power unit.

NO. 409. DAYCRAFT 5

Five tubes; 2 t.r.f., detector, 2 transformer audio. All a. c. heater tubes. Reflexed t.r.f. One dial. Volume control: potentiometers in r.f. plate and 1st audio. Watts consumed: 135. Console size: 34 x 36 x 14 inches. Output device. The heaters are supplied by means of a small transformer. A built-in rectifier supplies B and C voltages. Price $170, less tubes. The following have one more r.f. stage and are not reflexed: Daycraft 6, $195; Dayrole 6, $235; Dayfan 6, $110. All prices less tubes.

NO. 469. FREED-EISEMANN NR11

Six tubes; 3 t.r.f. (01-A), detector (01-A), 2 transformer audio (01-A and 71). Neutrodyne. One dial. Volume control: potentiometer. Watts consumed: 150. Cabinet size: 19¾ x 10 x 10½ inches. Shielded. Output device. A special power unit is included employing a rectifier tube. Price $225 including NR-411 power unit.

NO. 487. FRESHMAN 7F-AC

Six tubes; 3 t.r.f. (26), detector (27), 2 transformer audio (26 and 71). Equaphase circuit. One dial. Volume control: potentiometer across 1st audio. Console size: 24½ x 41½ x 15 inches. Output device. The filaments and heaters and B supply are all supplied by one power unit. The plate supply requires one 80 rectifier tube. Price $175 to $350, complete.

NO. 536. SOUTH BEND

Six tubes. One control. Sub-panel shielding. Binding Posts. Antenna: outdoor. Prices: table, $130, Baby Grand console, $195.

NO. 537. WALBERT 26

Six tubes; five Kellogg a.c. tubes and one 71. Two controls. Volume control: variable plate resistance. Isofarad circuit. Output device. Battery cable. Semi-shielded. Antenna: 50 to 75 feet. Cabinet size: 10¾ x 29½ x 16½ inches. Prices: $215; with tubes, $250.

NO. 538. NEUTROWOUND, MASTER ALLECTRIC

Six tubes; 2 t.r.f. (01-A), detector (01-A), 2 audio (01-A and two 71 in push-pull amplifier). The 01-A tubes are in series, and are supplied from a 400-mA. rectifier. Two drum controls. Volume control: variable plate resistance. Output device. Shielded. Antenna: 50 to 100 feet. Price: $360.

NO. 545. NEUTROWOUND, SUPER ALLECTRIC

Five tubes; 2 t.r.f. (99), detector (99), 2 audio (99 and 71). The 99 tubes are in series and are supplied from an 85-mA. rectifier. Two drum controls. Volume control: variable plate resistance. Output device. Antenna: 75 to 100 feet. Cabinet size: 9 x 24 x 11 inches. Price: $150.

NO. 490. MOHAWK

Six tubes; 2 t.r.f., detector, 2 transformer audio. All tubes a.c heater type except 71 in last stage. One dial. Volume control: rheostat on r.f. Watts consumed: 40. Panel size: 12½ x 8¾ inches. Output device. The heaters for the a.c tubes and the 71 filament are supplied by small transformers. The plate supply is of the built-in type using a rectifier tube. Prices range from $65 to $245.

NO. 413. MARTI

Six tubes: 2 t.r.f., detector, 3 resistance audio. All tubes a.c. heater type. Two dials. Volume control: resistance in r.f. plate. Watts consumed: 38. Panel size 7 x 21 inches. The built-in plate supply employs one 16-B rectifier. The filaments are supplied by a small transformer. Prices: table, $235 including tubes and rectifier; console, $275 including tubes and rectifier; console, $325 including tubes, rectifier, and loud speaker.

NO. 417 RADIOLA 28

Eight tubes; five type 99 and one type 20. Drum control. Super-heterodyne circuit. C-battery connections. Battery cable. Headphone connection. Antenna: loop. Set may be operated from batteries or from the power mains when used in conjunction with the model 104 loud speaker. Prices: $260 with tubes, battery operation; $570 with model 104 loud speaker, a. c. operation.

NO. 540 RADIOLA 30-A

Receiver characteristics same as No. 417 except that type 71 power tube is used. This model is designed to operate on either a. c. or d. c. from the power mains. The combination rectifier—power—amplifier unit uses two type 81 tubes. Model 100-A loud speaker is contained in lower part of cabinet. Either a short indoor or long outside antenna may be used. Cabinet size: 42½ x 29 x 17¾ inches. Price: $495.

NO. 541 RADIOLA 32

This model combines receiver No. 417 with the model 104 loud speaker. The power unit uses two type 81 tubes and a type 10 power amplifier. Loop is completely enclosed and is revolved by means of a dial on the panel. Models for operation from a. c. or d. c. power mains. Cabinet size: 52 x 72 x 17¾ inches. Price: $895.

NO. 539 RADIOLA 17

Six tubes; 3 t. r. f. (26), detector (27), 2 transformer audio (26 and 27). One control. Illuminated dial. Built-in power supply using type 80 rectifier. Antenna: 100 feet. Cabinet size: 25$\frac{5}{16}$ x 7⅞ x 8⅛. Price: $130 without accessories.

NO. 421. SOVEREIGN 238

Seven tubes of the a.c. heater type. Balanced t.r.f. Two dials. Volume control: resistance across 2nd audio. Watts consumed: 45. Console size: 37 x 52 x 15 inches. The heaters are supplied by a small a. c. transformer, while the plate is supplied by means of rectified a.c using a gaseous type rectifier. Price $325, including power unit and tubes.

NO. 517. KELLOGG 510, 511, AND 512

Seven tubes; 4 t.r.f., detector, 2 transformer audio. All Kellogg a.c. tubes. One control and special zone switch. Balanced. Volume control: special. Output device. Shielded. Cable connection between power supply unit and receiver. Antenna: 25 to 100 feet. Panel 7⅞ x 27½ inches. Prices: Model 510 and 512, consoles, $495 complete. Model 511, consolette, $365 without loud speaker.

NO. 496. SLEEPER ELECTRIC

Five tubes; four 99 tubes and one 71. Two controls. Volume control: rheostat on r.f. Neutralized. Cable. Output device. Power supply uses two 16-B tubes. Antenna: 100 feet. Prices: Type 64, table, $160; Type 65, table, with built-in loud speaker, $175; Type 66, table, $175; Type 67, console, $235; Type 78, console, $265.

NO. 522. CASE, 62 B AND 62 C

McCullough a.c. tubes. Drum control. Volume control; variable high resistance in audio system. C-battery connections. Semi-shielded. Cable. Antenna: 100 feet. Panel size: 7 x 21 inches. Prices: Model 62 B, complete with a.c. equipment, $185; Model 62 C, complete with a.c. equipment, $235.

NO. 523. CASE, 92 A AND 92 C

McCullough a.c. tubes. Drum control. Inductive volume control. Technidyne circuit. Shielded. Cable. C-battery connections. Model 92 C contains output device. Loop operated. Prices: Model 92 A, table, $350; Model 92 C, console, $475.

BATTERY OPERATED RECEIVERS

NO. 512. ALL-AMERICAN 44, 45, AND 66

Six tubes; 3 t.r.f. (01-A, detector) 01-A, 2 transformer audio (01-A and 71). Rice neutralized t.r.f. Drum control. Volume control: rheostat in r.f. Cabinet sizes: No. 44, 21 x 10 x 8 inches; No. 55, 25 x 38 x 18 inches; No. 66, 27¼ x 43 x 20 inches. C-battery connections. Battery cable. Antenna: 75 to 125 feet. Prices: No. 44, $70; No. 55, $125 including loud speaker; No. 66, $200 including loud speaker.

NO. 428. AMERICAN C6

Five tubes; 2 t.r.f, detector, 2 transformer audio. All 01-A tubes. Semi balanced t.r.f. Three dials. Plate current 15 mA. Volume control: potentiometer. Cabinet sizes: table, 20 x 8½ x 10 inches; console, 36 x 40 x 17 inches. Partially shielded. Battery cable. C-battery connections. Antenna: 125 feet. Prices: table, $30; console, $65 including loud speaker.

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NO. 485. BOSWORTH B6

Five tubes; 2 t.r.f. (01-A), detector (01-A), 2 transformer audio (01-A and 71). Two dials. Volume control: variable grid resistances. Battery cable. C-battery connections. Antenna: 25 feet or longer. Cabinet size 15 x 7 x 8 inches. Price $75.

NO. 513. COUNTERPHASE SIX

Six tubes; 3 t.r.f. (01-A), detector (00-A), 2 transformer audio (01-A and 12). Counterphase t.r.f. Two dials. Plate current: 32 mA. Volume control: rheostat on 2nd and 3rd r.f. Coils shielded. Battery cable. C-battery connections. Antenna: 75 to 100 feet. Console size: 18¾ x 40½ x 15½ inches. Prices: Model 35, table, $110; Model 37, console, $175.

NO. 514. COUNTERPHASE EIGHT

Eight tubes; 4 t.r.f. (01-A), detector (00-A), 2 transformer audio (01-A and 12). Counterphase t.r.f. One dial. Plate current: 40 mA. Volume control: rheostat in 1st r.f. Copper stage shielding. Battery cable. C-battery connections. Antenna: 75 to 100 feet. Cabinet size: 30 x 12½ x 16 inches. Prices: Model 12, table, $225; Model 16, console, $335; Model 18, console, $365.

NO. 506. CROSLEY 601 BANDBOX

Six tubes; 3 t.r.f., detector, 2 transformer audio. All 01-A tubes. Neutrodyne. One dial. Plate current: 40 mA. Volume control: rheostat in r.f. Shielded. Battery cable. C-battery connections. Antenna: 75 to 150 feet. Cabinet size: 17¼ x 5¼ x 7⅞. Price, $55.

NO. 434. DAY-FAN 6

Six tubes; 3 t.r.f. (01-A), detector (01-A), 2 transformer audio (01-A and 12 or 71). One dial. Plate current: 12 to 15 mA. Volume control: rheostat on r.f. Shielded. Battery cable, C-battery connections. Output device. Antenna: 50 to 120 feet. Cabinet sizes: Daycraft 6, 32 x 30 x 34 inches; Day-Fan Jr., 15 x 7 x 7. Prices: Day-Fan 6, $110; Daycraft 6, $145 including loud speaker; Day-Fan Jr. not available.

NO. 435. DAY-FAN 7

Seven tubes; 3 t.r.f. (01-A), detector (01-A), 1 resistance audio (01-A), 2 transformer audio (01-A and 12 or 71). Plate current: 15 mA. Antenna: outside. Same as No. 434. Price $115.

