RADIO BROADCAST

VOLUME XII

NOVEMBER, 1927, to APRIL, 1928

GARDEN CITY NEW YORK
DOUBLEDAY, DORAN & COMPANY, INC.
1928

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What is a Good Radio Set?

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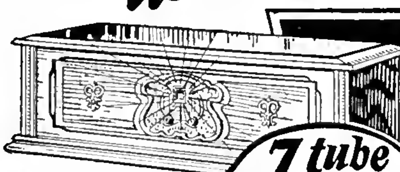

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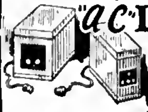

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NOVEMBER, 1927

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Contributing Editor

Vol. XII, No. 1

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AMONG OTHER THINGS. . .

FOR more reasons than one, the New York Radio Show is generally accepted as the event which crystallizes interest in all things radio. This is written as the show closed and a more impressive show we have never seen. "Impressive" from the point of view of the exhibits, certainly, but more impressive because of the tremendous interest in all things radio demonstrated by all sorts and conditions of people who thronged Madison Square Garden. Careful observation of the crowds and their interest indicated that while the complete sets drew much attention, the home-assembled receivers—built from kits, were equally interesting. This definite and lively interest in the home-built sets is especially important in view of the pronouncements of some knowing radio sages who aver that home building is seriously on the decline.

ACTUAL transmission and reception of "still" pictures by radio was demonstrated thousands of times during the week of the show by Austin G. Cooley who set up a complete Cooley "Rayfoto" transmitter and receiver in a special booth provided through the courtesy of G. Clayton Irwin, Jr., manager of the show. The picture converter or transmitter was set up, connected to a small radio transmitter and through a standard broadcast receiver, the pictures were received with great rapidity and success before the very eyes of eager crowds. The simplicity and speed of the receiver astounded those who saw the demonstration, and every visitor was eager to know when he could build the apparatus and how soon pictures would be sent and where he could get information. Experimental picture transmissions from various broadcasting stations will be sent even before you read these words; complete information on how the system works, how to build and operate it appears exclusively in this and following issues of Radio Broadcast. And those who wish to receive printed matter describing details of the system should at once address a letter to the undersigned who will see that all information is mailed at once. The impressive success of the Cooley "Rayfoto" demonstration proves beyond all question that a new era has dawned for the home experimenter, and to be frank, we are as enthusiastic over the possibilities opened up as the keenest of experimenters.

A WORD about the authors in this issue: the anonymous author of the absorbing leading article is a very well-known figure in aviation and radio. Ralph Langley, who explains his scheme for numbering broadcast channels, is executive assistant to the president, Crosley Radio Corporation. He was until recently in charge of receiver design for the General Electric Company. Howard E. Rhodes who describes what's new in A-power units is one of the able technical staff of this magazine. James Millen, who is a consulting engineer and a native of Long Island, will shortly desert these parts and settle in Boston.

IN THE next issue we shall have an important article by T. H. Nakken on the shielded grid tube indicating what such a tube means to American radio .There will be valuable constructional articles and a description of the technical features of well known manufactured receivers—information never published before. Austin Cooley will tell how to build a Cooley "Rayfoto" receiver—facts for which many experimenters are waiting.

—Willis Kingsley Wing.

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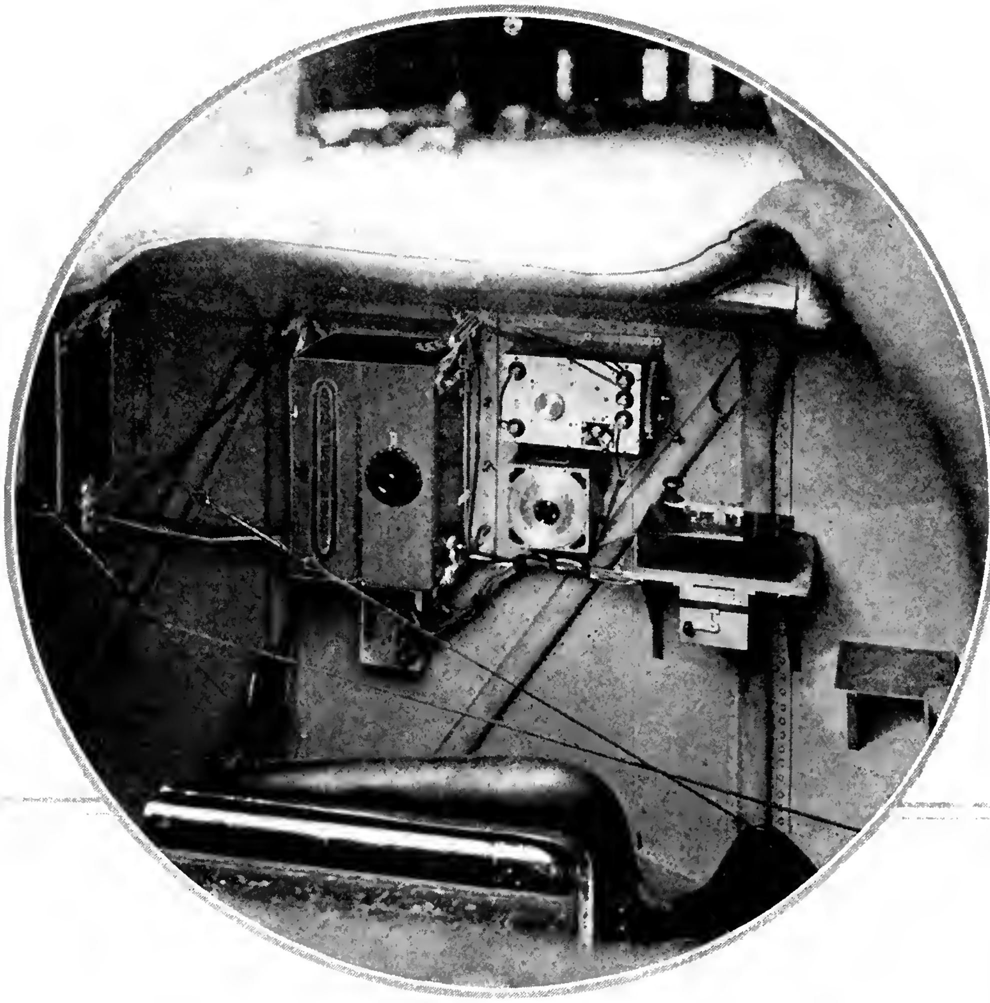
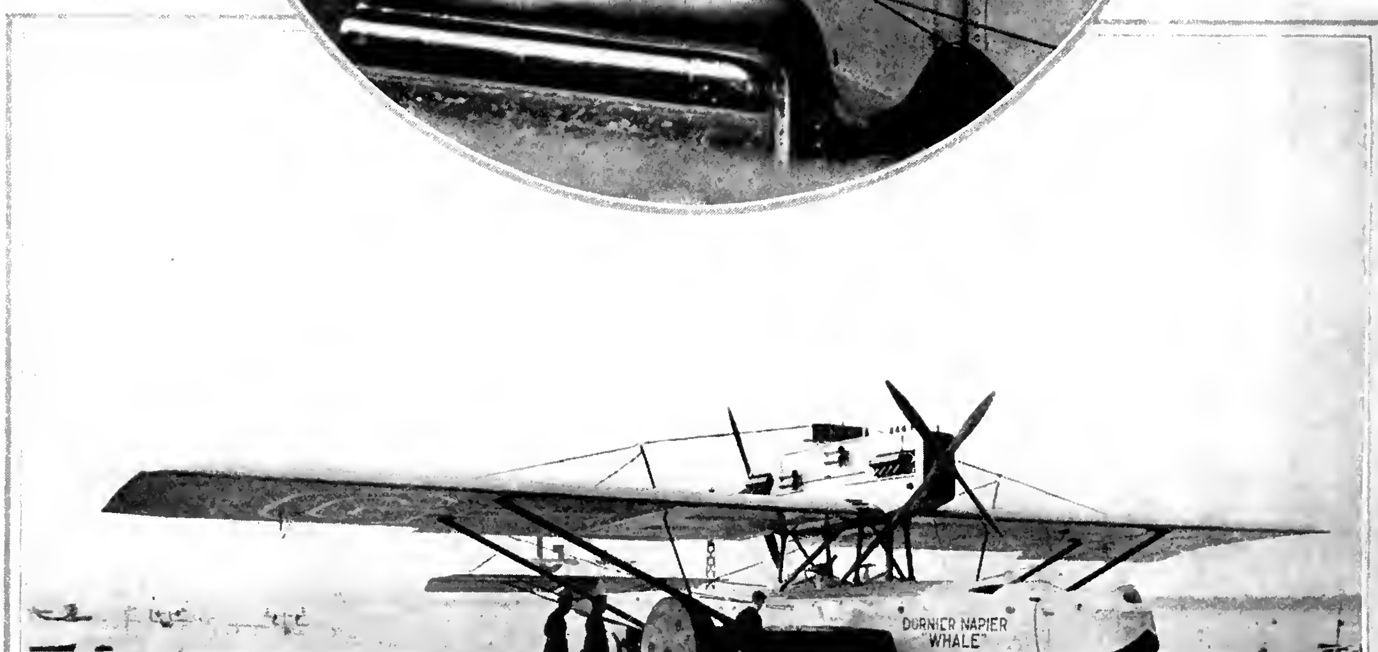




ONE AEROPLANE ON WHICH PROPER RADIO EQUIPMENT IS USED

THE Dornier-Napier Whale *of Captain F. T. Courtney, originally designed for a flight from London to the United States and return, has a 500-watt Marconi i.c.w. transmitter, using a 200-foot trailing antenna, an eight-tube r.f. amplifier ahead of a four-tube super-heterodyne, usable on commercial wavelengths, and a Marconi Bellini-Tosi direction finding antenna. The all-metal construction of the ship introduced special receiving problems which had to be solved. Note in the lower illustration part of the receiving antenna rising over the motor nascelle. The top photograph shows the radio controls. A wind-driven generator supplies power for the transmitter and charges special storage batteries. In case of a forced landing, a 40-foot mast can be erected, and the batteries are made to supply current to the motor generator which runs the main set. Few airships have been so completely equipped.*

What's the TROUBLE with *Aircraft* RADIO?

"Anonymous"

WHO is to blame for the fact that radio communication is not in general use in flying? Is it the radio engineer? Or can it be shown that the fault lies with the airman? Why did not Lindbergh and Chamberlin use radio? Who knows in what different manner the fatal flight of Nungesser and Coli might have ended had there been radio equipment aboard the *White Bird?* What of the *Golden Eagle* and the *Miss Doran?* Had these planes been equipped with radio would they have been lost? Probably not. There is reason to believe that even though forced down, so well would they have been followed by radio watchers on land that they might have been quickly found.

Commander Byrd made good use of radio at times in the flight that ended just short of Paris. But did he, schooled in the Navy and certainly aware of the possibilities for its use, make the most of his radio? One wonders. Why, when approaching the French coast, was he unable to learn the kind of weather awaiting him at Paris?

Hegenberger and Maitland were able to use their radio equipment but a small part of the time on their flight to Hawaii. Receiver trouble developed soon after leaving the Pacific Coast and it was not until they were within eight hundred miles of their goal that they were able to pick up signals again. The preparations for their flight were said to have been most thorough. The radio must surely have been thoroughly tested before the take-off, yet it failed them in time of need. They had planned to fly the course laid down by the radio beacon. To do this it was necessary to make continuous use of the radio receiver. Fortunately, when it failed, they were prepared to navigate by better-known means. Such was the thoroughness of Army Air Corps methods of preparation.

However, there has been no excuse for the lack of radio equipment of some sort on all of the trans-oceanic flights. The disturbance created by the ignition system which is almost always offered as an argument against it, is not an absolute bar to the use of radio. Ignition disturbance has no effect on the radio transmitter. Even a receiver could have been used to some extent in the presence of ignition noise. This is particularly true for a plane in which the cabin is located some little distance from the engine. Furthermore, the receiver could have been successfully used while passing over vessels at sea. The ship's transmitter under the circumstances of such short range would have pushed signals through the ignition disturbance at least sufficiently to have given information on weather and course.

RADIO MUST BE USED ON LONG FLIGHTS

IT WOULD be very interesting to know the reasoning which led to a decision to leave radio out of the plans for some of these flights. Undoubtedly the real reasons will not be given to the public. One strongly suspects that the lack of ability to handle radio on the part of the crew aboard each of these planes had a great deal to do with the matter. Of course, Lindbergh flew alone and could have made little use of any kind of radio equipment for that reason. Chamberlin knew little or nothing about radio, and it is likely that Levine, his passenger, knew less, inexperienced as he was in such matters. There is no telling how much Coli or Nungesser or Captain Hamilton, the British pilot, knew about the use of radio equipment.

None of these flights should have been undertaken without radio equipment, and a competent radio operator to handle it. On some of the flights one of the pilots acted as radio operator. This did not prove entirely satisfactory. Hegenberger, who flew with Maitland to Hawaii was fairly familiar with radio apparatus, but when his receivers (there were two aboard) became inoperative, he was unable to locate the source of trouble. It is doubtful if his knowledge of radio was sufficient to have enabled him to diagnose trouble as a trained radio operator could have done.

"ANONYMOUS" conceals the identity of an individual who is excellently qualified to write on the closely related problems of the airplane and radio. All we can say is that he is an expert who is well known in both fields. The author knows aviation—not from a swivel-chair vantage point, but from long flying experience and he knows radio from both the practical and distinctly technical angles. Too few radio men know anything about the problems that the aviator has to meet, and too few of the airplane folk know radio. Certainly there is a middle ground on which both may meet and this article is the first of several which will discuss this interesting field. The increasing fatality list of those attempting stupid and pointless trans-oceanic flights has demonstrated to almost the whole world that long-distance flying must be made safer and surer by every means at our command. And through radio will come much of this essential surety.

—THE EDITOR.

The desire to carry passengers on these flights has prevented a good radio operator being present. Miss Doran in the Pacific flight, and the Princess Lowenstein-Waltheim in the Atlantic flight of Captain Hamilton, and Philip Payne in *Old Glory* should have been replaced with radio operators, and, at least, radio receiving equipment. The fact that Brock and Schlee flew successfully to England without radio is no proof that radio was not needed. Redfern carried neither companion nor radio. He should not have been permitted to leave without both. And his companion should have been a good radio man.

Thus it is seen that some of these fliers were unmindful of the value of radio, and that others were unable to make the most of equipment which they had chosen to use.

Who is to blame that the value of radio has been so vastly underestimated in these flights? The question is important. Upon the correctness of the answer depends in a great measure the solution of one of the problems which at present confronts aviation.

WHY AVIATORS DON'T LIKE RADIO

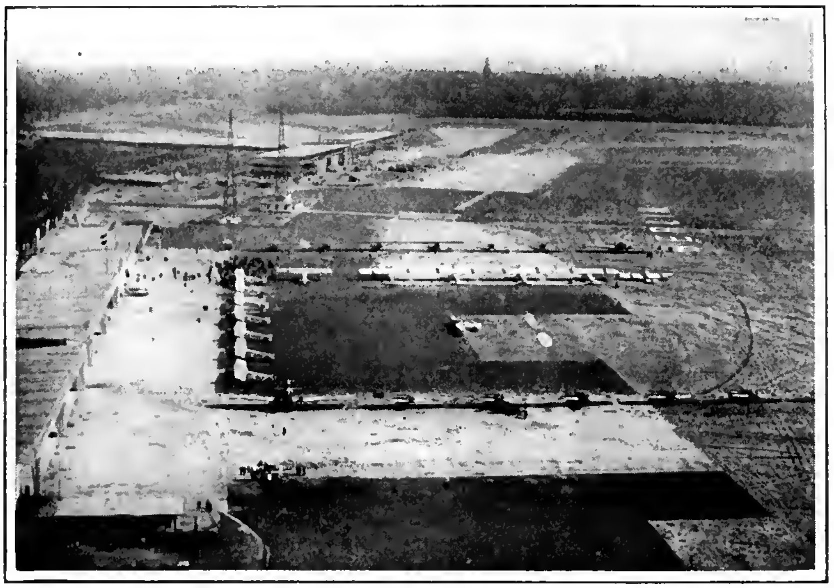
THERE have been many discussions on this subject between flying folk and men interested in radio. These discussions have usually been of a character to which the terms "heated," and sometimes "overheated," could justly be applied. Generally, the debates ended only in disagreement. The pilot and the engineer have not been brought to the same way of thinking. Not only have they disagreed as to who is to blame for the neglect of radio, but the pilot has strenuously objected times without number to the use of radio on his plane.

It is, of course, true that the military and naval flier has on occasion done much with the equipment designed for him by the radio engineer. Very often it was only because that flier was a member of an organization, in which obedience to an order is almost instinctive, that he made real use of his equipment. Often, it is true, he was pleased with the results of his effort and so converts to the cause of radio have gradually been made. They are, however, all too few. As for the commercial fliers, apparently little belief in the need for radio exists. One never hears of radio being used on their planes. Not even the Air Mail companies, or our own Post Office department, have seen fit to equip mail planes with even a receiver with which to receive information on the weather. The Air Mail for a time carried out experiments with radio but no practical or extensive use has yet been made of it.

What has the radio engineer to say for himself in the face of this obvious disdain on the part of the flier for radio? Were he a psychologist it might occur to him that the feeling of the pilots about the matter might be based on something inherent in the flying profession, or in the flier's training. Could he put himself in the place of the average war-trained flier he would remember that in the exciting days of the war the urge to fly was the strongest thing in his life. It was for that reason that he joined the Air Service instead of going into some other branch of the Service. That was why he worked as he never had worked before during preliminary training days at ground school. His eyes were always lifted to the men in the air. Everything but flying was subordinated. Nothing appealed to him either at ground school or at the flying school to which he was later ordered, as strongly as the airplane and flying. Motors, navigation, gunnery, photography, radio—all had to be learned; but he learned them, for if they were not learned he would not be taught to fly. But flying was the thing—devil take the rest. Whom did he worship the most, his gunnery instructor or his radio instructor, or any of the other ground instructors? None of these. He worshipped the man who taught him how to fly. Usually his flying instructor was the biggest man on his horizon. His radio instructor was usually a non-flier, "Keewee" being the term contemptuously applied to any ground officer of the Air Service. Usually this man made no impression, or a poor one at the most. He often stood between the cadet and his flying goal. For all who would fly must, in addition to many other things, learn to send and receive radio signals. If he could not pass the speed test he could not fly. That was the regulation, and many a good man was "shot down" by the elusive *da-dit-da* before he ever had a chance to learn to fly, and was accordingly sent away from flying school. At the advanced flying school came practice with actual transmitting and receiving of signals while in the air. This was usually even more boring than the practice in the code room. Generally, the radio failed to function. Anyhow, who wanted to sit in the rear cockpit of a ship which was being flown by someone else and fiddle with knobs and dials and try to pick up the faint signals bravely endeavoring to penetrate the noise and roar of the motor and the disturbance created by the ignition system?

Thus was built up all through the fliers' training, a genuine dislike for radio. As so many of the present fliers were war-trained, it is little to be wondered at that radio still has no appeal for them, and that the average flier has but little faith in it. A man was generally judged by his ability to handle his "ship." If he was clever with radio, providing he was able to fly, he was forgiven by his fellows.

Experienced fliers are among the most conservative of men, strange as that may seem. Little do they relish change or innovation. They have been flying through all kinds of weather and over all kinds of country without the use of radio. Why change now? Radio is just another thing to worry about. It probably won't work anyway, and the receivers in the helmet hurt your ears and you can't hear your motor. So poor old radio goes for consolation to the amateur who has been such a good friend all these years. All of which the radio engineer has probably not realized.



AT AN EUROPEAN AIRPORT

Elaborate means of radio communication are required by law on passenger air routes in some European countries. The two radio towers at the Tempelhof, Berlin, airport, are clearly discernable in this aerial picture

TECHNICAL PROBLEMS IN THE PLANE

IN ADDITION to the obstacles formed by the fliers' attitude, there have been many technical difficulties to overcome. Chief of these is the interference caused by the ignition system of the airplane engine. This has been a most serious obstacle and has not been completely overcome. It is true that, by completely shielding the ignition system, the troublesome noise can be reduced to a point where very satisfactory reception in an airplane is attained, but such shielding is difficult to install and even more difficult to maintain.

How is a motor shielded to reduce this interference? How does the ignition system of a motor produce interfering noises in a radio receiver?

The ignition system consists of a high- and low-tension side. The low-tension side consists of everything from the switches to the low-voltage side of the magneto in magneto ignition; and everything from the battery, including switches, generator, meters, voltage regulator, and distributors in the battery type of ignition. In the high-tension side we have everything from the high-tension side of the magneto in the first type of ignition, and from the distributors in the second type, down to the spark plugs. In these systems every make and break contact, as in voltage-regulator relay or distributor, produces a disturbance each time the circuit is opened or closed, which should be regular and very frequent, otherwise the pilot has something much more serious to worry about than the QRM from his ignition. The spark plug has not been mentioned in detail yet. Usually there are two of these little short-wave transmitters in each cylinder of the motor. The average airplane engine runs at speeds of from 1400 to 1800 revolutions per minute. This means that in an eight-cylinder, four-stroke-cycle engine, equipped with but one spark plug per cylinder, there will be at 1500 r.p.m., six thousand sparks per minute, or one hundred sparks per second. This produces a noise in a radio receiver which resembles the noise produced by a stream of shot on a loose tin roof. Oscillograms of this QRM indicate that part of the noise is due to induction, just as the "click" heard in a receiver when an electric light switch nearby is opened or closed, is caused by the change in current. The rest of the noise is produced by the oscillating spark in the gap in the spark plug itself. This is a true electro-magnetic disturbance of a definite wavelength. Apparently, then, it should be easy to reduce this interference by means of a short-wave trap; and so it should, but due to the difference in the constants of these small oscillating systems, the use of wave traps has not proved very satisfactory. Up to the present time the most satisfactory method of freeing the receiver of this annoying disturbance is by shielding the whole ignition system.

Completely shielding the ignition system requires that every wire and electric device about the whole plane which carries current be covered with an electric shield. This is usually a braided copper sleeve, slipped over the wire, or a metal container for such devices as regulators, distributors, and switches. This shield must be connected to the ground of the plane. The ground of an airplane consists of all the metallic parts, such as the motor, brace wires, cables and fittings. If you have a few inches of frayed shielding it will cause all the noise to come right back to the receiver. Shielding produces a hazard, the danger of which may be readily realized. If there is faulty insulation anywhere in the system, the vital ignition current will jump through to the ground and out goes part or all of the ignition, depending upon where the break occurs, and, it is needless to say, down comes the plane, to make as safe a landing as the pilot can. It would appear that the solution of this problem is to use nothing but the best of insulation. This is more difficult than it sounds. When a high-tension lead is shielded a corona discharge takes place through the insulation to the grounded shield. The corona produces a chemical change in insulation and it no longer insulates, the engine ceases to "percolate," and the aviator to "aviate."

Now, the pilot knows all this and his feeling for radio has increased in warmth, but not in a direction the radio engineer would like to see. The old feud still exists. The pilot says the engineer loads his plane with hazardous equipment, and the engineer says the pilot is too fussy about what happens to him.

THE FUTURE—WORK FOR ALL

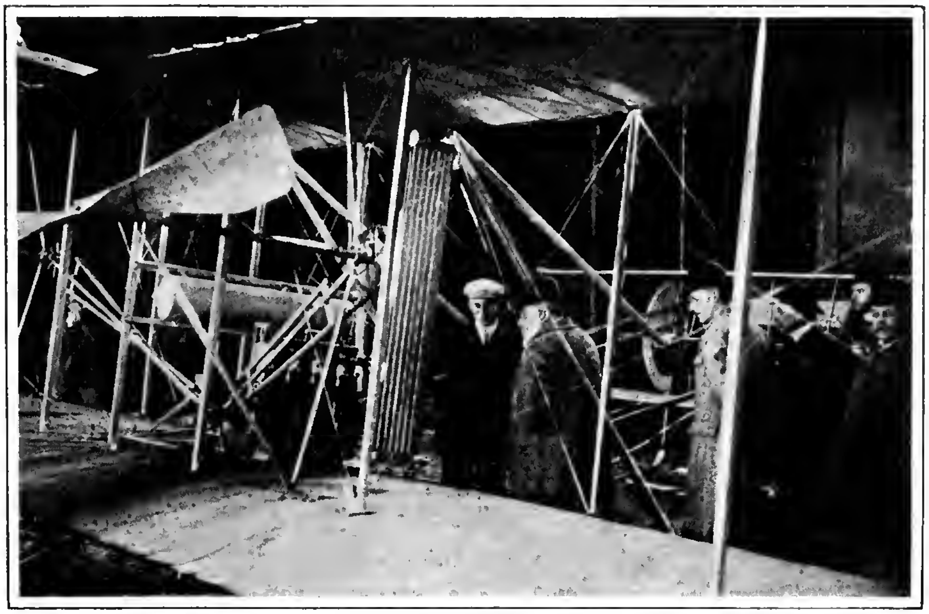
AND so it stands, until the necessity for radio communication between the air and the ground is made apparent to all concerned with flying. That this necessity exists there is no doubt in the minds of many besides the radio engineer, but now the demand for radio is insufficient to induce very much research on these problems.

Such problems can be and are, of course, being worked on in laboratories. However, there is a definite limit to what can be done in a laboratory on the ground. The conditions existing in a plane—the vibration, the noise of wind and motor and ignition, cannot be adequately reproduced in a laboratory; nor can engineers conceive of the conditions except by repeatedly experiencing them in test flights. What I am driving at is this. There should be a laboratory in which the ground and air work is connected and closely related. The engineer should be placed in a position not only to see the problem as the flier sees it, but both flier and engineer should be encouraged to work together. Confidence in the ability and work of the engineer will then come to the flier. Better radio sets will be built, and let us hope that they will be built as a part of the plane and not tacked on—an afterthought. Airplane designers will make provisions for these sets and the power required to operate them. Then, and then only, will pilots want radio, and make good use of what they get.

Before passenger carrying air lines are permitted to operate either in this country or on trans-oceanic flights, this matter of radio should be included in the regulations covering the safety and inspection of the planes. The Department of Commerce should make regulations to fit the needs of the moment. Because commercial aviation is in its growing stage, the regulations should be fairly elastic. But before passengers are permitted to risk their lives, regulations regarding suitable radio equipment and personnel to operate it should be laid down. These should cover all long flights, whether over water or land. By long flights is meant anything over 500 miles.

The radio beacon has had but a very short test outside of the Air Corps experimental tests. But it is apparent even on such short trial that regular flights over long distances of water should not be thought of without contemplating the use of such a beacon. For regular passenger routes over land, the beacon should be depended upon at least for night flying. However, the story of this beacon and its possibilities is too long to include here.

As in so many other things, practice and test are essential to development, and this is no less true of radio on aircraft. The more use made of it the more experience gained. Radio has a very definite and important place in aviation, and it is only to be regretted that use has not been made of it on all transatlantic and transpacific flights. It is likely that the unsuccessful flights would not have had so tragic an ending, had radio played the part that it must come to play in the future of aviation.



WHEN RADIO WAS NO MORE THAN A DREAM

King Edward VII receives a lesson in aeronautics at the hands of Wilbur Wright. Planes of ten years hence, equipped with powerful radio transmitters and receivers, will probably be as much in advance of present day design as are the planes of to-day as compared to this fragile looking craft of Wright's

THE MARCH OF RADIO

NEWS AND INTERPRETATION OF CURRENT RADIO EVENTS

What is the Matter With Radio Advertising?

FROM time to time, trade associations and better business bureaus formulate codes of ethics for the guidance of writers of radio advertisements. These codes aim to curb exaggerated claims as to long distance reception, quality of tone and other excesses so freely used in radio announcements.

The beautifully worded hyperboles, characterizing modern advertising, have received such spirited attacks recently, that we may look forward to saner and more informative advertising copy. So great is public interest that a book on this subject, *Your Money's Worth*, is threatening to become a best seller. Radio advertising receives its share of scathing criticism from these authors who leave no one unscathed.