NO. 503. FADA SPECIAL

Six tubes; 3 t.r.f. (01-A), detector (01-A), 2 transformer audio (01-A and 71). Neutrodyne. Two drum control. Plate current: 20 to 24mA. Volume control: rheostat on r.f. Coils shielded. Battery cable. C-battery connections. Headphone connection. Antenna: outdoor. Cabinet size: 20½ x 13¾ x 10¼ inches. Price $95.

NO. 504. FADA 7

Seven tubes; 4 t.r.f. (01-A), detector (01-A), 2 transformer audio (01-A and 71). Neutrodyne. Two drum control. Plate current: 43mA. Volume control: rheostat on r.f. Completely shielded. Battery cable. C-battery connections. Headphone connections. Output device. Antenna: outdoor or loop. Cabinet sizes: table, 25¼ x 13¼ x 11¼ inches; console, 29 x 50 x 17 inches. Prices: table, $185; console, $285.

NO. 436. FEDERAL

Five tubes; 2 t.r.f. (01-A), detector (01-A), 2 transformer audio (01-A and 12 or 71). Balanced t.r.f. One dial. Plate current: 20.7 mA. Volume control: rheostat on r.f. Shielded. Battery cable. C-battery connections. Antenna: loop. Made in 6 models. Price varies from $250 to $1000 including loop.

NO. 505. FADA 8

Eight tubes. Same as No. 504 except for one extra stage of audio and different cabinet. Prices: table, $300; console, $400.

NO. 437. FERGUSON 10A

Seven tubes; 3 t.r.f. (01-A), detector (01-A), 3 audio (01-A and 12 or 71). One dial. Plate current: 18 to 25 mA. Volume control: rheostat on two r.f. Shielded. Battery cable. C-battery connections. Antenna: 100 feet. Cabinet size: 21½ x 12 x 15 inches. Price $150.

NO. 438. FERGUSON 14

Ten tubes; 3 untuned r.f., 3 t. r.f. (01-A), detector (01-A), 3 audio (01-A and 12 or 71). Special balanced t.r.f. One dial. Plate current: 30 to 35 mA. Volume control: rheostat in three r.f. Shielded. Battery cable, C-battery connections. Antenna: loop. Cabinet size: 24 x 12 x 16 inches. Price $235, including loop.

NO. 439. FERGUSON 12

Six tubes; 2 t.r.f. (01-A), detector (01-A), 1 transformer audio (01-A), 2 resistance audio (01-A and 12 or 71). Two dials. Plate current: 18 to 25 mA. Volume control: rheostat on two r.f. Partially shielded. Battery cable. C-battery connections. Antenna: 100 feet. Cabinet size: 22½ x 10 x 12 inches. Price $85. Consolette $145 including loud speaker.

NO. 440. FREED-EISEMANN NR-8, NR-9, AND NR-66

Six tubes; 3 t.r.f. (01-A), detector (01-A), 2 transformer audio (01-A and 71). Neutrodyne. NR-8, two dials; others one dial. Plate current: 30 mA. Volume control: rheostat on r.f. NR-8 and 9: chassis type shielding. NR-66, individual stage shielding. Battery cable. C-battery connections. Antenna: 100 feet. Cabinet sizes: NR-8 and 9, 19¾ x 10 x 10½ inches; NR-66 20 x 10½ x 12 inches. Prices: NR-8, $90; NR-9, $100; NR-66, $125.

NO. 501. KING "CHEVALIER"

Six tubes. Same as No. 500. Coils completely shielded. Panel size: 11 x 7 inches. Price, $210 including loud speaker.

NO. 441. FREED-EISEMANN NR-77

Seven tubes: 4 t.r.f. (01-A), detector (01-A), 2 transformer audio (01-A and 71). Neutrodyne. One dial. Plate current: 35 mA. Volume control: rheostat on r.f. Shielding. Battery cable. C-battery connections. Antenna: outside or loop. Cabinet size: 23 x 10½ x 13 inches. Price $175.

NO. 442. FREED-EISEMANN 800 AND 850

Eight tubes; 4 t.r.f. (01-A), detector (01-A), 1 transformer (01-A), 1 parallel audio (01-A or 71). Neutrodyne. One dial. Plate current: 35 mA. Volume control: rheostat on r.f. Shielded. Battery cable. C-battery connections. Output: two tubes in parallel or one power tube may be used. Antenna: outside or loop. Cabinet sizes: No. 800, 34 x 15½ x 13½ inches; No. 850, 36 x 65½ x 17½. Prices not available.

NO. 444. GREBE MU-1

Five tubes; 2 t.r.f. (01-A), detector (01-A), 2 transformer audio (01-A and 12 or 71). Balanced t.r.f. One, two, or three dials (operate singly or together). Plate current: 30mA. Volume control: rheostat on r.f. Binocular coils. Binding posts. C-battery connections. Antenna: 125 feet. Cabinet size: 22¼ x 9¼ x 13 inches. Prices range from $95 to $320.

NO. 426. HOMER

Seven tubes; 4 t.r.f. (01-A); detector (01-A or 00A); 2 audio (01-A and 12 or 71). One knob tuning control. Volume control: rotor control in antenna circuit. Plate current: 22 to 25 mA. "Technidyne" circuit. Completely enclosed in aluminum box. Battery cable. C-battery connections. Cabinet size, 8¾ x 19¼ x 9¼ inches. Chassis size, 6¾ x 17 x 8 inches. Prices: Chassis only, $80. Table cabinet, $95.

NO. 502. KENNEDY ROYAL 7. CONSOLETTE

Seven tubes; 4 t.r.f. (01-A), detector (00-A), 2 transformer audio (01-A and 71). One dial. Plate current: 42 mA. Volume control: rheostat on two r.f. Special r.f. coils. Battery cable. C-battery connections. Headphone connection. Antenna: outside or loop. Consolette size: 36½ x 35¼ x 19 inches. Price $220.

NO. 498. KING "CRUSADER"

Six tubes; 2 t.r.f. (01-A), detector (00-A), 3 transformer audio (01-A and 71). Balanced t.r.f. One dial. Plate current: 20 mA. Volume control: rheostat on r.f. Coils shielded. Battery cable. C-battery connections. Antenna: outside. Panel: 11 x 7 inches. Price, $115.

NO. 499. KING "COMMANDER"

Six tubes; 3 t.r.f. (01-A), detector (00-A), 2 transformer audio (01-A and 71). Balanced t.r.f. One dial. Plate current: 25 mA. Volume control: rheostat on r.f. Completely shielded. Battery cable. C-battery connections. Antenna: loop. Panel size: 12 x 8 inches. Price $220 including loud speaker.

NO. 429. KING COLE VII AND VIII

Seven tubes; 3 t.r.f., detector, 1 resistance audio, 2 transformer audio. All 01-A tubes. Model VIII has one more stage t.r.f. (eight tubes). Model VII, two dials. Model VIII, one dial. Plate current: 15 to 50 mA. Volume control: primary shunt in r.f. Steel shielding. Battery cable and binding posts. C-battery connections. Output devices on some consoles. Antenna: 10 to 100 feet. Cabinet size: varies. Prices: Model VII, $80 to $160; Model VIII, $100 to $300.

NO. 500. KING "BARONET" AND "VIKING"

Six tubes; 2 t.r.f. (01-A), detector (00-A), 3 transformer audio (01-A and 71). Balanced t.r.f. One dial. Plate current: 19 mA. Volume control: rheostat in r.f. Battery cable. C-battery connections. Antenna: outside. Panel size: 18 x 7 inches. Prices: "Baronet," $70; "Viking," $140 including loud speaker.

NO. 489. MOHAWK

Six tubes; 2 t.r.f. (01-A), detector (00-A), 3 audio (01-A and 71). One dial. Plate current: 40 mA. Volume control: rheostat on r.f. Battery cable. C-battery connections. Output device. Antenna: 60 feet. Panel size: 12½ x 8¾ inches. Prices range from $65 to $245.

NO. 449. NORBERT "MIDGET"

One multivalve tube; detector, 2 transformer audio. Two dials. Plate current: 3 mA. Volume control: rheostat. Binding posts. C-battery connections. Headphone connection. Antenna: 75 to 150 feet. Cabinet size: 12 x 8 x 9 inches. Price $12 including multivalve.

NO. 450. NORBERT 2

Two tubes; 1 t.r.f., detector, 2 transformer audio. One multi-valve tube and one 01-A. Two dials. Plate current: 8 mA. Volume control: special. Battery cable. Headphone connection. C-battery connections. Antenna: 50 to 100 feet. Cabinet size: 20 x 7 x 5½ inches. Price $40.50 including multivalve and 01-A tube.

NO. 452. ORIOLE 90

Five tubes; 2 t.r.f., detector, 2 transformer audio. All 01-A tubes. "Trinum" circuit. Two dials. Plate current: 18 mA. Volume control: rheostat on r. f. Battery cable. C-battery connections. Antenna: 50 to 100 feet. Cabinet size: 25½ x 11½ x 12½ inches. Price $85. Another model has 8 tubes, one dial, and is shielded. Price $185.

NO. 453. PARAGON

Six tubes; 2 t.r.f. (01-A), detector (01-A), 3 double impedance audio (01-A and 71). One dial. Plate current: 40 mA. Volume control: resistance in r.f. plate. Shielded. Battery cable. C-battery connections. Output device. Antenna: 100 feet. Console size: 20 x 46 x 17 inches. Price not determined.

NO. 543 RADIOLA 20

Five tubes; 2 t. r. f. (99), detector (99), two transformer audio (99 and 20). Regenerative detector. Two drum controls. C-battery connections. Battery cable. Antenna: 100 feet. Price: $78 without accessories.

NO. 480. PFANSTIEHL 30 AND 302

Six tubes; 3 t.r.f. (01-A), detector (01- 2A), transformer audio (01-A and 71). One dial. Plate current: 23 to 32 mA. Volume control: resistance in r.f. plate. Shielded. Battery cable. C-battery connections. Antenna: outside. Panel size: 17¾ x 8½ inches. Prices: No. 30 cabinet, $105; No. 302 console, $185 including loud speaker.

NO. 515. BROWNING-DRAKE 7-A

Seven tubes; 2 t.r.f. (01-A), detector (00-A), 3 audio (Hmu, two 01-A, and 71). Illuminated drum control. Volume control: rheostat on 1st r.f. Shielded. Neutralized. C-battery connections. Battery Cable. Metal panel. Output device. Antenna: 50-75 feet. Cabinet, 30 x 11 x 9 inches. Price, $145.