Imagination—at least—is lacking when an entire industry depends upon a few standardized general appeals to sell its products to the public. If the advertising is to be believed, all receiving sets possess unbelievable selectivity, marvelous sensitiveness and magnificent tone quality, regardless of price. Rarely does any enlightening information appear in a radio advertisement by which a prospective purchaser may judge the superiority of one receiver over another. Magical phrases are concocted, playing upon the ignorance of the non-technical, to suggest fancied engineering superiority. The uninitiate must be guided by such medicine-man hokum as "utilizing the new intra-paralytic principle of interference submergence," "delightful tone quality obtained with the mastertonic sliding trombone transformers," or "securing magical selectivity by the matched prismatic quartz inductances."

Aside from such senseless and meaningless technical appeals, most radio advertising confines itself to generalized boasts. The same charge may be made not only against the advertising of radio sets, but that of automobiles, iceless refrigerators, and any mechanical or electrical product. The readers of RADIO BROADCAST frequently demand that some comparative technical tests be made to form a basis of judging the relative qualities of sets.

We have given considerable thought to this problem and we would unhesitatingly publish comparative information, could we discover a method of making comparative tests which would not involve the human element and which would be a real test of merit, taking into consideration all of the factors which contribute to the desirability of a radio receiver.

Take, for example, the factor of gain in the radio-frequency amplifier. We may impress a standard modulated signal from an oscillator upon a receiver and measure the resultant fluctuations in plate current of the detector circuit, thus giving an evaluation in the over-all gain of the radio-frequency amplifier. We may also obtain a selectivity curve for each receiver which gives a fair index to that quality. Furthermore, given an adjustable audio frequency oscillator, with which to modulate the incoming test signal, we can determine with a fair degree of accuracy the tonal range and characteristics of the audio frequency amplifier. These three tests would give an index to the three major qualities of a receiving set, namely its sensitiveness, selectivity and fidelity.

Unfortunately, carrying out such tests is far from simple. Most receivers have a gain control in the radio-frequency amplifier system which greatly complicates laboratory tests as a means of comparing receiving sets. Testing a five-tube receiver, the gain might well be adjusted as high as possible, so that it would show maximum amplification per stage. However, when so adjusted, it is likely to show more than normal distortion in its audio-frequency amplifier. On the other hand, more conservative adjustment of the radio frequency gain would handicap its sensitivity rating, although it might improve its showing with respect to tone quality. Five engineers could test a number of receivers and secure entirely different results.

If a sufficient number of test conditions are fixed so that the element of adjustment would be minimized, some receiving sets would be unduly handicapped by the test conditions in one respect or another. Consequently, laboratory comparisons, with the test methods we now have available, do not, for the present at least, seem to offer a means of supplanting generalities in radio advertising. But we may look forward to developments in this direction, as our experience with laboratory measurements of sets increases.

Another possible method of making advertising copy more informative is to give a few outstanding facts regarding a receiver, such as number of tubes, number of controls, and other specifications. But the number of tubes in a receiver is hardly a guide to its efficiency. There are ten-tube receivers which give no better results than other six-tube sets. The writer, for instance, has a four-tube receiving set with a 210 tube in the output, which he would confidently enter in any contest for sensitiveness, selectivity and tone quality. But, as a commercial product, it is practically useless. It takes an expert to tune the set and the filters, chokes and by-pass condensers, which are a part of it, would not fit into two set cabinets of normal dimensions. So the listing of specifications is hardly a panacea for indefiniteness in radio advertising.

What remains to assist the honest advertiser in preparing truly informative copy? If we rule out bunk, generalities and specifications, of what may the set manufacturer speak without being frowned upon? Only three general points suggest themselves—outward appearance, price, and reputation, the same factors which the automobile industry has found successful as selling appeals.

Another possibility is to consider some one, simple, technical detail —the thickness of shielding, the strength and rigidity of the chassis, or the accuracy with which tuning circuits are matched—as an indication of the skill and care displayed throughout the whole receiver. Such

SENATORE MARCONI TESTING BEAM TRANSMISSION

The inter-continental beam transmitters of the Marconi Company, now in operation, resulted from a long series of tests. This illustration shows Senatore Marconi testing a short-wave transmitter from a boat on a lake at Livorno, Italy, in 1916 a policy has advantages, being informative, specific, interesting, and, above all, based on facts instead of on generalities.

Prestige and reputation are the product of years of successful manufacture, and, consequently, production figures and value of sets sold by a manufacturer are a foundation of fact by which an old established manufacturer may distinguish himself from others.

A method, which has been successful in other fields, is to "sell" the engineer who designs the product. Certain companies have engineering and research staffs of acknowledged competence and reputation, whose designs are worthy of great public confidence.

A thorough and detailed study of the radio receiver and those who build it, on the part of the advertising copy writer, is the best preparation for writing advertising which features facts rather than fancy.

Action from the Radio Commission

THE Federal Radio Commission has begun suit against station KWKH, which it charges with the misdeed of using three times the power permitted by its license, for forty successive days. As a result, KWKH is liable to fines aggregating $20,000 at the rate of $500 a violation. If the Commission has a good case and wins out in the courts, it will certainly gain wide respect. The numerous violations of the Commission's regulation as to maintenance of assigned frequencies are likewise subject to fines of five hundred dollars a day. Certain stations frequently wander as much as ten kilocycles from their channels. The former WSOM, for example, was found at different times, within eight days, 24.8, 23.9, 12.5 and 16.1 kc. from its assigned channel.

The Commission, in a public statement, threatened to eliminate about twenty-five of the most flagrant wavelength wobblers but, as usual, grew softhearted in the end and gave them additional grace. Heterodyning is far too widespread to make listening to any but relatively nearby stations any very great pleasure.

The Commission's claim, however, that practically all heterodyning is due to frequency wobbling is not entirely founded on fact. There are altogether too many assignments of stations to the same frequency whose carrier waves are bound to create interference. The clearest broadcasting channels as a matter of fact, are at this time the higher frequencies between 1250 and 1500 kc. On these frequencies, we find mostly low-powered stations which do not interfere with each other.

The numerous hearings held in Washington, upon demand of some of the stations now assigned to these superior channels, are based on the fallacious superstition that the lower frequencies are the most desirable. At one time, when the lower frequencies were reserved for the better stations, while as many as twenty and thirty low- and medium-powered stations were huddled on the lower end of the broadcast band, the ambition to leave the higher frequencies was justified. Although conditions have changed, prejudice against the higher frequencies persists.

Mr. May, seeking a lower frequency for his advertising station, KMA, for example, testified before the Commission that it was a well known fact among radio engineers that the channels below 350 meters were "practically no good for broadcasting purposes," although, as an expert brought out, KDKA, KOA, WBBM, WOK, and numerous other stations, occupying these allegedly unsatisfactory frequencies, have built up nationwide audiences.

The claim that stations do not "get out" on the very high frequencies is made because the public is not accustomed to looking for its programs on these channels. There are too few worthwhile stations using them. Why not assign a few really good stations to the higher frequencies, so as to distribute the public's attention throughout the broadcast band?

Prospects for Patent Pooling

THE Radio Manufacturers' Association is looking into the matter of patent pooling and seeking to inaugurate a system of cross-licensing in the same manner that the automobile industry accomplished this through the National Automobile Chamber of Commerce. There is one great difference, however, in the radio situation and that lies in the fact that a single group has already concentrated most of the patents in its own hands and consequently no one has much to offer it for bargaining purposes.

We learn of the formation of a Radio Protective Association in Chicago with the object of battling against "radio monopoly" which, say the sponsors for the new organization, "will be taken to Congress, to the Department of Justice and to the Courts."

No matter how much outsiders may protest, there is no question about the fact that the Radio Corporation of America has in its hands most of the essential patents to the manufacture of the radio receiver and it is not at the mercy of any outside group. A patent is an entirely legal monopoly created by legislation in accordance with provisions in the Constitution of the United States. Furthermore, the Radio Corporation is extending licenses to competing companies on what appears to be a fair basis. A rather large minimum royalty guarantee is required of the set

TESTING "BEAM" TRANSMISSION IN 1916

Senatore Marconi's principal assistant in the development of the short-wave "beam" is C. S. Franklin who is here shown on the lake at Livorno, Italy, testing a short-wave receiver with transmissions from the parabolic reflector shown in the accompanying photograph. (*Right*) The "beam" system of short-wave communication has already satisfactorily linked England with Canada, India, Australia and South America, and the New York-London link will shortly be opened. C. S. Franklin, Senatore Marconi's chief research engineer, famed for his work in developing the "beam" method is shown here operating the beam transmitter with its parabolic reflector from the shore of the lake at Livorno maker; said to be $100,000 a year, which effectively throttles the small producer. Under the patent law, a patent holder has full rights to deny the issuance of licenses to anyone he chooses and, therefore, unless the legal attitude of the patent law is completely reversed, the R.C.A. is entirely within its rights.

The object of the patent law is to assure that inventors are encouraged and properly rewarded. Times have changed and invention is much less a product of individual genius than it is the marshalling of many minds, research facilities and laboratory experience. The reward, instead of going to individual inventors and their backers, now goes to large corporations which make it possible for the complex invention of this day to be made.

The major purpose of the patent is thus fulfilled, both under modern conditions and under those which obtained in the past. We may add a new interpretation in that the patent monopoly shall not be used in restraint of competition and compel patent holders to extend licenses to all those willing to pay just license fees. This plan is followed in Canada. But such a course in this country would be a new situation, a reversal of precedents. It would require new legislation. A possible and, indeed, probable solution of the present radio situation is that the Radio Corporation will extend licenses to smaller concerns on a smaller minimum guarantee, but upon a higher percentage of royalties than it extends to those guaranteeing $100,000 a year.

The radio industry is suffering from the existence of too many incompetent small manufacturers which are bound, in time, to be eliminated by natural economic processes. Hastening their passing by patent pressure is a painful but effective method which, however, reacts unfavorably against those exerting it. But, whatever the considerations animating the policy, the legality of the R. C. A.'s present patent course does not appear to be open to question.

Is Direct Advertising a Service?

A NUMBER of the direct advertising stations have appeared before the Commission, claiming great losses of audience and service range because of their high frequency assignments. Mr. May, speaking for KMA, recently spent three and a half hours on the stand, a record for a single witness before the Commission to date, to prove himself the most popular announcer in the United States and his station the greatest service to humanity of any station in the corn belt. 450,000 people wrote him during the first seven months of the year, a larger number than practically any but one or two key chain stations can claim.

On the other hand, every questionnaire, not specially circulated by the stations themselves or by farm papers, indicate the wholehearted public condemnation of direct advertising by radio. RADIO BROADCAST's questionnaire, in which 10,886 expressions of approval and disapproval were made, found KFNF the most unpopular broadcasting station in the country, 18.8 per cent. of the audience demanding its removal. Considering the fact that those who answered this questionnaire were distributed all over the United States, this seems to represent about 100 per cent. of the listeners within the annoyance range of this station. WJAZ won the disapproval of 15 per cent. of the listeners, most of this vote being a spite vote because WJAZ upset the Radio Act of 1912, rather than because of present day program unpopularity; while KMA came out third with condemnation from 13 per cent. of those answering.

SIGNORA MARCONI

The illustration shows the wife of the noted Italian with the radio receiver fitted up for her use in their palace in Rome. Signora Marconi was formerly the Countess Maria Cristina Bezzi Scali

However, 450,000 people do not write a station for nothing. There is no question but that there is a field for the local broadcasting station in the service of the small local merchant. The public, however, resents being sold harness, glue, tires, and laundry service in the guise of entertainment. The mail order buyer in the rural district is about the only group which responds. Evidently, in spite of the harsh dislike which we have of the direct advertising stations, we must confess that they have an audience and, as such, deserve consideration, but only in proportion to the importance of that audience.

Radio Engineering To-day

RALPH H. LANGLEY of the Crosley Company writes us at some length in comment on D. A. Johnson's criticism of radio engineers, which we headed, some months ago, "There Are no Radio Engineers." Mr. Langley points out the excellent progress made in building up technical knowledge through the work of the Institute of Radio Engineers and describes what is being done in the way of standardizing symbols and terms and measurements. Mr. Langley says:

> No branch of engineering can become an exact science, until its methods of measurement have been developed and standardized. But the progress which radio science has made in this respect during the past three years is remarkable and gratifying. It is now possible to predict with reasonable accuracy the field strength which will be delivered at any receiving point by any transmitter. The characteristics of the transmitted wave are accurately measurable. The field strength necessary to produce a given output voltage on any receiver can be determined from the measured characteristics of the receiver and of the antenna. The ability of the receiver to exclude undesired signals and its acoustic performance, as well as that of the loud speaker, are also subject to precise measurement. Transmitters have been metered and their characteristics known for many years. Thus every part of the broadcast mechanism has yielded to precise determination.

As a mushroom and a boom industry, radio was certainly unscientific. But progress has been made. An inspection of the twenty leading manufacturers' plants would quickly convince Mr. Johnson that the design and manufacture of the radio product is a precision task of the highest order, performed to the most rigid standards.

News of the Patent Field

A RECENT licensee under Radio Corporation patents, and probably the most important from the standpoint of royalties to be paid, is the Atwater Kent Manufacturing Company. This brings the total number of licensees to twenty-three, including some of the principal manufacturers of the industry. Within the pale are a number of companies who must produce considerably more sets and do a much larger share of the total radio business this year than last if they are to earn their royalty guarantee. On the other hand, there are still one or two large manufacturers outside the pale who have not yet indicated any intention or desire to obtain a license. No one knows yet just what their course will be. One possibility is an attempt to build receiving sets completely evading infringement of Radio Corporation patents. There are engineers who contend that this is not impossible, although really more than this result must be achieved. The sets must not only avoid patent difficulties, but must be as inexpensive to manufacture and as efficient so far as results are concerned as receiving sets made under Radio Corporation licenses. That is no small problem. ♦ ♦ ♦ Heins and Bolet accepted a consent decree in a case brought by the Westinghouse Company under Armstrong, Fessenden and Vreeland patents. ♦ ♦ ♦ The decree against the Claremont Machine Company, secured by the C. F. Mueller Company, for a machine for folding noodles was sustained. ♦ ♦ ♦ A decision rendered in the U. S. Circuit Court at Philadelphia upheld the Lektophone patent 1,271,529, declaring that Lumière's invention does not anticipate Hopkins and that the defendants' device, employing a flexible rubber liaison member, held in place by a rigid frame and covered by an ornamental hood, is an infringing device. ✝ ✝ ✝ The following sets are now licensed under R. C. A. patents: Zenith, Splitdorf, Stromberg-Carlson, Bosch, Crosley, All-American, Freed-Eisemann, Howard, King, Fada, Federal, Murdock, Freshman, Amrad, Steinite, Gilfillan, Day-Fan, Bremer-Tully, Atwater Kent, Federal-Brandes, A. H. Grebe, Pfansteihl and United States Electric (Apex, Case, Slagle, Workrite, and Sentinel).

The Month In Radio

THE evolution of marine radio communication was recently described by T. M. Stevens, General Superintendent of the Marine Department of the R. C. A. Broadcasting considerably hastened the adoption of a continuous wave transmission on a new series of channels, greatly mitigating interference with broadcasting. In 1922, there were twelve spark stations, using principally the waves of 450 and 600 meters, along the coast from Cape May to Bar Harbor. Both on account of congestion and because of the protests of broadcast listeners, seven of these twenty spark stations are now closed down and the remainder have been replaced by more efficient vacuum tube transmitters. Three hundred ship spark transmitters have also been converted into modified tube transmitters so that they no longer interfere with broadcasting programs.

A few small independent companies are still compelled to use spark transmitters, while many foreign ships with spark transmitters are still working in a manner to interfere with broadcast listening. It is understood that the independent radio companies, operating spark stations, are experiencing difficulty in obtaining properly licensed vacuum tube transmitting equipment. The foreign ship interference will probably be tackled by the International Conference at Washington. Under the circumstances, spark interference with radio programs is likely to be a thing of the past within two or three years, and, possibly sixty to eighty per cent. of the interference is already eliminated. ✝ ✝ ✝ Things have changed for ship operators since the writer pounded the key some twelve years ago. In those days, the emolument was sixteen dollars a month and now it averages a hundred. Considering that the work is generally pleasant and practically all expenses are paid, the radio operator's lot is one to be envied, when compared with that of the clerk with his dull routine and the artisan with his arduous and confining tasks. The radio operator's principal complaint, as we have gathered from interviewing a few, is that once senior operator on a desirable ship, contact with superiors is so limited that the opportunities for advancement are practically nil. Nevertheless, most of the executives of commercial radio companies were once "brass pounders." There is no employment more romantic, responsible and broadening than that of radio operating for the young enthusiast, seeking a career of adventure and promise. ✝ ✝ ✝ The listeners of KFWO, an efficient little 250-watter at Avalon, owned by Lawrence Mott of short-wave fame, have been receiving play-by-play reports of the games played in Chicago by the Cubs. Why this station should go so far afield to present its listeners with this feature is explained by the fact that Mr. William Wrigley, Jr., is so interested in the doings of the Cubs that, while he summered at Catalina, play-by-play reports were sent him by telegraph. Mr. Mott suggested to Mr. Wrigley that these play-by-play reports be diverted to KFWO and then broadcast. Colonel Green has a rival! ✝ ✝ ✝ The Egyptian government plans to erect a broadcasting station. There are already three thousand sets in operation which, to receive the principal European programs, must be highly sensitive. Eighty-five per cent. of the population of Egypt lives within 150 miles of Cairo and hence a single station can greatly stimulate a market which American manufacturers may do their share in supplying. ✝ ✝ ✝ Any listeners, hearing broadcasting station SOL, have been victims of a slight error which is excusable, due to the distance involved. They are doubtless hearing station XOL, operated by the Tientsin Government in China. Its power is 500 watts and it uses a wavelength of 480 meters. A special license is required from the Chinese government to act as an importer of radio sets and one American Company has taken advantage of this privilege by conforming with the regulation. ✝ ✝ ✝ A beam station, another link in the Marconi worldwide service, has recently been opened for commercial use at Johannesburg, South Africa. ✝ ✝ ✝ WLW, using its short wavelength, supplied an Australasian program recently, enjoyed by listeners of 2 FC, Sydney, Australia, and 1 YZ, Auckland, New Zealand. America is the largest exporter of broadcasting programs in the world. ✝ ✝ ✝ The interference problems of Australia are causing distressing controversy. A new 15-kw. broadcaster is to open at Wellington on 420 meters. What worries the Australians is if Sydney on 440 and Adelaide on 400 meters will not suffer serious interference. Cautious fellows these Australians! ✝ ✝ ✝ JOAK, Tokio, already frequently heard on the Pacific Coast on its thousand watts, is to go on 40,000 watts, which should certainly bring it within range of a good part of the United States during early morning, midwinter hours. It won't be long now before a few American broadcasters will have to close down because of foreign interference. ✝ ✝ ✝ There are 206,334 listeners in Australia, duly licensed and paying license fees. ✝ ✝ ✝ The British Broadcasting Corporation issued a statement recently that it had discovered the advantages of rating stations in terms of kilocycles rather than meters. The advantages of the kilocycle rating have become obvious to the American listener and have been used in this magazine since August, 1925. In talking to the members of the Federal Radio Commission, we have been pleased to notice that, though at the first the word "wavelength" was rather frequently in the conversation, it did not take long for the Commission to adopt "frequency" as the only practical term to designate the radiation of a broadcasting station.

WHO REPRESENTS THE LISTENER?

OUR editorial some months ago, entitled "Where Are the Listeners' Organizations?" has brought forward a good deal of correspondence from ambitious would-be executive secretaries, disillusioned leaders who have attempted to form local organizations and readers requesting RADIO BROADCAST to sponsor such an organization. A number have expressed the opinion that listener organizations would be more of a nuisance than an aid to broadcasting. W. W. Waltz, for example, writes that, although in his area WJZ, WEAF, WGY and KDKA are the obvious program leaders, there is a certain advertising station which any Philadelphia listener will recognize, "whose sole idea is to sell every ampere that can be forced off of their antenna. There is no use in trying to describe the junk they broadcast. Everything from near-dirty stories to grand opera selections by the most horrible orchestras in existence. One complaint after another has been made, officially and otherwise, in regard to the manner of operation of this station. Their equipment is modern, but it is adjusted to give a wave like a spark set. And believe it or not—is the most popular station in the city!" The conclusion to be drawn is that no organization can be truly representative of listener tastes.

HOW LONG, OH LORD, HOW LONG?

WE TAKE a special delight in reminding the authors of publicity statements boasting of revolutionary inventions, of the prior discovery and origin of these same inventions, in the hope that more care and conservatism may be displayed, as time goes on, by the publicity romance writers. We note that Mr. C. Francis Jenkins, who has spent many years in research in telephotography, announces the development of radio guiding channels to keep aviators on a definite course and of a receiving set giving visual indication of deviation from the guiding course. The former has already been widely used experimentally, especially by the Navy Department, and is a well known invention. The visual indicator is not so widely used, although its development in direction-finding apparatus was recorded in these columns several months ago. About twenty-five ships on the Great Lakes are already equipped with the visual direction indicator.

FADING TESTS AT MELBOURNE, AUSTRALIA

Station 3 LO at Melbourne has made a gift to the University of Melbourne for research on the causes of radio fading. R. O. Cherry, working under Professor Laby of the University, is here seen calibrating the portable receiver for measuring signal intensities. The set is carried in an automobile

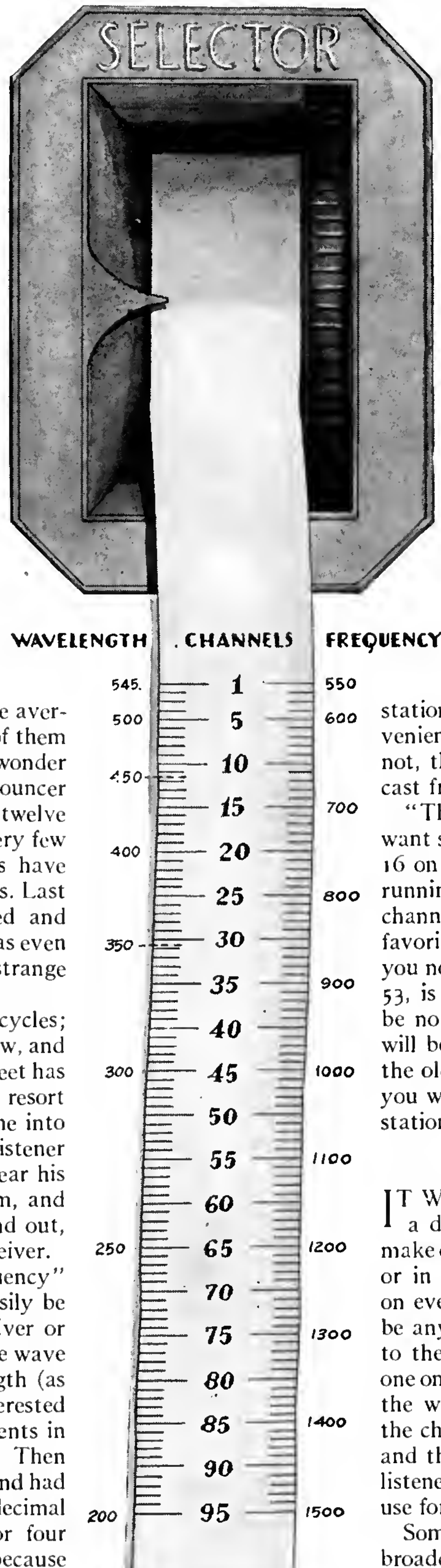
METERS, KILOCYCLES, OR "CHANNEL NUMBERS"?

By RALPH H. LANGLEY

Crosley Radio Corporation

ONE of the most practical and interesting suggestions tending to simplification of radio as far as the non-technical user of radio receivers is concerned is that of Mr. Langley, which he so interestingly discusses in this article. The use of radio receivers will become more and more widespread as the receiver becomes more simple to operate. Great strides in this direction have been made, what with single-control operation and direct light-socket powering of sets. But still, thousands of listeners who don't even know the difference between alternating and direct current, try to solve the dual mysteries of wavelengths and kilocycles which confront them in their local newspaper radio programs and on the dials of their receiving sets. Mr. Langley rightly asks, why should they bother with this wavelength-kilocycle terminology? Frequency calculations in kilocycles—or meters if you belong to that school—are important and necessary for the engineer and the technician, but the listener has no earthly concern for them.

A committee of the National Electrical Manufacturers' Association has been appointed to consider Mr. Langley's suggestion and to take appropriate action. That committee consists of R. H. Langley, chairman; L. W. Chubb, George Lewis, M. C. Rypinski, J. M. Skinner, R. H. Manson, and A. E. Waller. —THE EDITOR.



PERHAPS there is no such thing as "the average broadcast listener." But millions of them come pretty close to the average, and I wonder just what they think when they hear the announcer say that he is broadcasting "on a frequency of twelve hundred and sixty kilocycles." In all but a very few cases, I venture to say that their thoughts have nothing to do with the meaning of these words. Last year it was a "wavelength of two hundred and ninety one and one tenth meters" and that was even worse. Why so many numbers and so many strange words?

Wavelength in meters, and frequency in kilocycles; related to each other by some mathematical law, and yet not related to anything the man in the street has ever heard of. Even the radio engineer must resort to a tabulation or a slide rule to translate one into the other, and yet each and every broadcast listener is expected to use them when he wants to hear his favorite stations. The newspapers print them, and you are expected to know, or somehow to find out, where they all come on the dials of your receiver.

The change from "wavelength" to "frequency" was, of course, a very logical one. It can easily be demonstrated that the current in your receiver or in the distant transmitter has a frequency. The wave out in space is the thing that has a wavelength (as well as a frequency). Primarily we are not interested in the wavelength out in space—but the currents in the receiver—which the listener can hear. Then again, the wavelength listings were irregular and had to be given with at least four figures and a decimal point. The frequencies are given in three or four figures, and the last one is always a zero, because the frequencies are spaced in multiples of ten. But they start at 550 and stop at 1500, and the system is still far from being simple for Mr. Average Listener to understand.

Some manufacturers have tried to put these strange numbers on the dial of the receiver when it was built. Then if you knew and could remember the wavelength or the frequency of the station you wanted to get, you could set the receiver to that point, and there was the station. There were a lot of mechanical difficulties in doing this, but more than anything else, it was the complexity of the numbers themselves that kept the conventional "zero to one hundred" dial on the sets. Here, of course, is another set of numbers, that must be read from a dial and related to the wavelength or the frequency or the call letters of the stations. It is no secret that the average listener does not know to whom he is listening, or how to find a particular station, except in the case of a very few that are near to him. The others are too hard to find, and many that he could hear and hear well, he does not bother with.

It would be possible to record the locations of our homes and places of business by their latitude and longitude. Your home address, for example might be given as "north 43° 28′ 37.42″, east 76° 18′ 58.13″." That would be just about as easy and just about as logical and just about as technically correct as wavelength in meters or frequency in kilocycles for a broadcasting station. But our houses and our offices are conveniently numbered and so are our telephones. Why not, then, use plain simple numbers for the broadcast frequencies and wavelengths?

"This is station XYZ on Channel 16." When you want station XYZ again, you will turn to the number 16 on the dial. There will be numbers on the dial running from 1 to 96, representing the 96 broadcast channels. You will soon remember the fact that your favorite stations are at 16, 23, 38, 67, and 84. If you notice in the paper that station PQR, on channel 53, is giving an unusually good program, there will be no difficulty about finding it. And the numbers will be the same on all receivers. When you trade in the old set, or when you go over to John's house, you will not be at a loss to know where to find the stations.