NO. 516. BROWNING-DRAKE 6-A

Six tubes; 1 t.r.f. (99), detector (00-A), 3 audio (Hmu, two 01-A and 71). Drum control with auxiliary adjustment. Volume control: rheostat on r.f. Regenerative detector. Shielded. Neutralized. C-battery connections. Battery cable. Antenna: 50-100 feet. Cabinet, 25 x 11 x 9. Price $105.

NO. 518. KELLOGG "WAVE MASTER," 504, 505, AND 506.

Five tubes; 2 t.r.f., detector, 2 transformer audio. One control and special zone switch. Volume control: rheostat on r.f. C-battery connections. Binding posts. Plate current: 25 to 35 mA. Antenna: 100 feet. Panel: 7½ x 25½ inches. Prices: Model 504, table, $75, less accessories. Model 505, table, $125 with loud speaker. Model 506, consolette, $135 with loud speaker.

NO. 519. KELLOGG, 507 AND 508.

Six tubes, 3 t.r.f., detector, 2 transformer audio. One control and special zone switch. Volume control: rheostat on r.f. C-battery connections. Balanced. Shielded. Binding posts and battery cable. Antenna: 70 feet. Cabinet size: Model 507, table, 30 x 13½ x 14 inches. Model 508, console, 34 x 18 x 54 inches. Prices: Model 507, $190 less accessories. Model 508, $320 with loud speaker.

NO. 427. MURDOCK 7

Seven tubes; 3 t.r.f. (01-A), detector (01-A), 1 transformer and 2 resistance audio (two 01-A and 12 or 71). One control. Volume control: rheostat on r.f. Coils shielded. Neutralized. Battery cable. C-battery connections. Complete metal case. Antenna: 100 feet. Panel size: 9 x 23 inches. Price, not available.

NO. 520. BOSCH 57

Seven tubes; 4 t.r.f. (01-A), detector (01-A), 2 audio (01-A and 71). One control calibrated in kc. Volume control: rheostat on r.f. Shielded. Battery cable. C-battery connections. Balanced. Output device. Built-in loud speaker. Antenna: built-in loop or outside antenna, 100 feet. Cabinet size: 46 x 16 x 30 inches. Price: $340 including enclosed loop and loud speaker.

NO. 521. BOSCH "CRUISER," 66 AND 76

Six tubes; 3 t.r.f. (01-A), detector (01-A), 2 audio (01-A and 71). One control. Volume control: rheostat on r.f. Shielded. C-battery connections. Balanced. Battery cable. Antenna: 20 to 100 feet. Prices: Model 66, table, $99.50. Model 76, console, $175; with loud speaker $195.

NO. 524. CASE, 61 A AND 61 C

T.r.f. Semi-shielded. Battery cable. Drum control. Volume control: variable high resistance in audio system. Plate current: 35 mA. Antenna: 100 feet. Prices: Model 61 A, $85; Model 61 C, console, $135.

NO. 525. CASE, 90 A AND 90 C

Drum control. Inductive volume control. Technidyne circuit. C-battery connections. Battery cable. Loop operated. Model 90-C equipped with output device. Prices: Model 90 A, table, $225; Model 90 C, console, $350.

NO. 526. ARBORPHONE 25

Six tubes; 3 t.r.f. (01-A), detector (01-A), 2 audio (01-A and 71). One control. Volume control: rheostat. Shielded. Battery cable. Output device. C-battery connections. Loftin-White circuit. Antenna: 75 feet. Panel: 7½ x 15 inches, metal. Prices: Model 25, table, $125; Model 252, $185; Model 253, $250; Model 255, combination phonograph and radio, $600.

NO. 527. ARBORPHONE 27

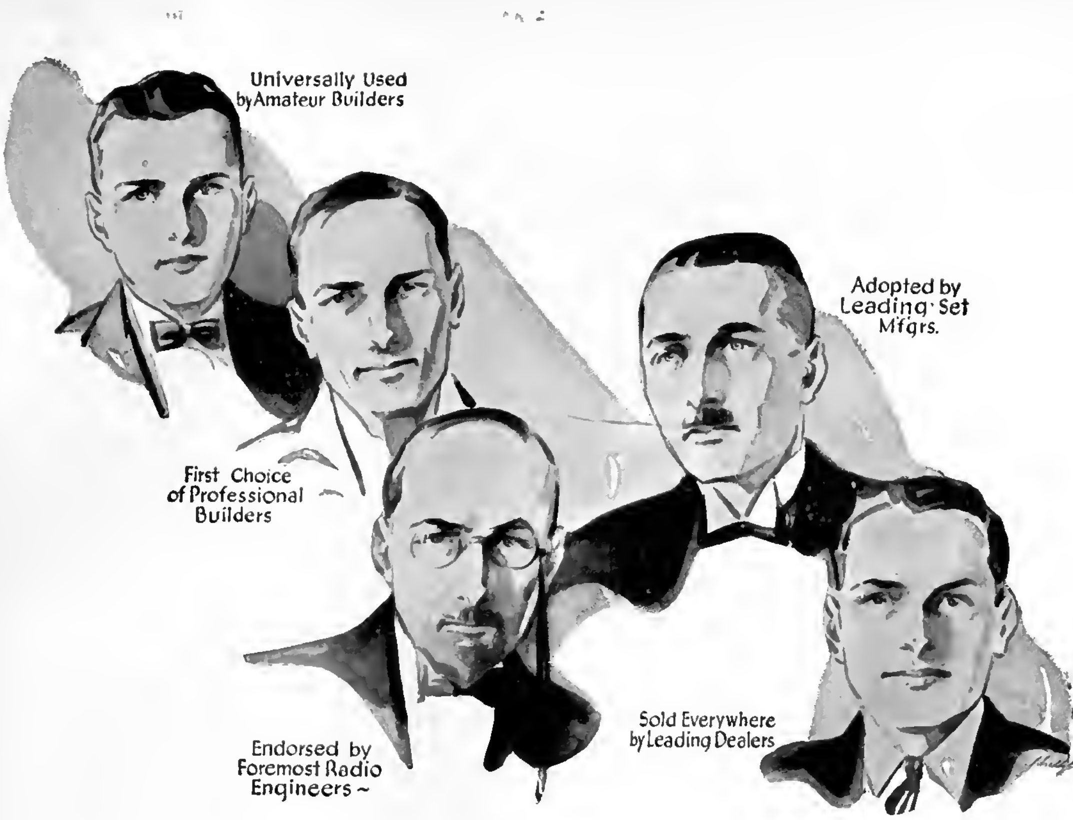
Five tubes; 2 t.r.f. (01-A), detector (01-A), 2 audio (01-A). Two controls. Volume control: rheostat. C-battery connections. Binding posts. Antenna: 75 feet. Prices: Model 27, $65; Model 271, $99.50; Model 272, $125.

NO. 528. THE "CHIEF"

Seven tubes; six 01-A tubes and one power tube. One control. Volume control: rheostat. C-battery connection. Partial shielding. Binding posts. Antenna outside. Cabinet size: 40 x 22 x 16 inches. Prices: Complete with A power supply, $250; without accessories, $150.

NO. 529. DIAMOND SPECIAL, SUPER SPECIAL, AND BABY GRAND CONSOLE

Six tubes; all 01-A type. One control. Partial shielding. C-battery connections. Volume control: rheostat. Binding posts. Antenna: outdoor. Prices: Diamond Special, $75; Super Special, $65; Baby Grand Console, $110.



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RESISTORS & POWEROHMS

INTERNATIONAL RESISTANCE CO., Dept. D, 2½ South 20th Street, Philadelphia, Pa.

NO. 530. KOLSTER, 7A AND 7B

Seven tubes; 4 t.r.f. (01-A), detector (01-A), 2 audio (01-A and 12). One control. Volume control: rheostat on r.f. Shielded. Battery cable. C-battery connections. Antenna: 50 to 75 feet. Prices: Model 7A, $125; Model 7B, with built-in loud speaker, $140.

NO. 531. KOLSTER, 8A, 8B, AND 8C

Eight tubes; 4 t.r.f. (01-A), detector (01-A), 3 audio (two 01-A and one 12). One control. Volume control: rheostat on r.f. Shielded. Battery cable. C-battery connections. Model 8A uses 50 to 75 foot antenna; model 8B contains output device and uses antenna or detachable loop; Model 8C contains output device and uses antenna or built-in loop. Prices: 8A, $185; 8B, $235; 8C, $375.

NO. 532. KOLSTER, 6D, 6G, AND 6H

Six tubes; 3 t.r.f. (01-A), detector (01-A), 2 audio (01-A and 12). One control. Volume control: rheostat on r.f. C-battery connections. Battery cable. Antenna: 50 to 75 feet. Model 6G contains output device and built-in loud speaker; Model 6H contains built-in B power unit and loud speaker. Prices: Model 6D, $80; Model 6G, $165; Model 6H, $265.

NO. 533. SIMPLEX, SR 9 AND SR 10

Five tubes; 2 t.r.f. (01-A), detector (00-A), 2 audio (01-A and 12). SR 9, three controls; SR 10, two controls. Volume control: rheostat. C-battery connections. Battery cable. Headphone connection. Prices: SR 9, table, $65; consolette, $95; console, $145. SR 10, table $70; consolette, $95; console, $145.

NO. 534. SIMPLEX, SR 11

Six tubes; 3 t.r.f. (01-A), detector (00-A), 2 audio (01-A and 12). One control. Volume control: rheostat. C-battery connections. Battery cable. Antenna: 100 feet. Prices: table, $70; consolette, $95; console, $145.

NO. 535. STANDARDYNE, MODEL S 27

Six tubes; 2 t.r.f. (01-A), detector (01-A), 2 audio (power tubes). One control. Volume control: rheostat on r.f. C-battery connections. Binding posts. Antenna: 75 feet. Cabinet size: 9 x 9 x 19½ inches. Prices: S 27, $49.50; S 950, console, with built-in loud speaker, $99.50; S 600, console with built-in loud speaker, $104.50.

NO. 481. PFANSTIEHL 32 AND 322

Seven tubes: 3 t.r.f. (01–A), detector (01–A), 3 audio (01–A and 71). One dial. Plate current: 23 to 32 mA. Volume control: resistance in r. f. plate. Shielded Battery cable. C-battery connections. Output device. Antenna: outside. Panel: 17¾ x 8½ inches. Prices: No. 32 cabinet, $145; No. 322 console, $245 including loud speaker.

NO 433. ARBORPHONE

Five tubes; 2 t.r.f., detector, 2 transformer audio. All 01-A tubes. Two dials. Plate current: 16 mA. Volume control: rheostat in r.f. and resistance in r.f. plate. C-battery connections. Binding posts. Antenna: taps for various lengths. Cabinet size: 24 x 9 x 10½ inches. Price: $65.

NO. 431. AUDIOLA 6

Six tubes; 3 t.r.f. (01–A), detector (00–A), 2 transformer audio (01–A and 71). Drum control. Plate current: 20 mA. Volume control: resistance in r.f. plate. Stage shielding. Battery cable. C-battery connection. Antenna: 50 to 100 feet. Cabinet size: 28½ x 11 x 14½ inches. Price not established.

NO. 432. AUDIOLA 8

Eight tubes; 4 t.r.f. (01-A), detector (00-A), 1 transformer audio (01-A), push-pull audio (12 or 71). Bridge balanced t.r.f. Drum control. Volume control: resistance in r.f. plate. Stage shielding. Battery cable. C-battery connections. Antenna: 10 to 100 feet. Cabinet size: 28½ x 11 x 149 inches. Price not established.

NO. 542 RADIOLA 16

Five tubes; 3 t. r. f. (01-A), detector (01-A), 2 transformer audio (01-A and 112). One control. C-battery connections. Battery cable. Antenna: outside. Cabinet size: 16½ x 8¼ x 7½ inches. Price: $69.50 without accessories.

NO. 456. RADIOLA 20

Five tubes: 2 t.r.f. (99), detector (99), 2 transformer audio (99 and 20). Balanced t.r.f. and regenerative detector. Two dials. Volume control: regenerative. Shielded. C-battery connections. Headphone connections. Antenna: 75 to 150 feet. Cabinet size: 19¾ x 11¾ x 16 inches. Price $115 including all tubes.

NO. 457 RADIOLA 25

Six tubes; five type 99 and one type 20. Drum control. Super-heterodyne circuit. C-battery connections. Battery cable. Headphone connections. Antenna: loop. Set may be operated from batteries or from power mains when used with model 104 loud speaker. Price; $165 with tubes, for battery operation. Apparatus for operation of set from the power mains can be purchased separately.

NO. 493. SONORA F

Seven tubes; 4 t.r.f. (01–A), detector (00–A), 2 transformer audio (01–A and 71). Special balanced t.r.f. Two dials. Plate current: 45 mA. Volume control: rheostat in r.f. Shielded. Battery cable. C-battery connections. Output device. Antenna: loop. Console size: 32 x 45½ x 17 inches. Prices range from $350 to $450 including loop and loud speaker.

NO. 494. SONORA E

Six tubes; 3 t.r.f. (01-A), detector (00–A), 2 transformer audio (01–A and 71). Special balanced t.r.f. Two dials. Plate current: 35 to 40 mA. Volume control: rheostat on r.f. Shielded. Battery cable. C-battery connections. Antenna: outside. Cabinet size: varies. Prices: table, $110; semi-console, $140; console, $240 including loud speaker.

NO. 495. SONORA D

Same as No. 494 except arrangement of tubes; 2 t.r.f., detector, 3 audio. Prices: table, $125; standard console, $185; "DeLuxe" console, $225.

NO. 482. STEWART-WARNER 705 AND 710

Six tubes; 3 t.r.f., detector, 2 transformer audio. All 01–A tubes. Balanced t.r.f. Two dials. Plate current: 10 to 25 mA. Volume control: resistance in r.f. plate. Shielded. Battery cable. C-battery connections. Antenna: 80 feet. Cabinet sizes: No. 705 table, 26½ x 11¼ x 13{{3}{8}} inches; No. 710 console, 29¾ x 42 x 17¼ inches. Tentative prices: No. 705, $115; No. 710 $265 including loud speaker.

NO. 483. STEWART-WARNER 525 AND 520

Same as No. 482 except no shielding. Cabinet sizes: No. 525 table, 19¾ x 10 x 11¾ inches; No. 520 console, 22¾ x 40 x 14 1/16 inches. Tentative prices: No. 525, $75; No. 520, $117.50 including loud speaker.

NO. 459. STROMBERG-CARLSON 501 AND 502

Five tubes; 2 t.r.f. (01–A), detector (00–A), 2 transformer audio (01–A and 71). Neutrodyne. Two dials. Plate current: 25 to 35 mA. Volume control: rheostat on 1st r.f. Shielded. Battery cable. C-battery connections. Headphone connections. Output device. Panel voltmeter. Antenna: 60 to 100 feet. Cabinet sizes: No. 501, 25½ x 13 x 14 inches; No. 502, 28 13/16 x 50 7/8 x 16¾ inches. Prices: No. 501, $180; No. 502, $290.

NO. 460. STROMBERG-CARLSON 601 AND 602

Six tubes. Same as No. 549 except for extra t.r.f. stage. Cabinet sizes: No. 601, 27 5/16 x 16¾ x 14 3/16 inches; No. 602, 28¾ x 51½ x 19⅝ inches. Prices: No. 601, $225; No. 602, $330.

NO. 486. VALLEY 71

Seven tubes; 4 t.r.f. (01–A), detector (01–A), 2 transformer audio (01–A and 71). One dial. Plate current: 35 mA. Volume control: rheostat on r.f. Partially shielded. Battery cable. C-battery connections. Headphone connection. Antenna: 50 to 100 feet. Cabinet size: 27 x 6 x 7 inches. Price $95.

NO. 472. VOLOTONE VIII

Six tubes. Same as No. 471 with following exceptions; 2 t.r.f. stages. Three dials. Plate current: 20 mA. Cabinet size: 26½ x 8 x 12 inches. Price $140.

It isn't a Question of DX-ing any more— Quality of Tone *is the thing*

MOST listeners-in want crystal clear, undistorted tones more than distance.

They seem to want to set their dials for a desired program and get it right—to get it full, strong and free from the annoyance of blurring and what might be termed "warped" tones.

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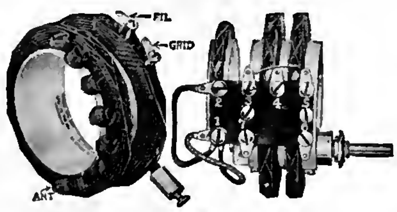

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THE new Sickles Shielded Tuned Radio Transformer prevents both outside and local interference. It is remarkably compact, sharp tuning, sturdy.

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The ideal coil for the Naald Localized Control Tuning Unit and for the Truphonic Catacomb Assembly.

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Don't underestimate the importance of accurate and quiet tubular leaks in the performance of your receiver. Metaleak is smaller than most, but interchangeable on any standard mounting. All resistances —40c to 65c.

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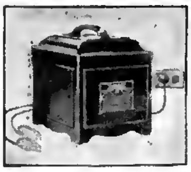
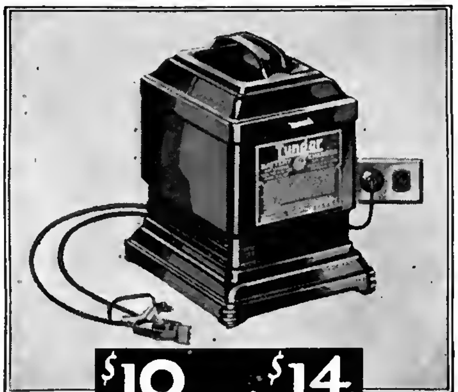
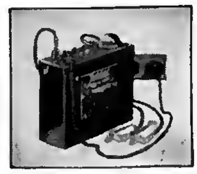

5-Ampere Tungar

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Just turn on Tungar (the name of the General Electric battery charger) at night, leave it as you would the light in the hall . . . . in the morning your storage batteries are pepped up and ready for active duty

More than 1,000,000 G-E Tungars are in use today. For the Tungar long ago established its reputation for dependable, trouble-free, economical service.

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Tungar causes no radio interference. It cannot blow out tubes.

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It is a G-E product developed in the Research Laboratories of General Electric.

The 2- or 5-ampere Tungars charge 2-, 4-, and 6-volt "A" batteries, 24- to 96-volt "B" batteries in series; and auto batteries, too. No extra attachments needed.

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New Low Prices
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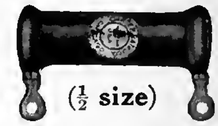
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This hard, glassy enamel has the same rate of expansion as the porcelain tube and the resistance wire that is wound on it. Consequently the Resistor may be operated at high temperatures without damaging it.

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Resistors from 750 to 20,000 ohms, two types—2 in. long, dissipating 20 watts; 4 in. long, dissipating 40 watts.

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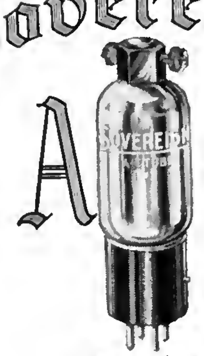

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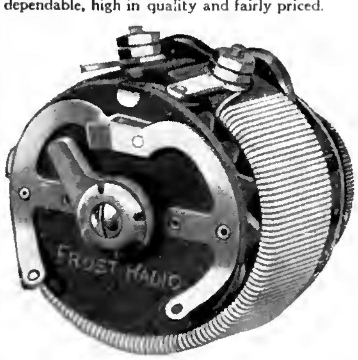

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4 Adjustable "B" Voltages in any combination

from 0 to 180

also adjustable "C" Voltage from 0 to 50

Type 445 Plate Supply Price $55

UX-280 or CX-380 Rectifier Tube for above, $5

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CORWICO "FLEXIBUS" HOOK-UP WIRE

"Corwico" Flexibus (Solid or Stranded) is a flexible insulated tinned copper hook-up wire which makes a neat and efficient product for "point to point" and sub-panel wiring. It is covered with a varnished cambric flame proof insulation finished in red, green, yellow, brown or black.

No chain is stronger than its weakest link. That's why the wire you use in your radio set or the wire that is used in the set you buy, is an important factor. Why take a chance, when for the same price and in many cases less, you can have the best by specifying "Corwico" radio wires. Their superior merits and all-around efficiency have been proven by amateurs, experts and radio receiving set manufacturers everywhere.

The next time you need wire for any radio purpose, ask your dealer for "Corwico." If he can't supply you, write us direct.

"Corwico" Radio Wires

Antenna Wire (Solid, Stranded and braided)	Hook-up Wire
	Lead-in Wire
Complete Aerial Kits	Annunciator Wire
Magnet Wire	Loop Aerial Wire
Battery Cable	Litz Wire
Bus Bar Wire	Flexible Wire

"Corwico" Radio Wires are sold by all leading dealers. Write for free booklet on radio wires and their uses.