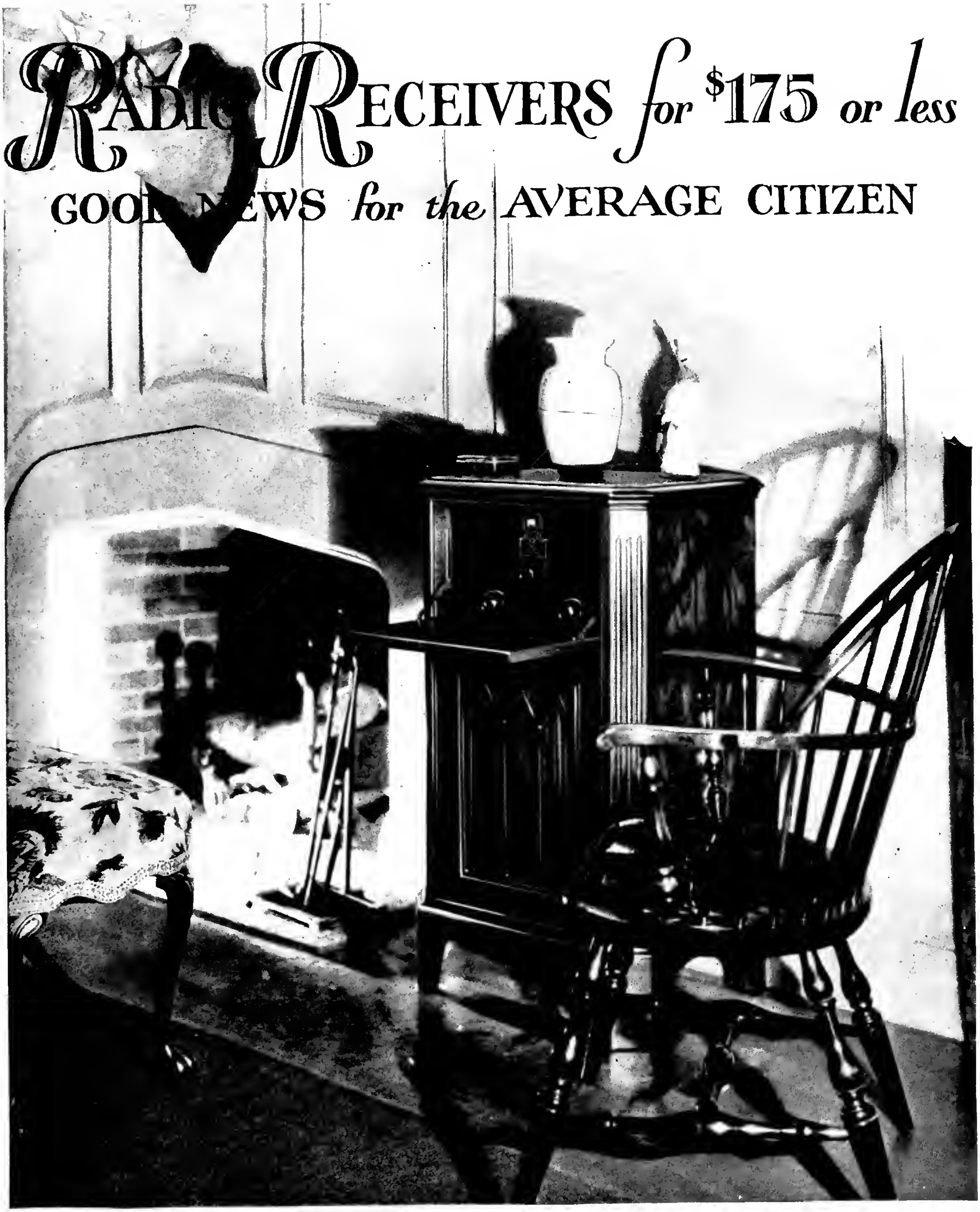
A DIAL WITH NINETY-SIX NUMBERS

IT WILL be more desirable, of course, to arrange a dial with these simple numbers, than it is to make one that reads in frequencies from 550 to 1500, or in wavelengths from 199.9 to 545.1 with tenths on every one of the 96 of them. And there will not be any unnecessary "meters" or "kilocycles" tied to them. They will just be plain numbers like the one on your front door. You can have a table showing the wavelengths and frequencies corresponding to the channel numbers if you want it; the newspapers and the magazines will print them. But the average listener will not want any such list; he will have no use for it.

Some day the range of frequencies allotted to broadcasting may be increased. When this is done, it is almost certain to be in the direction of the short waves. Then our series of 96 numbers will have to be continued, from 96 up. By starting the number series at the long-wave or low-frequency end, we shall leave room for expansion into the short waves, and we shall also have the smaller numbers for those channels now assigned to the larger and more widely known stations.

RADIO RECEIVERS *for* $175 *or less*

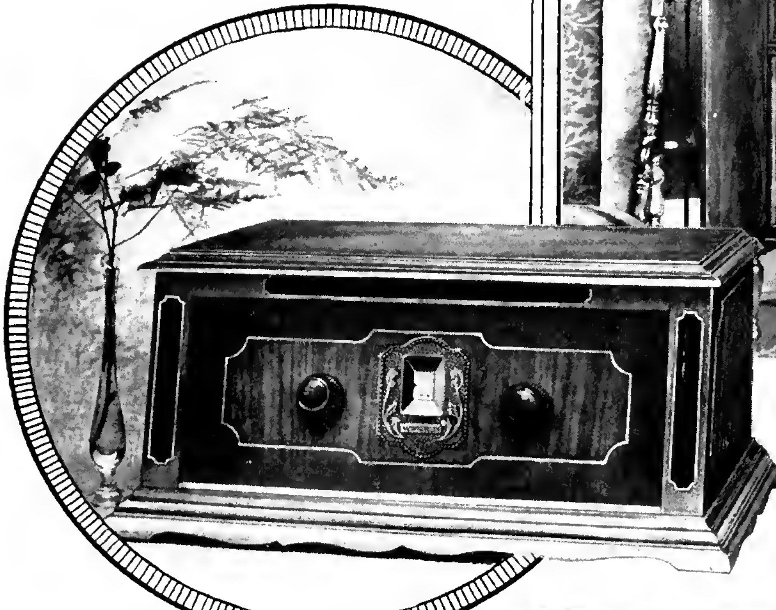
GOOD NEWS *for the* AVERAGE CITIZEN

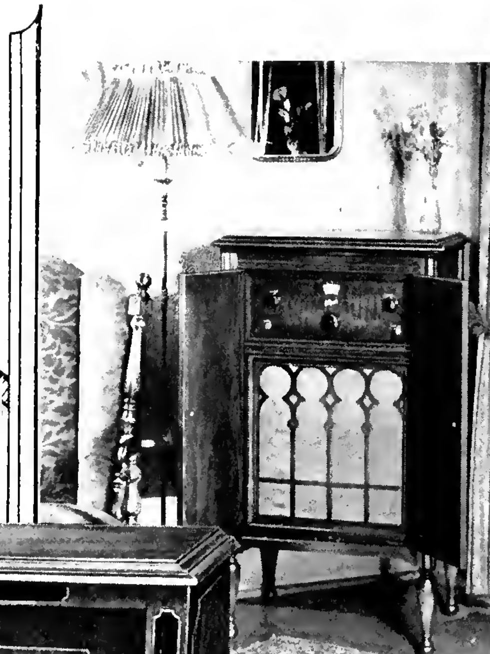


IT IS an erroneous impression that to possess a modern radio receiver combining both artistic merit and fidelity of reproduction one must spend an inordinate amount of money. The fact is that set makers have produced electrically good receivers and housed them in cabinets that will grace any home—and all at a genuinely moderate price. This and the following pages show attractive moderate-priced receivers ranging in cost from $175 to less than $100. The inspiration for the Bosch 76 receiver shown above is Gothic and it is evident how effectively it may be combined with the furnishings of many a living room. This six-tube RFL circuit receiver uses either a loop or antenna and has an interesting volume control and vernier tuning adjustment. Its price is $175

THE "MILAN"

A cone loud speaker is supplied with this Apex receiver, the price for chassis, cabinet, and loud speaker, being only $135.00. The circuit comprises six tubes, the audio amplifier employing impedance coupling, which is responsible for excellent quality of reproduction. The set is fully shielded and a single dial controls the tuning





BELOW

The Kennedy "Coronet," priced at $125.00. Seven tubes, including four matched r. f. stages, are used

BY AUDIOLA, CHICAGO

A six-tube console receiver for $110.00. There are three r. f. stages, and tuning is accomplished by means of a single knob

FOR LESS THAN $100

The Workrite 17 has an all-metal chassis, shielded r. f. coils, single-control illuminated drum dial, and a combination switch and volume control. Price $95.00

WHAT $70.00 WILL BUY

A table model of the Freshman "Equaphase." As described elsewhere in this issue of Radio Broadcast, the "Equaphase" principle makes possible the elimination of the cause of oscillation

THE "IROQUOIS" CONSOLE

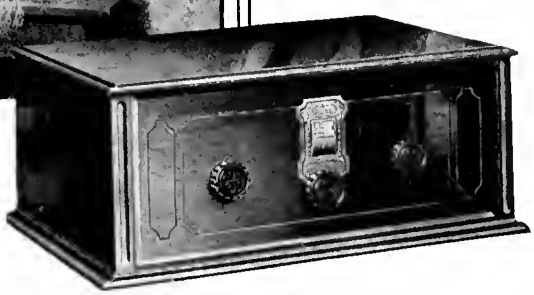
This attractive six-tube, one-dial receiver, by Mohawk of Chicago, retails for $130.00, less accessories, for battery operation. For electrical operation the receiver may be obtained at an additional cost of $110.00, in which case it is complete with accessories

AN EXAMPLE OF COMPACTNESS

Here is a six-tube receiver by Stewart-Warner which is offered at $80.00. There are three r. f. stages, one of which is untuned. A single dial controls tuning, but there is an auxiliary one for bringing the antenna circuit into exact resonance, and also a volume control

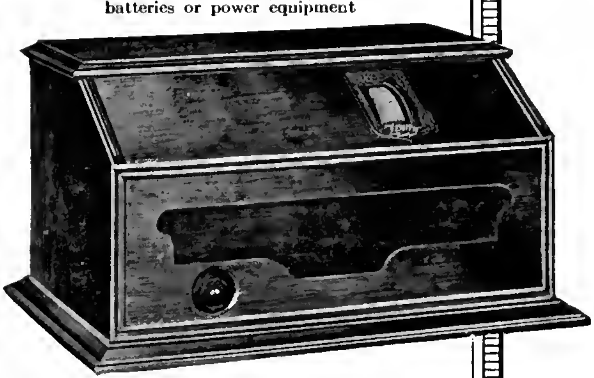
OF THE NEUTRODYNE FAMILY
For $100.00 it is now possible to obtain a single-control neutrodyne receiver. The Freed-Eisemann NR-9 is such a receiver and, in addition to the single-control feature, it is completely shielded and has a pilot light on the front panel. Equal amplification throughout the broadcasting frequency spectrum is claimed by the manufacturers

BELOW
The "Warwick," at $138.00, is one of the offerings of Amrad for the 1927-28 season. It is a single-control neutrodyne, completely shielded, and may be used with either loop or antenna



BY SPLITDORF
This is a receiver for the man who still believes in two-dial tuning. There are six tubes in all, three of these being r. f. stages. It is wired for use of a power tube in the last audio stage. The price is $75.00. The elliptical cone shown is priced at $35.00

McMILLAN'S "RIDGEWAY"
Yet another shielded six-tube, single-control receiver, this one being priced at $110.00. A long air column and deep-toned horn are included. There is ample space for batteries or power equipment



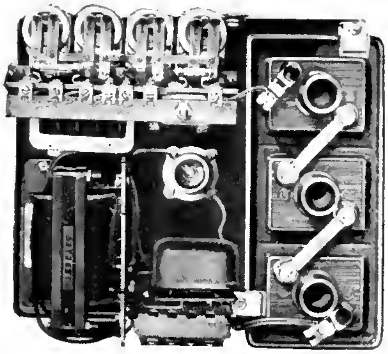
ZENITH MODEL 12
Single control is again manifest in this six-tube receiver, four variable condensers being manipulated by a simple movement of the illuminated dial. The chassis is of metal, and the receiver is completely shielded. The cabinet is of mahogany. Price $100.00

What Receiver Shall I Buy?

THE moderate-priced receivers exhibited at radio shows throughout the country this Fall are attracting widespread attention because the offerings in this class more than those in any other price range present greater values than ever before. Radio is now old enough so that those who bought radio sets two and three years ago are now thinking about replacing the old outfit with a more modern and satisfactory one. These pages show a few of these decidedly interesting receivers which can be had at a moderate price and which at the same time guarantee excellent electrical performance. These receivers are simple to control, more than ordinarily compact, and what is of growing importance, are handsome. There are table receivers for those who have but little space for a set, and more pretentious console sets for those who want both a radio receiver and an attractive piece of furniture. Practically all the console models in the medium-price range not only provide space for a loud speaker but also have convenient compartments for A and B socket power units and the convenient relay switch which, through the on-off switch on the receiver panel, controls both A and B units. Many buyers are interested in the console set with these compartments because they can at any time purchase A and B units for their set and, in effect, completely "socket-power" it.

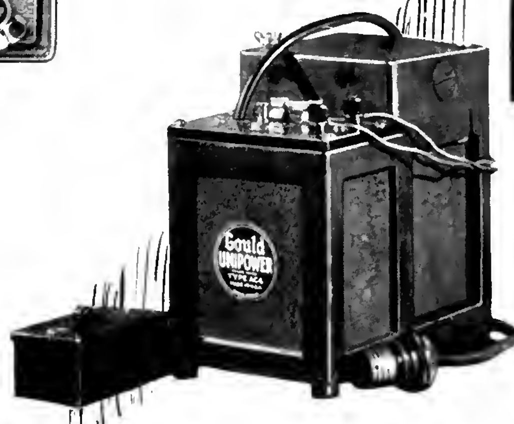
A ROLA CONE

Here is a table model of the well-known Rola cone loud speaker, retailing at $28.50. This unit is equipped with a low-pass electrical filter for the elimination of tube distortion. The heavy turned-wood disk serves as an acoustical baffle surface.