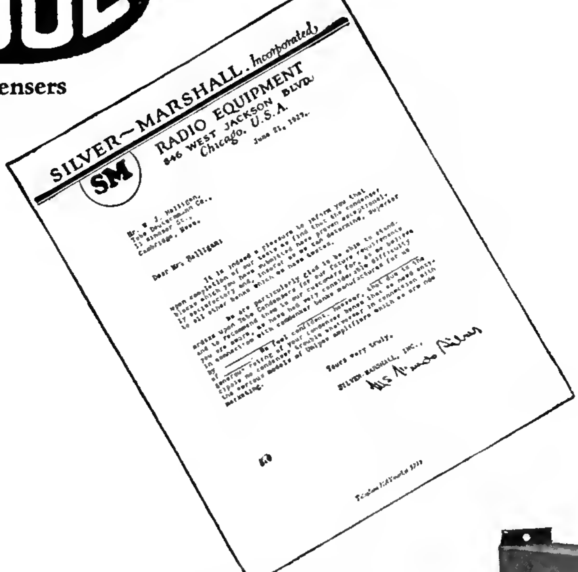
CORNISH WIRE COMPANY

30 Church Street New York City

TOBE

Condensers

"Superior to all others tested"


SILVER-MARSHALL, Incorporated
SM
RADIO EQUIPMENT
846 WEST JACKSON BLVD.
Chicago, U.S.A.

Recognized radio engineers have for a long time known the excellence of Tobe Condensers. They have the quality of continuing to function perfectly over long periods of time. Now the Tobe No. 662 high voltage B Block has been selected exclusively by McMurdo Silver for use with the new Silver-Marshall UNIPAC and Mr. Silver has written us the above reproduced letter. Send for price list B-10.

Tobe Deutschmann Co.

Cambridge - - Mass.

Making Radio Installations Safe

Safety Provisions Specified by the Board of Fire Underwriters in Making Antenna Installations—The Lightning Hazard —Danger From Power Lines

By EDGAR H. FELIX

AN ONCOMING bolt of lightning never stops to argue. It has only one thing in mind—an incredible hurry to reach Mother Earth. Your little, puny pound of copper antenna wire, strung up a few feet above the surface of the earth, has no more influence in attracting a bolt of lightning than a mosquito has to entice you to a symphony concert. If lightning ever strikes your antenna, it is merely a coincidence. The presence or absence of an antenna on a building has nothing to do with either the attraction or repulsion of lightning.

There is in the atmosphere at all times, but more especially during the summer months, a certain amount of static electricity present. Any body of metal or wire tends to collect this atmospheric electricity if it is not connected to ground, and the electrical potentials built up may become of dangerous proportions. A lightning arrester provides an easy path to ground for these charges which tend to accumulate on the antenna, but is so constructed that it does not afford a path to ground for the radio signals. When there is a thunder-shower in the immediate vicinity, the potentials induced in the antenna are greater than at other times, and almost continuous discharges take place through the arrester to ground.

With a lightning arrester properly installed, there seems to be very little danger from this atmospheric electricity, or induced currents from near-by electrical disturbances. To support the contention, let us consider the evidence of experts. Victor H. Tousley, Chief of Electrical Inspectors in the Chicago District, reports that of the 34 cases where the Chicago Fire Department was called out in response to a fire caused by lightning, only 12 of the buildings had antennas; and, in only four of these was there any evidence that lightning had followed the antenna wire to the ground.

William S. Boyd, an electrical engineer of Chicago, has, for some years, been compiling statistics regarding fires caused by lightning striking radio installations. His report lists only 15 damaged by lightning during the years 1922 to 1924—not a very formidable figure. Six of these accidental "hits" damaged only the antenna because the lightning arrester did its work effectively.

In the entire district of Philadephia, there is a record of only one fire caused by lightning striking a radio antenna, according to an officer of the Fire Underwriters' Association in that city. The antenna and lightning arrester were destroyed, but no damage was done to the receiving set.

Another hazard, which depends purely on the matter of placement of the antenna and good workmanship in putting it up, is the likelihood of the antenna coming into contact with electric wires, either low tension or high tension. The most important provisions, formulated by

(*Continued on page 412*)

LINCOLN

New!

No More Socket Trouble

A socket's only job is to provide a perfect contact. The New Eby Socket has a 3 point wiping spring contact the full length of the prong, the most scientifically perfect type known. The prongs are completely enclosed and fit snugly against the phenolic walls of the socket—**they can't spread.**

With the New Eby Socket your socket troubles are gone. Easy to mount above or below Bakelite, Wood or Metal.

Specified in most of the leading popular circuits.

List Price 40c

THE H. H. EBY MFG. CO.
INCORPORATED
4710 Stenton Ave.
Phila., Pa.

Makers of Eby Binding Posts

EARNS $500.00 *In His Spare Hours*

That's the record of Member Lyle Follick, Lansing Mich. Member Werner Eichler, Rochester, N. Y. writes, "I have made over $50. a week in my spare time"

With its proven money making plans, advice, co-operation in furnishing parts at wholesale and training, the Radio Association of America is helping its members start radio stores, secure better positions, increase their salaries, earn $3. an hour upwards in spare time building sets and serving as radio "doctors."

Join the Association without delay, because we have a plan whereby your membership may not—need not—cost you a cent. Only a limited number of these memberships are acceptable. Write before it's too late.

RADIO ASSOCIATION OF AMERICA
Dept. RB-10 4513 Ravenswood Ave., Chicago

Send me your book and details of your Special Membership Plan.

Name ....

Address ....

City .... *State* ....

TRY IT 30 DAYS FREE
BEFORE YOU BUY

ALL METAL SHIELDED CHASSIS

8 tube one dial MIRACO
TRADE MARK REGISTERED

Only $69.75 Retail List Completely Assembled

MAGNIFICENT TONE~SUPER SELECTIVE~POWERFUL DISTANCE GETTER

All Electric or Battery Set!

America's big, old, reliable Radio Corporation* (8th successful year) *guarantees* its big, powerful, latest 6, 7 and 8 tube Miraco sets to give "the finest, most enjoyable performance obtainable in *high grade* radios." Unless 30 days' use in your home fully satisfies you and everybody who hears it that a Miraco is unbeatable at any price for beautiful, clear cathedral tone, razor-edge selectivity, powerful distance reception, easy operation, etc.—*don't buy it! Your verdict final*—absolutely no strings to this. Save or make lots of money on sets and equipment by writing for testimony of nearby users and *Amazing Special Factory Offer.*

Run from "AC" Current or Batteries

Miraco's work equally fine on electric house current or with batteries. Take your choice. Many thousands of Miraco users—who bought after thorough comparisons—testify they enjoy programs Coast to Coast, Canada to Mexico, loud and clear—with the magnificent cathedral tone quality of costliest sets. Don't comfuse Miraco's with cheap, "squawky" radios. Miraco's have finest parts, latest approved shielding, metal chassis, etc.—as used in $200 sets.

Deal Direct with Big Reliable Makers

Your Miraco reaches you completely assembled, rigidly tested, fully guaranteed. Easy to connect and operate. *30 days free trial.* 3 year guarantee if you buy. Choice of beautiful consoles [with latest built-in orthophonic type speakers having 8 feet of tone travel] and table cabinets, also offered. You take no risk, you insure satisfaction, you enjoy *rock-bottom money-saving-prices by* dealing direct with one of radio's oldest, most successful builders of fine sets.

Big Discounts to User-Agents

MIRACO "Powerplus" sets—bothin8and7tubemodels—havemagnificentlybeautiful, clearcathedraltonequality. Turn one dial for stations everywhere. Ultra-selective. Miraco multi-stagedistanceamplificationgives "power-plus" on far-offstations. Latest all-metal shielded chassis. Illuminated dial. Fully guaranteed. *Try one free for 30 days!* Choice of beautiful cabinets.

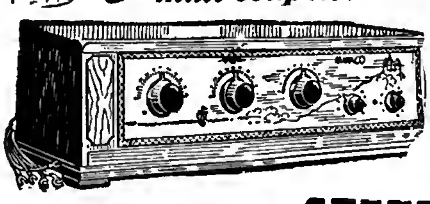
7 tube one dial METAL SHIELDED CHASSIS $49.75 RETAIL LIST

Dealers Write!

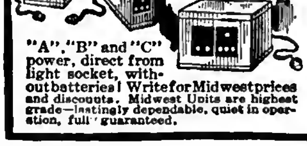
* MIDWEST RADIO CORP.
Cincinnati, Ohio

BEAUTIFULLY ILLUSTRATED Free! *Catalog and amazing Special Offer*

mail coupon!



Electrify Any Radio with MIDWEST NO-BATTERY "A-C" Light Socket Power Units



"A", "B" and "C" power, direct from light socket, without batteries! Write for Midwest prices and discounts. Midwest Units are highest grade—lastingly dependable, quiet in operation, full guaranteed.

30 Days Free Trial

6 tube Super $36.75 RETAIL LIST

MIDWEST RADIO CORPORATION
Pioneer Builders of Sets
406-C Miraco Building, Cincinnati, Ohio.

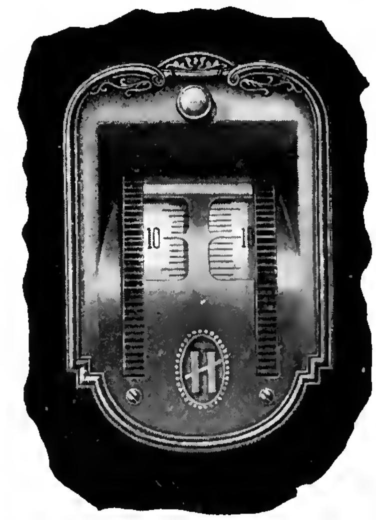
THIS COUPON IS NOT AN ORDER

Without obligation, send free catalog, AMAZING SPECIAL WHOLESALE PRICE OFFER, testimony of nearby Miraco users.

NAME

ADDRESS

A "Million-Dollar" Front For Your Receiver



FRONT VIEW

The New

HAMMARLUND

Illuminated

Drum Dial

An up-to-the-minute tuning improvement every set-builder will want to install.

HAMMARLUND waited to produce a drum dial that would make the single-control of tuning condensers really practicable.

Local stations can now be tuned in over the entire wave band by the simple movement of two fingers. Distant stations, requiring a finer adjustment, are brought in by a slight realignment of the individual halves of the dial.

Viewed from the front, the new Hammarlund Drum Dial gives to any receiver a delightful, professional finish. The bronze escutcheon plate, richly embossed and oxidized, endows the panel with a classic beauty.

BACK VIEW

Mechanical Features

Over-size die-cast frame; Bakelite drums, with knurled edges; translucent celluloid wavelength scales, illuminated by a small electric light, with handy switch, connecting with the "A" Battery circuit. Adaptable to all standard panel proportions.

APPROVED RADIO NEWS LABORATORIES

HAMMARLUND MANUFACTURING COMPANY

424-438 W. 33rd Street, New York

Already many leading radio designers have officially specified Hammarlund Precision Products for their latest circuits.

For Better Radio Hammarlund PRECISION PRODUCTS

Dealer inquiries invited concerning several other new and appealing Hammarlund developments, having a wide sales appeal.

BIG RADIO CATALOG

From the "Big, Friendly Radio House"

NEW 1928 Book offers finest, newest well-known sets; parts, eliminators, accessories at lowest prices. Set-builders, dealers, agents —WRITE for this CATALOG!

Western Radio Mfg. Co.

134 West Lake St. Dept. 47

CHICAGO, ILL.

RADIO PANELS

BAKELITE—HARD RUBBER

Cut, drilled and engraved to order. Send rough sketch for estimate. Our complete Catalog on Panels, Tubes and Rods—all of genuine bakelite or Hard Rubber—mailed on request.

STARRETT MFG. CO.

521 S. Green Street Chicago, Ill.

6 TUBE RADIO ONE DIAL Only $32.50

Latest advanced circuit. All steel chassis totally shielded. Balanced parts of best quality. Marvelous power and selectivity. Gets the long range stations as clear as a bell. One dial single control. An unsurpassed value—just one of our many mighty bargains.

FREE Log and Call Book and Big New Catalog—just off the press. Full of Radio Bargains. Send for your free copy now!

American Auto & Radio Mfg. Co.

HARRY SCHWARTZBERG, Pres.

Dept. 122 American Radio Bldg., Kansas City, Mo.

Safe Radio

the Board of Underwriters, are abstracted as follows:

PERTAINING TO THE LIGHTNING HAZARD

1. LIGHTNING ARRESTER. Each lead-in wire shall be equipped with an approved lightning arrester, operative when 500 volts or more are impressed on it, and connected to a ground either inside or outside the building, as near to the arrester as possible. The arrester should not be installed near any inflammable material. If a grounding switch is used, it should shunt the arrester, and should have a capacity of 30 amperes at 250 volts.

2. APPROVED GROUNDS. The ground used is preferably made to a cold-water pipe, where such a pipe is available and is in service and connected to the street mains. Other permissible grounds are: the grounded steel frames of buildings, the grounded metal work in the building, and artificial grounds such as driven pipes, rods, plates, cones, etc. Gas pipe shall not be used for a ground. The ground should be installed so as to be safe from mechanical injury. An approved ground clamp should be used for connecting the wires, and the pipe should be thoroughly cleaned.

3. GROUND WIRE. The protective grounding conductor may be of bare or insulated wire made of copper, bronze, or approved copper-clad steel. The ground wire shall in no case be less in current-carrying capacity than the lead-in wire, and in no case shall it be smaller than No. 14 if copper, nor smaller than No. 17 if of bronze or copper-clad steel. The ground wire should be run in as straight a line as possible from the protective device to the ground connection. Inside wiring should be fastened in a workmanlike manner and should not come closer than two inches to electric conductors, unless porcelain tubing forms a permanent separation from such conductors. This last applies to all inside wires.

7. FUSES IN GROUND LEADS. No fuses shall be used in any lead-in conductors or in the ground wire.

REQUIREMENTS FOR PROTECTION FROM HIGH VOLTAGE

8. INSTALLATION NEAR HIGH VOLTAGE MAINS. The antenna and counterpoise, outside the building, shall be kept well away from any wires carrying a potential of 600 volts or more, including railway, trolley, or feeder wires, in order to avoid accidental contact. These voltages are sufficient to cause shock dangerous to life and to cause fires. Antenna installations near electrical wires of less than 600 volts potential must be installed in a durable manner and shall be provided with suitable clearances so that there is no possible chance of accidental contact, due to sagging or swinging.

9. SPLICES IN ANTENNA WIRE. Splicing in antenna or lead-in wires should be soldered unless made with an approved splicing device.

10. LEAD-IN CONDUCTORS. Lead-in conductors shall be of approved copper-clad steel or other metal which does not corrode excessively, of no smaller gauge than No 14, unless approved copper-clad steel is used when the gauge may be No. 17.

11. LEAD-IN CONDUCTORS OUTSIDE THE BUILDING. The lead-in conductor shall not come closer than four inches to any electric light or power wires unless separated therefrom by a porcelain tube or other firmly fixed non-conductor.

12. LEAD-IN INSULATOR. An approved lead-in insulator should be used.

13. STORAGE BATTERY CIRCUIT. An important and new provision rarely obeyed is the requirement that fuses of not less than 15-amperes capacity shall be installed and located preferably at or near to the battery. An approved circuit breaker of the same minimum capacity may be used. The leads from the battery to the receiver shall consist of conductors having approved rubber insulation.

Clearly, these rules are simple and easily com-

(Continued on page 414)

Best tubes—Best reception

New broadcast developments make it necessary to have the latest types of tubes for fullest enjoyment of your receiving set.

Bring it up to date with a complete installation of the new Gold Seal radio tubes—specially developed for modern reception. You will be delighted with the improvement.

You can make the changes yourself—no trouble. Our new booklet tells you all about it. Send today for your copy—it is free. Use coupon below.

All Standard Types

Gold Seal Electrical Co.
250 Park Ave., New York

Send me copy of the new booklet.

Name ____________________

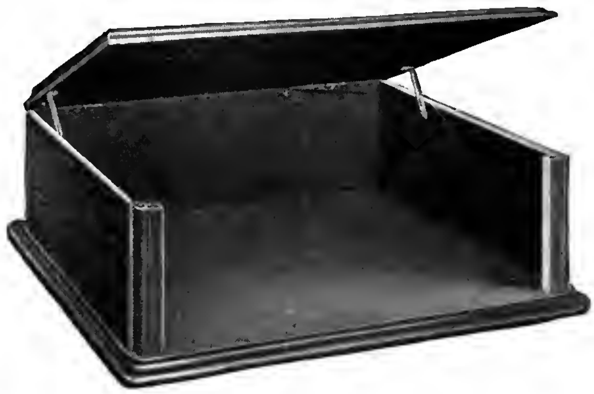
Address ____________________ R. B.

Gold Seal *Radio Tubes*

Vee Dee

All-Metal Cabinet—

For 1927-28 Hook-Ups!

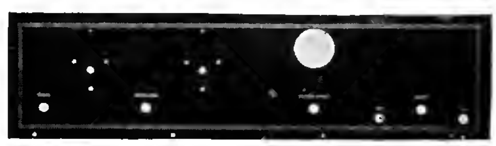


Model 250
For A. C. or Battery Sets
Using
7x18
7x21
8x18
8x21
Panels

Inside dimensions 25"x14¼"x9⅛". Hinged top—with stay joint. Rigidly formed for strength and appearance. Felt foot rest—rubber lid stops. A welded job doing away with troubles of swelling, shrinking, cracking, splitting and uncertain fit.

The original beauty of natural wood grains combined with the efficiency of all metal construction! By our photo litho process, we reproduce mahogany and walnut hardwood, and novelty finishes, so gorgeous in their conception that they excite the admiration of all who see it.

Spacious interior dimensions are demanded for housing all the latest hook-ups! Vee Dee metal cabinets are designed for that purpose. 90% of all the 1927-1928 hook-ups are covered by the dimensions of Vee Dee No. 250 cabinet illustrated above. Beautiful—practical! Low price!



Metal Panel for Citizens Super Eight

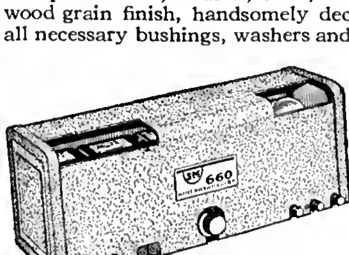
Constructed in accordance with Citizens Radio Call Book and McMurdo Silver, Remler, Cockaday co-ordinated designing

Metal Panel and Chassis for Silver-Marshall 1927 Model Super-Heterodyne

Complete assembly consisting of panel and chassis, fully drilled, beautiful wood finish with special two-color decoration, all fibre bushings and washers included, also screws, bolts and hardware accessories.

S. C. 2 Assembly Unit

Complete Panel, Chassis, 7x18, fully drilled. Beautiful wood grain finish, handsomely decorated. Kit includes all necessary bushings, washers and hardware accessories.



Unipac Housing

Especially designed and provided for Silver-Marshall Power Hook-ups—including cabinet and chassis, drilled and with all small hardware.

Metal Panels and Chassis in All Standard Sizes

JOBBERS, DEALERS—WRITE FOR PRICES

Set Builders—If your dealer cannot supply you, write direct

The Van Doorn Company

160 North La Salle Street - - - - - Chicago, Illinois

Factory, Quincy, Illinois

Independent Radio Corporation

Manufacturers of

Precision Radio Apparatus

1516 Summer Street Philadelphia

Safe Radio

plied with. Compliance with them gives you a safe installation. Failure to follow them invites unnecessary and totally avoidable risk. Furthermore, failure to comply invalidates your fire insurance policies automatically.

BOOK REVIEW

A Home-Constructor's Handbook

Practical Radio Construction and Repair. By James A. Moyer and John F. Wostrel. Published by the McGraw-Hill Book Company, Incorporated, New York. 319 Pages and 157 Illustrations. Price $2.00.

"Practical Radio Construction and Repair" contains a potpourri of useful and practical information. Its authors have compiled their pages out of a large practical knowledge and experience in set building. The title implies a handbook of radio construction and repairing—a reference volume for the dealer's service man. It does not fail in that respect so much from incompleteness as it does from poor arrangement. But it has much to commend it.

The first part of the book deals with what may be termed the accessories of the radio receiver—the antenna, the vacuum tube and its power supply, and, tucked away with these subjects, a chapter on the tool equipment needed for radio construction. Then follows a series of chapters on radio-frequency amplifiers, describing several methods of controlling regeneration and including a few words about super-heterodyne amplification. Next follows a brief description of systems of audio-frequency amplification.

The subsequent few chapters deal with constructional details. The first set to be described in detail is the Browning-Drake receiver. The writers then again return to audio-frequency amplifiers, presenting a strong case for a popular resistance-coupled amplifier kit. The superiority of resistance coupling over transformer coupling is emphasized by means of a set of curves. Apparently, an inferior transformer and a superior resistance amplifier were used as the basis of the test. A chapter on impedance amplification, devoted to a description of the Thordarson amplifier, follows that comparing resistance and transformer coupling.

Returning again to receiving sets, the authors next describe the "Universal," the Acme reflex, the Cotton super-heterodyne, and a short-wave receiver. In general, these descriptions follow closely the conventional magazine style of exposition, with lists of parts, and details for assembly and operation. No commercial receivers are described or even considered.