FOR A AND B CURRENT

This Philco power unit will provide 180 volts at 60 mils., and therefore is adequate for a receiver employing six or more tubes, with a power tube in the output stage. The unit, costing $79.50, is supplied in an attractive metal case. A built-in trickle charger keeps the A battery in good condition

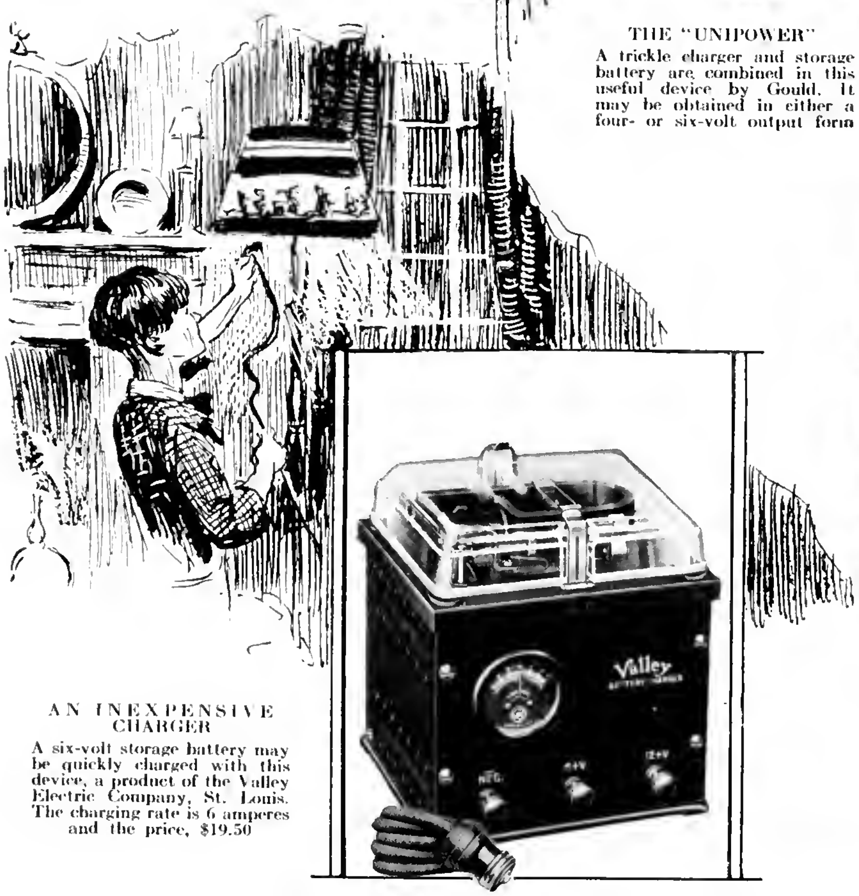


A CONSOLE LOUD SPEAKER

The exponential horn type of loud speaker, of which this is an example, is becoming increasingly popular, due to its excellent reproducing qualities. The one here is by Temple, Chicago, and lists at $65.00

THE "UNIPOWER"

A trickle charger and storage battery are combined in this useful device by Gould. It may be obtained in either a four- or six-volt output form

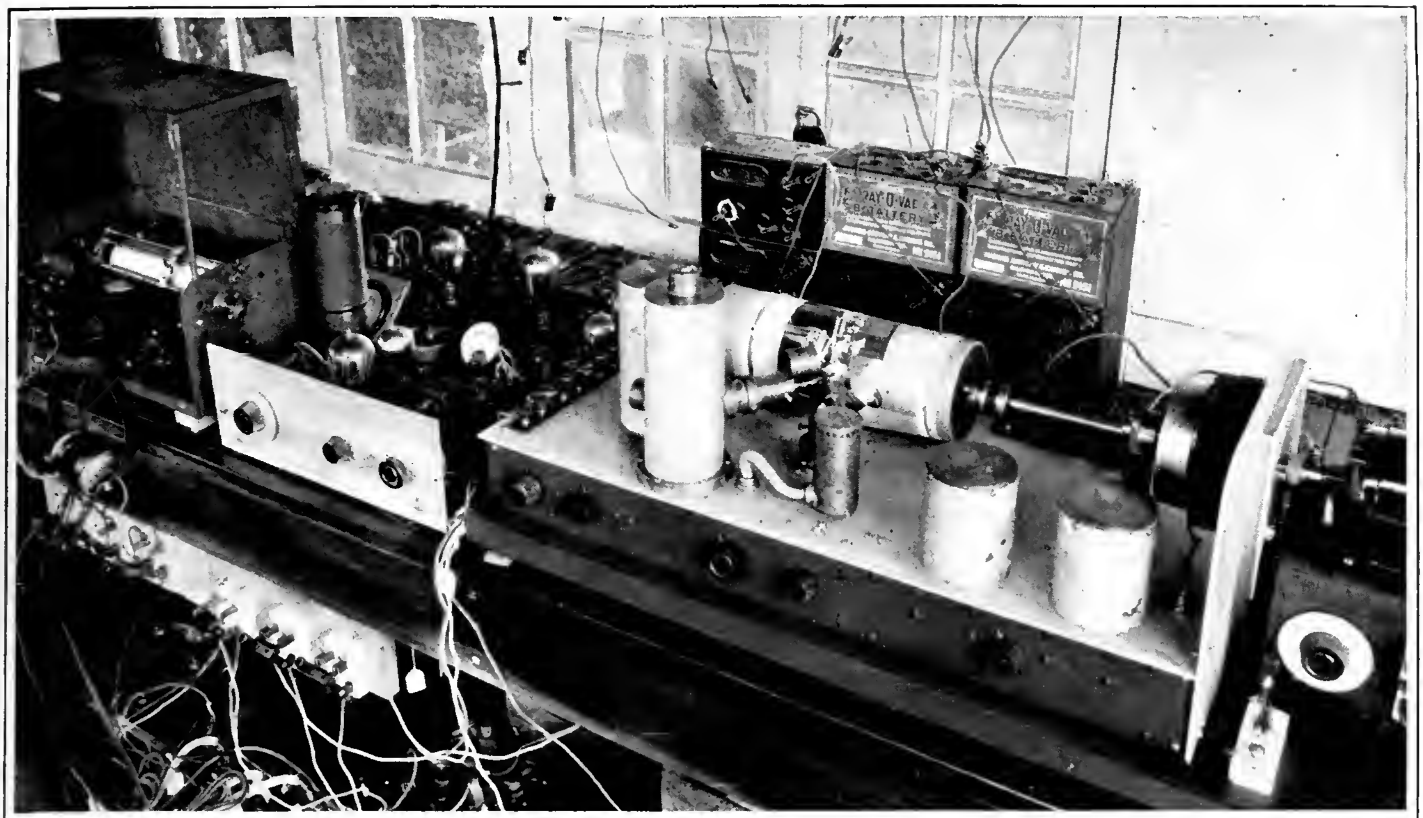


AN INEXPENSIVE CHARGER

A six-volt storage battery may be quickly charged with this device, a product of the Valley Electric Company, St. Louis. The charging rate is 6 amperes and the price, $19.50

FOR A AND B CURRENT

Another device which is capable of converting your a. c. house current into suitable power for your receiver—by Exide. The B output is 180 volts maximum, while the A supply is six volts. A trickle charger keeps the A battery well charged. The approximate cost of operating this device is one cent an hour



RADIO BROADCAST Photograph

AN EXPERIMENTAL SET-UP

This photograph, taken about four years ago in RADIO BROADCAST Laboratory, shows some of the early photograph transmission and reception apparatus designed by the author

How the Cooley "Rayfoto" System Works

By AUSTIN G. COOLEY

THE articles announcing a system of radio picture reception appearing in the September and October issues of RADIO BROADCAST have attracted widespread attention among radio experimenters. Even without specific data as to the actual operation of the Cooley "Rayfoto" system, experimenters have been fairly besieging the writer since the appearance of these articles and the demonstration of the "Rayfoto" transmitter and receiver at the New York Radio Show.

All the obstacles to making this new field available to the experimenter are being removed, one by one. Engineers are busy designing components and manufacturers are busy getting into production to meet the demand. And, for the broadcasters, an important method of supplying broadcasting stations with "picture" programs has been evolved. In this article we shall sketch briefly just how the Cooley "Rayfoto" system functions, what each part does, and what its purpose is. These technical details will give the experimenter a clear picture of what the difficulties are and what technical knowledge is needed for him to assemble and operate the apparatus. The Cooley "Rayfoto" recorder is no more difficult to build than a five-tube receiver.

THE SYSTEM IN BRIEF

IN A few words, the cycle of transmitting and receiving a "Rayfoto" picture is as follows: The subject, any ordinary positive or negative print, is placed on the drum of the transmitter or convertor which revolves and feeds it along a shaft before an optical system, which, in turn, focuses the reflected light on to a photo-electric cell.

The amplified currents from this cell are 800-cycle audio-frequency currents varying in amplitude in accordance with the subject. These currents control the radio transmitter output and the signals are received on a conventional broadcast receiver. They are then fed into the "Rayfoto" printer which produces a corona discharge in accordance with the strength of the received signal. The corona discharge takes place at the point of a corona needle which feeds along a revolving drum as the needle traces over a photographic paper wrapped around the drum. At the end of each revolution of the drum the received signals are diverted from the printer unit to a relay which is actuated when a synchronizing signal is received at the beginning of the revolution of the convertor drum. This relay in turn operates the trip magnet which releases the recorder drum so it may start off at the same time as the convertor drum. After the needle has fed along the entire length of the paper, the latter is removed from the drum, developed, washed, fixed, and washed again. The result is a picture of a prize fighter who has been knocked out a few minutes before; or a picture of a railroad wreck just occurred; or maybe a picture of some sweet young thing who may have won a bathing beauty contest in the afternoon.

Phototelegraphy is not complicated and involves nothing that is really new in physical science, but many of the "kinks" involved must be well understood if good initial success is to be expected. Most of the difficulties ordinarily involved in picture reception work will be prevented because manufacturers will supply equipment especially designed for the purpose and if the experimenter understands the principles of the system and can handle amplifier and oscillator circuits, he should have no difficulty in setting up his "Rayfoto" recorder and having good picture reception right from the beginning.

All systems of phototelegraphy have one

¶ *All you need for picture reception is a standard receiver, an oscillator, a stop-start motor mechanism, photographic paper, and enthusiasm. The important part of the receiving mechanism is the motor mechanism. With oscillators and receivers we are all familiar. The motor mechanism and all other necessary components duly approved and labelled with the Cooley Rayfoto label will soon be on the market. Those eager to be the first in their communities to receive pictures by radio may send their names and addresses to* RADIO BROADCAST *and these will be sent to the manufacturers making the parts. The total cost will not be more than $100.*—THE EDITOR

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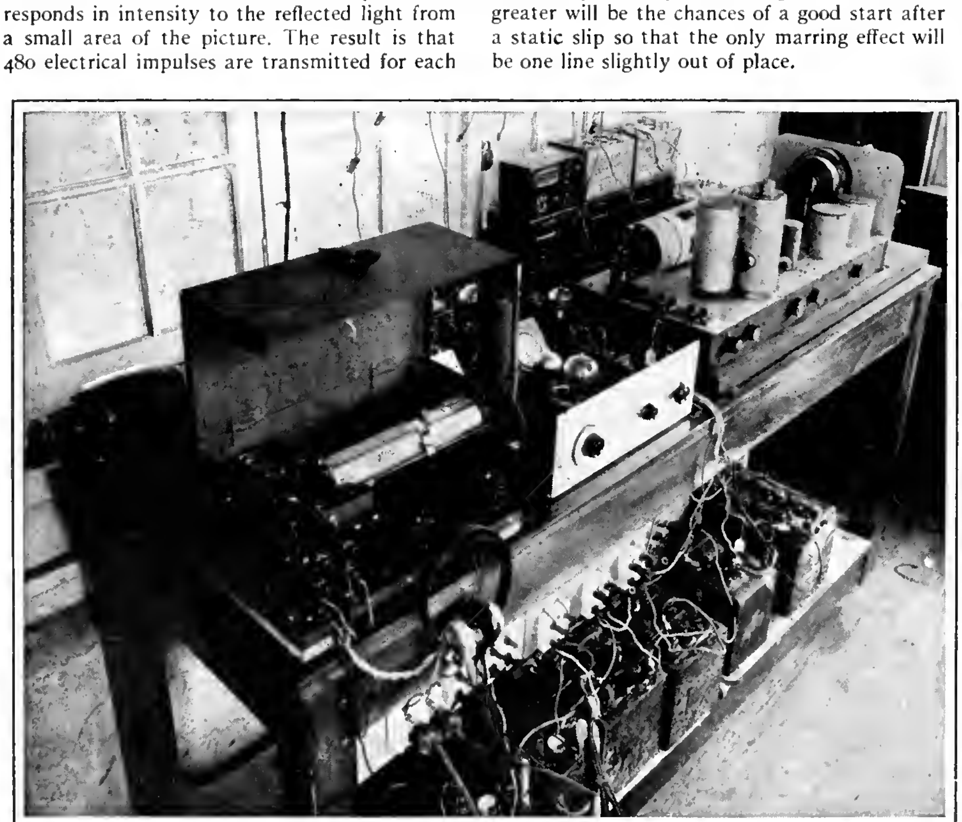
limitation in common: They can transmit only one shade and one unit area of the picture at a given instant and therefore transmission must be accomplished by dividing up the subject to be transmitted into thousands of small areas.

The "Rayfoto" and many other systems transmit the signals for each unit area in rapid succession and the resultant signal varies in amplitude in accordance with the shading of the picture. The speed at which the impulses are transmitted depends largely upon the ability of the receiving apparatus to reproduce rapidly the electrical impulses on the recording medium. The corona method of printing used by the Cooley "Rayfoto" system is capable of printing faster than any other system the author knows of, but for simplicity and low first cost we are using a signal frequency of about 800 cycles per second, which does not permit printing as rapidly as is possible with the system when higher frequencies are used. The possibility of operation at higher frequencies has been taken into consideration in designing the present equipment so that the speed of transmission can gradually be increased without necessitating any radical changes in equipment.

As explained in the October issue of RADIO BROADCAST, the picture or subject to be transmitted is placed, at the transmitting station, upon the drum of the picture transmitter, which we will hereafter call the "convertor." A small spot of the picture is illuminated and the reflected light from this spot actuates a photoelectric cell, the signals from which control the radio transmitter after the photo-electric cell currents have been sufficiently amplified. Each time the drum is revolved, the spot of light traverses a different path an eightieth of an inch wide across the picture. The line is broken up into 480 sections by the optical system so that 480 electrical impulses are transmitted every revolution of the drum and each impulse corresponds in intensity to the reflected light from a small area of the picture. The result is that 480 electrical impulses are transmitted for each revolution of the drum, or about 800 per second when the drum is making one hundred revolutions per minute. Running at this speed the drum feeds along the shaft T, Fig. 1, at the rate of one and a quarter inches per minute. The drum is two inches in diameter and about five inches long. This will give us an operating speed of four minutes for a five-by-six-inch picture.