The appeal of this book is confined generally to the home constructor and his problems and not to those of the dealer service man; an outstanding exception is the last chapter, where the service man is suddenly remembered. This last chapter makes interesting reading, containing, as it does, a fairly complete and practical set of troubles likely to be encountered in a radio receiver under various conditions. A few brief samples are quoted to show the type of information in this section:

Set Gives Squealing Sound Constantly.—A constant squealing sound in a receiving set is generally due to a defective vacuum tube which in the course of time has become soft or gassy. Continuous squealing may also be due to a very badly run-down B battery or, to a less degree, to a worn-out C battery. A burned-out primary

(Continued on page 416)

Radio • Is • *BETTER* • With • Dry • Battery • Power

made to run the *full* race!

*A*NY horse can make a good start..... But it takes real stamina to *finish!*

So it is with batteries. *Staying* power is the quality to look for—unfailing power over a long period of service. Millions prefer Burgess *Chrome* Batteries for just this reason. They hold up..... They *last.*

Next time, buy black and white striped Burgess *Chrome* Batteries. You are certain to get longer and better service for your money.

Chrome—the preserving element used in leather, metals, paints and other materials subject to wear, is also used in Burgess Batteries. It gives them unusual *staying* power. Burgess *Chrome* Batteries are patented.

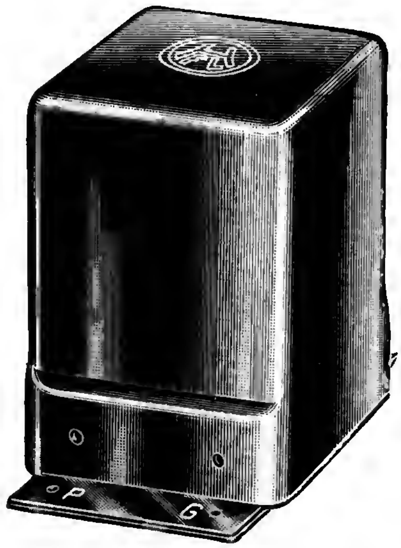
Ask Any Radio Engineer

BURGESS BATTERY COMPANY
General Sales Office: CHICAGO
Canadian Factories and Offices: Niagara Falls and Winnipeg

BURGESS
FLASHLIGHT & RADIO
BATTERIES

HFL Transformers HFL

Two additions to last year's Radio Sensation The Amazing Achievement in Audio Amplification



H. F. L. C-16 Audio Transformers and C-25 output Transformer—New companions of a Great Unit, will work in any circuit and improve any radio set.

Designed to fulfill the exacting requirements of set builders who demand

EFFICIENCY
SENSITIVITY
PRECISION AND
HIGH QUALITY

The new C-16 and C-25 Transformers will work in any circuit and will improve any Radio Set.

H. F. L. Facts

H. F. L. Units have been used, approved and most highly endorsed by *Radio News, Citizens' Call Book, Radio Review, Radio Age, Radio Engineering, Radio Mechanics, Chicago Evening Post,* the *Daily News* and others. Thousands of engineers and fans, who have turned to H. F. L. Units for better reception, hail them as the finest transformers known to Radio—unexcelled for Power, Selectivity and Purity of Tone.

Perfectly matched, skillfully designed, carefully made, rigidly tested—in a word, H. F. L. transformers are technically correct to the minutest detail.

All H. F. L. transformers are designed for baseboard mounting or invisible subpanel wiring—each unit is enclosed and sealed in a genuine bakelite moulding.

H. F. L. Units are easily connected into the assembly, simplify set construction, and make a beautiful finished job.

H. F. L. Units Give Wonderful Clear Reception

Engineers acclaim H. F. L. C-16 a marvellously efficient Audio Transformer. It carries signals at highest volume and lowest amplitude without blasting or developing harmonics. Operates with all power tubes as well as standard tubes.

H. F. L. C-25 Output Transformer handles the voltage output of power amplifying tubes, at the same time matches the impedance of the average speaker to the tubes. Protects loud speaker unit without reducing plate voltage.

Mechanical features of these two transformers are: A coil designed and treated to exclude moisture and withstand heavy electrical surges without breaking down—complete magnetic shielding to avoid interstage coupling—terminals brought out so as to insure short leads.

Endorsed by America's Leading Engineers—Guaranteed by the Manufacturers

PRICES

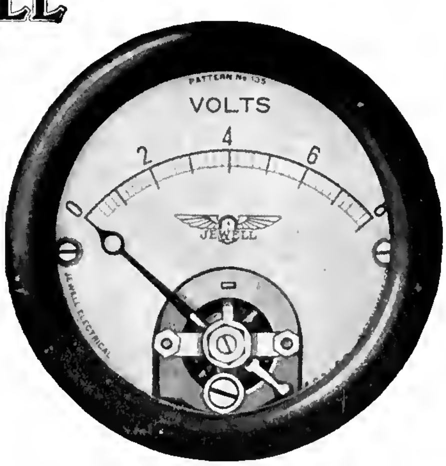
No. H-210 Transformer	$8.00
No. H-215 Transformer	8.00
No. C-16 Transformer	8.00
No. L-425 R. F. Choke	5.50
No. L-430 R. F. Transformer	5.50
No. C-25 Output Transformer	8.00

Set Builders—Dealers

If your jobber cannot supply you with H. F. L. Transformers, write us for name of nearest jobber.

HIGH FREQUENCY LABORATORIES
131-M NORTH WELLS STREET, CHICAGO, ILL.

JEWELL



Pattern No. 135 Radio Voltmeter

A Quality Instrument

Your Radio Will Be Better

Voltmeter control of filament voltage will make any radio receiving set better. It enables you to retain that nicety of balance in filament emission, which brings in reception clear and exact with maximum volume. It will prevent premature burnout of the radio tubes due to excessive filament voltage, for, with a voltmeter mounted on the panel and connected to the filaments, you will know at all times just what voltage is being applied to the filaments.

The Jewell Pattern No. 135 voltmeter is good looking and rigidly constructed and is the ideal instrument for filament control. The black enamelled case is two inches in diameter and contains a miniature, but very high grade, D'Arsonval moving coil type movement, which is equipped with a zero adjuster. Movement parts are all silvered and the scale is silver etched with black characters.

The addition of this meter to your set will improve its appearance besides being a great help to better and economical reception

Write for descriptive circular No. 776 and ask for a copy of our radio instrument catalog No. 15-c

Jewell Electrical Instrument Co.

1650 Walnut Street, Chicago

"27 Years Making Good Instruments"

Book Review

winding of one of the transformers or a poor connection in the jack connecting the loud speaker and closing the battery circuits will also cause this same effect.

Set Operates When Plug of Telephone Receiver Is Put in Jack of Detector Circuit, but Does not Operate in Stages of Amplification.—This difficulty may be due to reversed connections of the A battery, or the primary winding of the audio-frequency transformer in the detector circuit may be burned out.

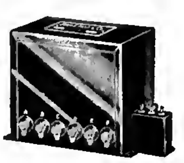
No serious attempt is made to correlate the practical information in this last section in a manner lending itself to easy reference.

The set constructor will find much of interest in the book because it is, on the whole, reliable and accurate. We might pick out statements here and there to quibble over, such as that in the chapter on audio-frequency amplifiers. Speaking of audio-frequency transformers, the authors say: "Some manufacturers claim that they can make transformers which amplify consistently over a wide range of wavelengths," a correct, though rather unconventional way of referring to audio-frequencies. Another case of a different kind: "If the sound volume from the loud-speaker is weak, tap the vacuum tubes with a finger nail to determine whether or not the audio amplifiers are operating satisfactorily; if they are not, the tapping by the finger nail will cause a ringing sound in the loud speaker." To include, in a final summary of testing instructions, so broad a generality, having so many conceivable exceptions, is, to say the least, somewhat careless.

A general criticism which may be made of many radio books is the superficial knowledge of their authors. Moyer and Wostrel are certainly exempt from any such accusation because they have the outstanding virtue of knowing what they are talking about. But they have not met the needs of service men working for the radio dealer; the authors' viewpoint is that of the amateur set builder.

The preferred circuits for home construction are well selected and described; there are plenty of diagrams to browse among and, to one who reads the book from cover to cover, many new facts are likely to be discovered. But, if one wants to find out in a hurry such a practical constructional point as whether the jack should be so wired that the sleeve or the tip of the plug goes to the B-plus lead, or the quickest way of finding safely which tube is burned out with a set in which the filaments are wired in series, there is no telling if, how, and where the desired information will be found.

Edgar H. Felix.



Set Builders!

All socket power devices must depend upon Condensers for successful operation. Fast Hi-Test Condensers have extra capacity and are built to withstand every requirement Millions now in use and since 1919, one of the oldest established and reliable manufacturers,

Illustration shows condenser pack used in Q. R. S. or Raytheon A-B-C unit. For perfect operation, build your A.B.C. packs with Fast condensers, whether specified or not. They fit all units.

Features of Fast Hi-Test Condensers

Condenser life depends upon its dielectric strength. Fast condensers have extraordinarily high insulation resistance. By-pass condensers are all of the short-path type, affording zero resistance to radio frequency curve. Absolutely non-inductive.

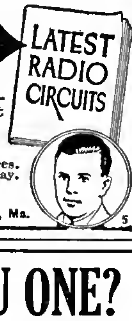
An exclusive feature—by-pass condensers enclosed in one-piece dies-press steel housing, makes them positively impervious to all climatic conditions or abuse. Before being encased condensers receive special laboratory treatment whereby moisture content is effectually removed and once removed, they stay that way, for the housing seals them permanently thereafter. That's why Fast Hi-Test condensers give such excellent, dependable service.

Free condenser booklet brings the facts. Dealers and jobbers, send for price list.

JOHN E. FAST & CO. 3982 Barry Ave., Dept. D, Chicago, U. S. A.

BIG NEW CATALOG FOR RADIO BUILDERS

FREE My big 1928 Radio Catalog, **Call Book** and Trouble Finder. 132 pages about Radio. Chock full of newest circuits—kits, transmitter parts, short wave outfits, eliminators and speakers. Thousands of bargains at lowest wholesale prices. A regular Radio Encyclopedia—**Free.** Write today.



American Auto & Radio Mfg. Co.
HARRY SCHWARTZBERG, PRES.
Dept. 125 American Radio Bldg., Kansas City, Mo.

R U ONE?

Co-operative membership in E I A RADIO is establishing an honest, industrious man in each locality in a successful radio industry of his own. Young married men preferred. Apply by letter, giving the name of your county, to

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USE THIS COUPON FOR COMPLETE SETS

Radio Broadcast Service Department
Radio Broadcast, *Garden City, New York.*
Please send me information about the following manufactured receivers indicated by number:

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Name..

Address..
(*Number*) (*Street*)

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(*City*) (*State*)

ORDER BY NUMBER ONLY

This coupon must accompany each order. RB 1027

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Single Control 7-Tube $77

RETAIL PRICE
Completely Assembled

The Randolph
SINGLE CONTROL - ILLUMINATED DRUM

POWERFUL seven-tube radio at factory price. Test it without spending a cent. We claim the Randolph Seven will out-perform any radio and we want you to satisfy yourself that it will. To do this, we will send you this powerful radio to try for 30 days. Test it for distance, clearness, ease of operation, tone and every other way you can. Unless it more than satisfies you, return it to us. **Every Randolph set must make good before it is sold.**

BIGGEST DISCOUNTS to AGENTS and DEALERS

WORK either full or part time and make big money. Tremendous advertising campaign helps you sell. Regardless of whether you have ever sold before, be sure to get our proposition. The Randolph sells on first demonstration. Men and women both can make money this easy way. Get your demonstration set for thirty days FREE TRIAL.

Battery or ALL ELECTRIC OPERATION

The Randolph Seven is sold for use with batteries or connected for operation direct to electric light socket—absolutely batteryless—no chargers or batteries—just **plug in** socket and **tune in.** 100% efficient either way. Its construction and performance have been tested and approved by leading radio engineers and authorities and leading radio and scientific publications.

Single Control—Illuminated Drum

One drum dial operated by one simple vernier control tunes in all stations with easy selectivity to tremendous volume. No overlapping of stations. Illuminated drum permits operation in the dark. Volume control for finer volume modulation. This is a 7-tube tuned radio frequency receiver with power transformers and power amplification. Space wound solenoid coils Full and completely shielded. A real receiver of the highest quality. Tremendous distance, wonderful tone quality, simple to operate.

The Randolph cabinets are in themselves beautiful pieces of furniture made of carefully selected solid burl walnut. Bas-relief bronze escutcheon plates are mounted on the dial panel. In design and appearance it is a cabinet worthy of the high-quality radio it contains. Solid walnut beautifully shaped surrounds the soft verdi-green panel.

Nothing has been spared to make the Randolph Seven the leading radio receiver. We are so sure that it will surpass even your best hopes that we know how safe we are in making the **30 day free trial offer.**

Read What Owners Say

I have logged more than 50 stations from coast to coast.—Lloyd Davenport, Littlefield, Texas.

I have logged 52 stations from Cuba to Seattle—the set is a world beater.—J. Tampkinson, Detroit, Mich.

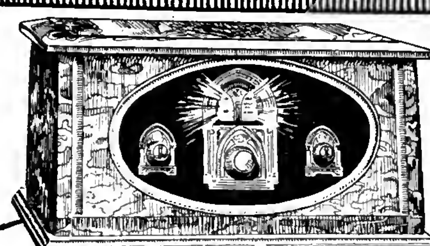
Your set is a revelation—has all others tied to the post for distance and selectivity.—Waldo Powers, Vergennes, Vermont.

On strength of its performance sold two more sets this week. T. Scanlow, Orlando, Florida.

Beautiful Ampliphonic Console Set

Made of the finest carefully selected solid walnut. Two-tone shaded finish. Has built-in cone loudspeaker that compares with any on the market and accurately reproduces high and low notes. Send for the folder today that shows this beautiful console in full colors and gives complete details. **Compares with most table sets in price.** For **battery** or **all-electric operation** ready to **plug in** and **tune in.** Write for complete descriptions.

Randolph Radio Corporation
711 W. Lake St. Dept. 121, Chicago, Ill.



6-Tube $55

Retail Price
SINGLE CONTROL

The Randolph

Now yoo can have a **new, modern, single-control, six-tube radio.** Do not compare this set with old atyle 2-dial 6-tube sets selling for about the same price. The Randolph 1928 Senior Six has also been tested and approved by the leading radio engineers.

Comes in a beautiful solid walnut cabinet of hand-rubbed finish. Single control. Illuminated Drum with space for logging. Absolutely dependable and very selective. **Sent for 30 Days Free Trial. You test it before you buy.**

Mail Coupon Now

The Randolph Radio Corporation are pioneers in the manufacture of radios. All of its vast and unlimited resources have been used in making and perfecting of the Randolph Receivers. Because of our long and successful experience in the radio business, we are perfectly confident in sending out a Randolph Radio on trial. We know what it will do. Mail us the coupon now for the greatest radio offer ever made.

USE THIS COUPON TODAY!

Randolph Radio Corporation.
711 West Lake Street, Dept. 121
Chicago, Illinois.

Send me full particulars about the RANDOLPH Six and Seven-Tube Table and Console Sets with details of your **30 Day FREE Trial Offer.**

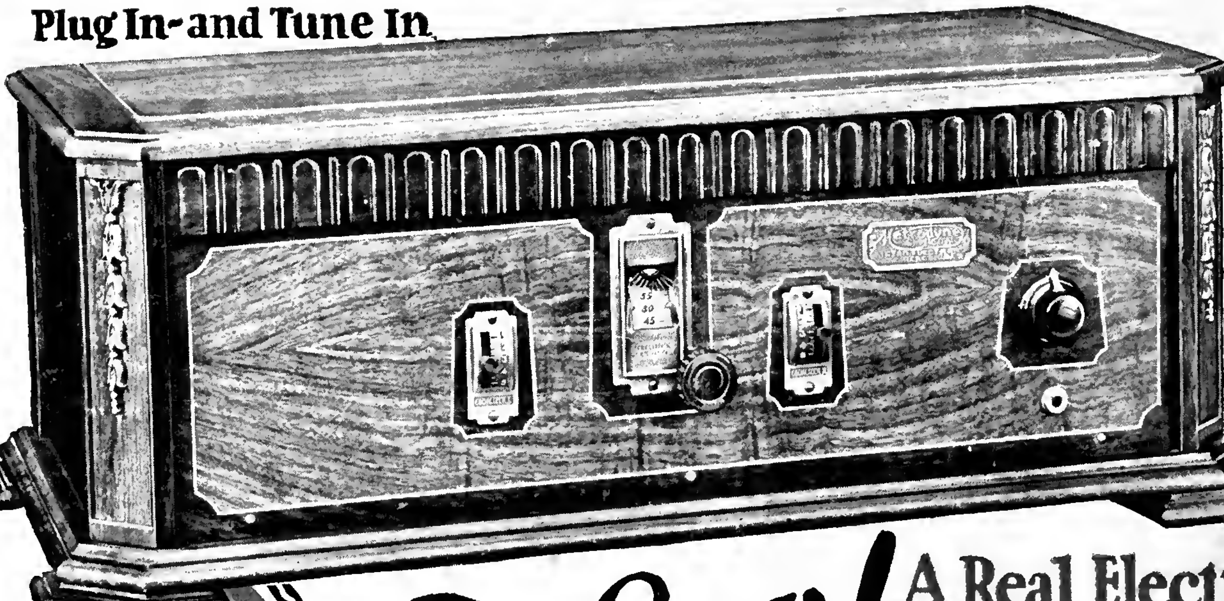
Name..

Address..

City........................ State........................

Mark here ( ) if interested in Agent's proposition.

Plug In-and Tune In



Now! A Real Electric Radio Set

Three Year Guarantee

Shipped direct from our factory at rock bottom prices—cost less than most battery sets

No Batteries, Chargers or Eliminators

No Acids; No Liquids—Plug In—Press Button—"Tune In"

30 Days Free Trial

AGENTS! DEALERS! BIG PROFITS!

Make big money taking orders for Metrodynes. All or part time. Metrodyne All Electric Radios are in a class by themselves. Unequalled for quality, performance and price. Demonstrate at home and take orders. Lowest wholesale prices. Your demonstrating set on 30 days' free trial. Mail coupon below for details.

Metrodyne

ALL ELECTRIC RADIO

7 Tubes—Single Dial Set

100% Electric Radio

At last! The radio you've dreamed about! If you have electricity in your home you can now really enjoy coast to coast radio reception without the care, bother and muss of batteries, chargers, eliminators, etc. The Metrodyne All Electric is a real, genuine batteryless radio set. Simply insert the plug in the socket, press the switch button and "tune in." You could not possibly buy a better radio set than the Metrodyne All Electric, no matter what price you paid.

BEAUTY—EFFICIENCY DEPENDABILITY

The Metrodyne All Electric Radio is a 7 tube, single dial set. Only the highest quality low loss parts are used throughout. Solid walnut cabinet, beautiful two-tone effect, with handsome gilt metal trimmings. Size of cabinet, 28 inches long, 13 inches deep, 10 inches high. Has electrically lighted dial so that you can log stations in the dark. Only one dial to tune in all stations. Excel lent tone qualities — wonderful volume — very selective.

Gorgeous Console Electric Radio

Here is the Metrodyne All Electric Console Radio — a gorgeous, genuine walnut cabinet, in a beautiful two-tone finish. Has a built-in genuine Metro-Cone large size speaker. Brings in programs with great volume, reproducing the entire range from the lowest to the highest notes with remarkable clearness and distinction. All metal parts are finished in old gold. Wonderful electric radio, in a cabinet that will beautify the appearance of any home.

Costs Less Than Most Battery Sets

Do not confuse the Metrodyne electric radio with ordinary light socket sets, because the Metrodyne is truly an **all electric** radio — consumes less than 2c worth of power a day. Comes to you **direct from the factory.** Its low cost brings it down to the price of an ordinary battery set. We are so confident that you will be delighted with this wonderful, easy-to-operate **batteryless radio** that we offer to ship it to your home for **thirty days' free trial** — you to be the judge.

Mail This Coupon

We are one of the pioneers of radio. The success of Metrodyne sets is due to our liberal **30 days' free trial offer,** which gives you the opportunity of trying before buying. Thousands of Metrodynes have been bought on our liberal free trial basis — **WRITE TODAY!**

METRO ELECTRIC COMPANY
2165 N. California Ave. Dept. 607, Chicago, Illinois

METRO ELECTRIC COMPANY
2165 N. California Ave., Dept. 607
Chicago, Illinois

Gentlemen:
Send me full particulars about Metrodyne All Electric Radio and your **thirty days' free trial offer.**

Name ....

Address ....

If you are interested in AGENT'S proposition place an "X" in the square → ☐

MAIL COUPON NOW!

THE COUNTRY LIFE PRESS, GARDEN CITY, NEW YORK