The beginning of each revolution is marked by an impulse made up of twenty strong 800-cycle signals in succession. This impulse is used at the receiver to start the recording drum off at exactly the same time as the transmitter drum, for it is necessary that the two drums start off together. To accomplish synchronism in this way, known as the "stop-start" method, the recording drum must start a revolution at the same instant as the transmitter drum. It is necessary that the recorder drum run slightly faster than the convertor drum, then stop at the end of the revolution for an instant until the convertor drum completes its revolution. A trip magnet operated by the strong synchronizing impulse releases the recording drum at the proper time.

This trip magnet is operated through a relay which is connected to the rest of the system only after the revolution of the recording drum has been completed. Between the time the recorder drum stops and the time the synchronizing impulse is received, there must be no strong signals received, so we paste a strip of white paper at the end of the picture being transmitted so the signals will be weak while the recorder drum is stopped. Should a crash of static or some other disturbance be received during this waiting period, or "recorder lap," as it is called, the recorder drum will be released in advance of the synchronizing signal. By making the recorder lap very small, the danger of such a "static slip" will be reduced proportionately. The wider the white strip on the picture being transmitted, the greater will be the chances of a good start after a static slip so that the only marring effect will be one line slightly out of place.



RADIO BROADCAST Photograph

SOME EARLY "RAYFOTO" EQUIPMENT IN RADIO BROADCAST LABORATORY

The apparatus on the right of this picture is a Cooley photograph transmitter and in the center is an amplifier and "corona" apparatus. The picture receiver at the left has been redesigned in many ways to make its operation as simple as possible. This apparatus was photographed four years ago

We will consider here a few of the principles involved that affect the characteristics of the received picture. In picture work, we wish to reproduce at the recorder shades of light and dark corresponding exactly to those of the transmitted subject. The light reflected from the subject varies the current through the photoelectric cell in a ratio almost directly with the intensity of the light, and this current, after amplification, is made to control the power input to the radio transmitter modulator which therefore varies directly proportionately to the reflected light, due to the characteristics of the Heising modulator.

The final modulated radio signal sent out over the air will vary as the square root of the reflected light. The received signal is amplified lineally in the radio-frequency stages of the receiver. The detector output varies as the input squared, however, and therefore the current in the plate circuit of the detector will be directly proportional to the reflected light. The signal then can be amplified in the audio amplifier and delivered to the "Rayfoto" printer with an intensity directly proportional to the reflected light at the transmitter.

Limited by the data available at the present time, this is as far as we can go with the signal and know definitely what we are doing in the way of maintaining the proper signal ratio through the various circuits. We have no exact data on the relation of the input to output of the Cooley "Rayfoto" printer. Also we do not know the relation of the power delivered by the "Rayfoto" printer to the effect it has on the receiving paper. This factor is quite flexible and can be controlled considerably by the selection of the printing paper and its time of development in the photographic solutions. The printing paper we recommend today probably will not be the paper you will be using next year. It is therefore necessary to have some control over the system so we may match our amplification characteristics to conform with those of the recording paper we may choose to use. For example, if the received picture does not show sufficient contrast in the lighter shades but too much in the darker shades, we must adjust our amplification characteristics to correct for this. One way it can be done is to reduce the filament voltage on one of the amplifier tubes so that the strong signals are cut off somewhat by running over the top knee of the characteristic curve while the signals of lower value are on the straight portion of the curve. Additional correction may be obtained by reducing the time of development in the photographic solution.

The most convenient place for signal characteristic control is in the detector circuit, because of its "squared" characteristic. This characteristic may be varied considerably by proper proportioning of the grid condenser and grid leak. If the grid leak can be brought down to a very low resistance, say 500 ohms, and the plate voltage made adjustable over a range of from 4 to 40 volts, additional control of considerable value will be gained. Instead of varying the plate voltage, a variable grid battery may be used.

EFFICIENT AUDIO STAGES NECESSARY

A GOOD picture must not only represent exact shadings of the subject but it must also show up most of the small details of the original. A poor audio amplifier system will blur up the details in black shades and will not permit any of the details in the light shades to appear. The amplifier must not oscillate at any audio or super-audio frequency or even tend to oscillate. Oscillations in audio amplifiers most generally occur because of feed-back through the B batteries from one stage to another and can be prevented by the use of low-resistance batteries, a very large condenser across batteries of moderately high resistance, or by the use of independent batteries for the audio amplifier. The first pictures transmitted will contain sufficient contrast so that imperfect amplifying characteristics will not appear very noticeable. Nevertheless, the progressive experimenter should try to keep one step ahead of the game.

The plate current drain on the B batteries due to the Cooley "Rayfoto" printer will be about 10 or 15 milliamperes, so that the total current drain of the printer and an ordinary five-tube receiver will be in the neighborhood of 45 milliamperes. However, this additional drain of 15 milliamperes will only be present when the printer is being used and, since it will not be operated for long periods at a time, an ordinary set of B batteries should be good for many months of service. A total voltage of about 200 volts is required.

Naturally an amplifier that can be operated without oscillating is much more efficient than one that tends to oscillate and which therefore requires the introduction of some loss to prevent oscillations. In many cases, however, it is more convenient to use an amplifier we already have and which can be "doctored" up a little to make it serviceable for "Rayfoto" work. A resistance across the secondary of one or more of the transformers will prevent the amplifier from oscillating. The required resistance may vary between 100,000 ohms and 2 megohms.

Many broadcast receivers have sufficient amplification in their own system so that additional audio amplification is not necessary. You may test out your receiver in the following manner to determine whether any additional amplification is required to operate the recorder: Place a milliammeter in the plate circuit of the last amplifier stage; cut the current down to 0.2 milliamperes by increasing the C battery potential; short-circuit the loud speaker terminals; then tune-in a local broadcasting station. If the milliammeter jumps up over 15 milliamperes, no additional amplifier stage is needed. Even if it only goes to ten mils. it will not be necessary to use the added stage but this amount of current will allow only a very small margin of safety.

If an added stage of amplification is required, a special transformer should be used, one that is capable of operating without saturation and which will not produce oscillations in the audio system. Special transformers for this work will soon be available.

The Cooley "Rayfoto" printer is the device for producing the corona discharge that affects the photographic recording paper. It converts the received audio-signal into a fluctuating source of light corresponding to the transmitted signal. This unit consists of a modulated oscillator feeding a corona coil. The corona discharges are secured from the high-voltage side of the corona coil secondary winding.

Readers may wish to have some explanation of the nature of the corona we refer to here. Visually, the corona discharge at the needle point riding on the paper is a small spray of blue sparks similar in appearance to those produced by a violet-ray machine. This discharge occurs when a difference of potential of 13,000 to 26,000 volts per centimeter (which, incidentally, won't hurt you) exist around the needle point. This potential is produced by the radio-frequency amplifying transformer, known as the corona coil. The primary of this coil is part of a vacuum-tube oscillator operating at a frequency of 333 kc. (about 900 meters). The plate circuit is supplied by the signals from the radio receiver. After being amplified to supply enough power to the modulation transformer, these signals are strong enough to produce a strong corona discharge when strong signals are received. For the sake of efficiency and shading, about one hundred volts of direct current is supplied, in series with the modulation transformer to the plate of the oscillator. This boosting voltage must not be sufficient to produce a corona that will print when weak signals are coming through.

The oscillator of the "Rayfoto" printer radiates for some distance if the frequency is high, and to prevent such interference we have chosen the reasonably low frequency of about 333 kc. We do not recommend an oscillator frequency corresponding to more than this unless careful shielding is used.

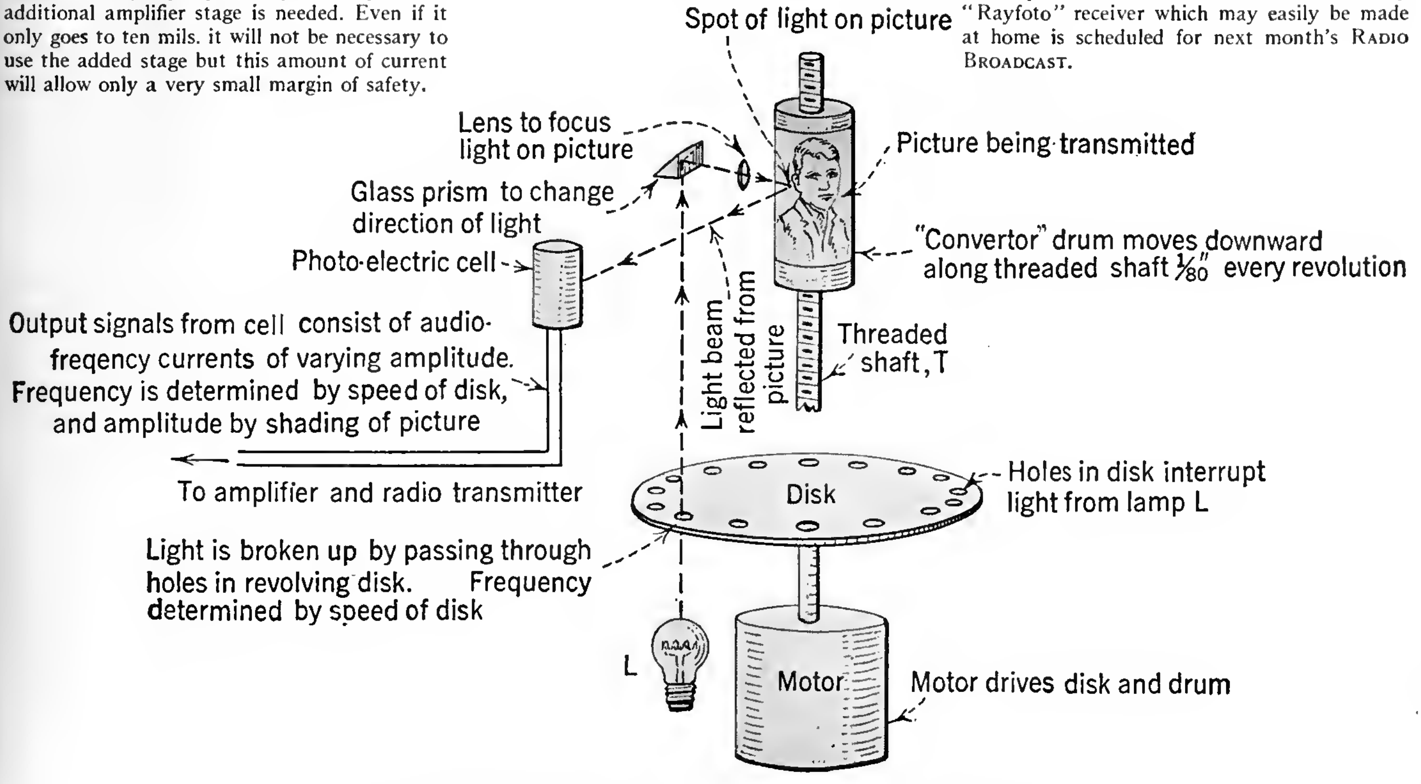
The "Rayfoto" recorder is the mechanical unit of the system which consists of the receiving drum driven by a motor and controlled with a "stop-start" system of synchronizing. A screw feed arrangement feeds the corona needle along the drum as it revolves so that the needle moves along at approximately the same speed that the convertor drum as the transmitter moves along its shaft.

The "stop-start" mechanism consists of a slip clutch between the motor drive and the drum, and a trip magnet arrangement that stops the drum at the end of each revolution until the synchronizing impulse is received. This impulse trips the armature of the magnet which operates through a relay. By this system, the transmitter and receiver are synchronized about twice a second, thereby eliminating much delicate and expensive synchronizing apparatus.

The recorder drum is the same size as the one at the transmitter but since the recorder has a slight "lead," that is, runs slightly faster than the convertor drum, the received picture will be stretched out a small amount, depending upon the amount of lead. To compensate this, the gears between the drum and screw feed shaft will be of such a ratio that the needle will feed along a little faster than the transmitter drum so that the proper proportions are restored. As a result the received picture will be slightly larger than the one transmitted.

It is desired to keep the lead as small as possible so as to prevent excessive stretching of the picture. Also, if the lead is too much, the trip magnet may be tripped from a subject signal instead of the synchronizing signal. If the lead is too small, the synchronizing signal may be received before the recorder drum has finished its revolution and has switched the relay in the circuit. Consequently the relay will be operated by the next strong subject signal.

Complete constructional data for a Cooley "Rayfoto" receiver which may easily be made at home is scheduled for next month's RADIO BROADCAST.



A PICTURE DIAGRAM OF THE COOLEY TRANSMITTER

This drawing shows graphically how the Cooley picture transmitter produces electrical signals varying in strength in accordance with the shading of the picture being transmitted

In Stromberg-Carlson receivers, a manufacturing refinement, not evident to the casual observer, is found in the cord connecting the set to the light socket. It is made with unusual care

REFINEMENTS OF THE MODERN RADIO RECEIVER

By EDGAR H. FELIX

THE modern manufactured receiver has become a precision product, built under most exacting conditions prescribed by skilled engineering departments. It is no longer a heterogeneous combination of parts, wired together in conformation to circuits supposedly possessed of magical qualities. Performance is the product of a thousand and one engineering decisions carried out with a care so far above and beyond that which the average buyer can appreciate that engineering refinements are no longer considered suitable as selling arguments by which to sway the buyer's preferences.

Where should the by-pass condenser across the filament leads be placed? Is the improved performance attained by placing it directly underneath the tube sockets sufficient to warrant a special moulding? Does a one per cent. difference in moisture content of the insulating paper of fixed condensers reduce losses sufficiently to justify an additional cost of twelve cents per receiver and does that involve an increasing percentage of condenser breakdowns? Should three more turns be used on the radio-frequency transformer primary to get slightly improved quality or does that involve a sacrifice in selectivity too great to be permitted under present broadcasting conditions? Should the audio-frequency system be designed to cut off at 5500 cycles or at 4800, in the first case giving slightly improved reproduction; in the other, slightly reducing the effect of certain types of interference noises?

It is such highly technical questions as these, clouded in a veil of mystery to all but the experienced radio engineer, that makes one radio set better than another. The placing of a socket half an inch one way or another may make an imperceptible difference in performance, but it is the multiplication of such details, carefully determined after engineering study, that assures the buyer of his money's worth.

In a sense, we have come to a parting of the ways between the factors that make real radio performance and those which make up the buyer's mind between one radio set and another. There is a premium on the little, superficial improvements which the buyer can appreciate because they are the only practical ways of expressing engineering ingenuity to the ultimate consumer.

ONE REFINEMENT OF FADA

THE Fada receivers of this year, for example, employ a new simplified power switch and volume control, an obvious convenience which any prospective purchaser will appreciate. One control takes the place of two. Hidden in the beautiful cabinet, is a chassis made of $\frac{1}{16}$ inch pressed automobile body steel. It is supported on a three-point suspension with absolute rigidity so that the parts mounted in it cannot get out of alignment. The accurate matching of variable condensers contributes not only to selectivity but to quality of reproduction. In past years, an accuracy of one per cent. in capacity throughout the tuning range has been considered satisfactory. The Fada condensers are matched to an accuracy of $\frac{1}{8}$ of 1 per cent. and the same standard is applied to the tuning inductances coupled with them. These are a few of the hidden values which make for good performance.

The shaft on which the tuning drums and variable condensers are mounted is one-half-inch flash copper plated piston rod steel and is gauged to a tolerance of .0005 of an inch! The day of the curtain rod condenser support is over. The pistons in your automobile are gauged to no closer tolerance.

Advertisements shout uniformly about the most selective receiver with the best tone quality, but give the discriminating buyer no real facts to help him appreciate the performance of a receiver. Generalities may sell the uninformed and help to create name familiarity, but sterling worth, built in by ingenious engineering and painstaking manufacture, is hardly ever conveyed to the reader of advertising.

GOOD THINGS YOU DON'T SEE

ANOTHER instance of superficial selling points which make an obvious appeal to the uninformed buyer and the equally important hidden refinements which contribute even more significantly to good performance is found in the Freed-Eisemann receiver. Several models are equipped with a voltmeter so that the set owner can readily check the A, B, and C voltage applied to every tube of his receiver. Since accurate voltage supply is of vital importance in the performance of the receiver, the selling value of that feature is obvious. But how many buyers know of the two special bonding clips which ground the shielding of the detector stage in order to dissipate more readily the radio-frequency currents generated in that shield? It is a minor point, but an expression of the engineering care which makes the modern radio receiver.

Recently, the writer visited the Stromberg-Carlson factory at Rochester, New York. A complete understanding of the refinement which is concealed in the cabinet of the Stromberg-Carlson receiver hardly ever penetrates beyond the monument to engineering skill and idealistic production standards which that new factory actually is. One could write a thousand words on how the cord by which you tap the a. c. power line is made! Only a detail, but it assures unfailing service for a period of years. It means no frayed cord and no breakdowns, an advantage which passes practically unnoticed in the attention of almost every buyer of that receiver. But to give him that advantage, special engineering standards have been set for every item of material used in the flexible cord. The fine copper wires which, woven together, make an everlasting cable, are ten times as strong as ordinary wire. Special flexible conductor, which does not break if sharply bent, is employed. The individual strands are so fine that they cut the finger like a razor blade. Covering these wires are insulating materials adding a factor of safety far above and beyond that considered necessary. And finally, selected cotton is woven over the insulating material, giving a mechanical strength so that the copper wire itself is relieved of most of its load. Last, but not least, comes an outer covering of silk so woven that there will be no untwisting of the cable and it will hold its lustre for a period of years. Outwardly, there is but little to distinguish this little engineering masterpiece from an ordinary power connecting cord which will fray, untwist, and break in the course of time, particularly if it must be pulled out each time the vacuum cleaner is used. Probably not one salesman in ten thousand selling the Stromberg-Carlson receiver ever considers this refinement—one of a thousand which conscientious engineering has built into that product.

SOMETHING ABOUT CONDENSERS

ONE feature which every radio enthusiast appreciates is the advantage of straight frequency-line tuning condensers over the straight capacity-line type. The desirability of even spacing of stations over the tuning dial throughout the broadcast range is obvious. But, with the almost universal tendency toward multiple condensers, needed to obtain single control, the necessity for straight frequency-line condensers has caused many an engineer gray hairs. It is very difficult to secure uniformity in quantity with condensers having the peculiarly shaped plates necessary in straight frequency-line tuning. With straight capacity-line used in connection with matched inductances, uniformity is easily attained and tuning circuits readily matched. All that need be done to match the stages is to adjust the condensers at any point on the wavelength scale, after the receiver is assembled. Once that is done, absolute accuracy is likely to obtain at all dial settings. But straight capacity-line condensers mean that, at the short wavelength end of the dial, stations are hopelessly crowded, while, at the upper end, they are widely and wastefully separated.

A fine example of engineering refinement in meeting this problem is embodied in the Federal receiver. Condensers with square plates, sliding in rigid grooves, assure absolute uniformity of capacity variations and attain a standard of accuracy almost impossible to secure with condensers having specially formed plates to secure the straight frequency-line effect. But the buyer of a Federal does not sacrifice the advantages of straight frequency-line tuning by the use of these condensers. An ingenious and well designed gang tuning control mechanism gives him all the advantages of straight frequency-line tuning The mechanism is a masterpiece of mechanical design.

Another example of true engineering beauty is embodied in the antenna tuning compensator which is a part of the mechanism. With multiple tuned circuits, the designer has the choice of several ways to compensate any variations in antenna capacity. He may use a broadly tuned antenna or input stage which gives but little or no amplification. Such a stage contributes its share of tube noise and accentuates nearby station interference. Or else he may employ a sharply tuned stage which has a separately adjusted compensating condenser. Of course, the most efficient and satisfactory method to the user is an antenna stage which tunes sharply and contributes its share of amplification. Those having receivers with a vernier antenna compensating condenser have noticed that, although they have a main tuning dial which gives the set the appearance of one control, they must actually adjust two dials—the main tuning control and the compensator—to tune-in a station properly.

With the Federal receiver, the compensator is geared with the main tuning adjustment and automatically keeps the antenna circuit in step with all the rest throughout the tuning range.

THE R.F. OSCILLATOR USED BY BOSCH TO MATCH COILS

The author would not be surprised to discover that the electrical law determining the correct compensating adjustment needed for all types of antenna systems and working out the mechanical arrangement which assures adherence to that law was a bigger engineering job than designing the entire radio set marketed in 1924.

All this engineering precision applied in design may be nullified by carelessness in production. The electrical and mechanical measurements made in the modern radio plant are of an order of precision unrivaled in any field of quantity production. Atwater Kent, for example, makes 159 precise tests, each requiring engineering knowledge to perform, in producing a single receiver. Some of these tests entail mechanical precision measurements; others electrical measurement of currents of mere millionths of an ampere. But every test contributes to the purchaser's assurance of reliable radio service.

MATCHING INDUCTANCES IN QUANTITY

HOW one manufacturer applies engineering precision to production is best expressed in the words of William F. Cotter, radio engineer for the American Bosch Magneto Corporation:

"The subject of sorting and matching of inductance coils is one to which we have given considerable thought. Its importance is recognized by every manufacturer. With one test fixture capable of handling the job, it would be comparatively easy to install a check of the manufactured product and be assured of a high degree of accuracy. However, when two or more test fixtures are required to handle the volume of coils manufactured, and where it is desired to check these coils at radio frequency, a more serious problem presents itself.

"We have employed several methods over the last three years The one I describe, however, represents our latest development and is the result of all our past experience.

"A radio-frequency oscillator is built up around the standard 201-A tube. Incorporated in the tuned circuit of the oscillator at nearly ground potential is a resistance of approximately 10 ohms. Across this resistance is shunted in series the coil to be tested and a variable condenser with its separate vernier condenser. When this series circuit is brought to resonance, the total resistance of the shunt circuit comes down somewhat in the neighborhood of the 10-ohm resistance, and one-half of the oscillation current is diverted to the series tuned circuit. Included in this tuned circuit is, of course, the usual thermo-galvanometer.

"By means of a properly chosen vernier condenser, the coils coming through can be checked for accuracy and sorted in as many divisions as experience shows necessary. However, while this is suitable for one test fixture, the problem of keeping two or three fixtures oscillating at the same frequency presented itself. Naturally, if the frequency of the individual oscillators varies, say 10 per cent, it is quite impossible to group coils together just by dial readings.

"We have solved this problem by building a crystal oscillator as one of the test fixtures. Other oscillators of ordinary type are built and each is equipped with a vacuum-tube detector. The oscillators are placed so that it is possible to couple in some of the energy from the crystal oscillator. By means of a headset, the operator adjusts his oscillator to zero beat with the crystal oscillator. Usually, it is not necessary to check this setting more than two or three times a day. By this method, coils may be checked and sorted with an accuracy of a few tenths of one per cent."

That is engineering refinement. It is the kind of "detail" which makes the 1927 radio receiver a precision product.

The broadest appeal to the radio buyer, and one to which most people respond, by and large, is the outward beauty of the product and the name reputation of the manufacturer. Faced, as a prospective buyer is, with numerous products attractive from these standpoints, he is easily swayed from one brand to another by superficial selling points. The more discriminating and intelligent buyer—and in the radio field, because of the host of persons who have a smattering of technical knowledge, this class is predominant and influential—looks to the hidden qualities, the expression of engineering ingenuity and manufacturing skill, as well as the performance qualities, in deciding between one receiver and another. The glittering generalities which have characterized successful advertising and have successfully built up huge quantity production, are at last beginning to suffer a reaction. There are too many "best" automobiles and too many "finest" radio sets. But facts, the refinements, the details, presented to those who can understand them, are indisputable evidence of inherent quality.

"What is a Good Radio?"

By KEITH HENNEY

Director of the Laboratory

A RADIO receiver, as any engineer will tell you, is a complicated and highly organized machine, designed to perform several functions none of which is independent of the others. It is because of these interconnected functions that the engineer will wish he were in Europe if you ask him:

"What is the best radio?"

An automobile, on the contrary, is comparatively simple. It has but one function to perform, it must take energy in some inert form, say unconfined gasoline, and convert it into some other dynamic form which is useful in carrying someone somewhere.

To answer a question regarding the best automobile, then, is simpler, especially since the automobile industry has been established long enough for the most expensive car to be usually the best. Unfortunately, radio has not even this truth to go on, for, all things considered, the most expensive radio does not always pan out to be the best.

A radio must do three things, and therefore there are three problems of design. They deal with:

1. SENSITIVITY. The receiver must be sensitive enough to pick up the signals one wants and amplify them sufficiently to give good loud speaker volume.
2. SELECTIVITY. The receiver must accept signals from the one station the owner wants and reject all others.
3. FIDELITY. The loud speaker signals must be a faithful reproduction of the original in tone and in relative volume.

Thus a perfectly selective and sensitive receiver would pick up any station operating at any distance on any frequency, and would turn a deaf ear to all others, no matter how near the given station in frequency or distance, or how great their power. If the receiver has 100 per cent. fidelity of reproduction, signals as loud as the original would come from the loud speaker, and with all tones exactly as they originate in the studio.

Needless to state, there is no such receiver.

There are several reasons for this. As mentioned above, these varied functions of a receiver depend upon each other, and not always to the same degree. For example, an infinitely selective receiver would be in the present state of the art, highly unsatisfactory from the standpoint of fidelity. Advertising writers to the contrary, one cannot have something for nothing, even in radio.

There are those, however, who desire to know which of two receivers is the better, and among these are the reputable manufacturers themselves. It is for this reason that set testing methods have changed.

Not so long ago, when a receiver had been put together and wired someone took it to a test bench where it was hooked to batteries and an antenna. If signals came out of a horn somewhere the set worked. It was sent to the dealer at once. This was an obvious test.

The obvious, as we all know, is not always the best. In the case of good radio receivers, this older, obvious test has given way to more scientific tests which do not depend upon a smoke covered antenna or the often tired ears of a test man, but upon tireless and unemotional instruments.

In spite of the fact that these tests have been practised—sporadically, we suspect—in the better known laboratories, it has been only within the last half year that descriptions of them began to appear in the technical literature. So new is the industry that standard tests have not been developed, nor have engineers even agreed among themselves regarding even the nature of these tests. Probably while this is being read, committees of the various radio organizations and radio engineering societies will be weighing conditions of test and endeavoring to set definitions of the perfect receiver, definitions that everyone will recognize.

WHAT HAPPENS INSIDE THE BOX?

NOW, before trying to find how much of anything a receiver does, it is well to get an idea of what happens inside the box, to discover if possible what should happen and how much. Then we shall have some idea of what to look for and what the relative order of magnitude will be. For example, harking back to the automobile, almost everyone knows that an automobile has a carburetor. Some people know what it is for; the writer does not. There is also a clutch and some other apparatus which everyone who is about to buy or run or design or fix a car should know all about. He should know what these various pieces of equipment are for, what happens if you leave some of them at home, and when the car runs properly, what the magnitudes of the various operations are. The quantity of gas and oil per mile, or hour, revolutions per minute, miles per hour, ability to climb hills, "pick-up," etc., are all terms that have both definition and dimensions.

A radio receiver also has several pieces of component apparatus. Each has a different function, and in each piece of apparatus something happens when the set is operating properly. What we must know first is what is each part for, how it does its work, and then how much should a good unit do? This will enable us to define a perfect receiver, and if we have laboratory equipment and patience, or if the manufacturers will supply us with the proper data, we shall be able to decide just where in the scale of goodness our particular receiver stands.

The inner works of the receiver, except superheterodynes, consist of three parts: a set of tubes which serve as radio-frequency amplifiers, boosting in magnitude the incoming signals without change in form and very sharply tuned; a detector more broadly tuned which changes the signals into an audible form; and third, audio amplifiers which bring the detector signals to loud speaker volume. The last are not tuned at all, or at least very broadly.

The radio frequency amplifiers are intimately connected with the transmitting station. The receiving antenna or loop is situated in a reservoir of energy, part made by man, part by nature; part useful, part disturbing. A fair share of this energy is created by broadcasting stations which pour their output into what scientists call the "ether" and what the layman calls the "air."

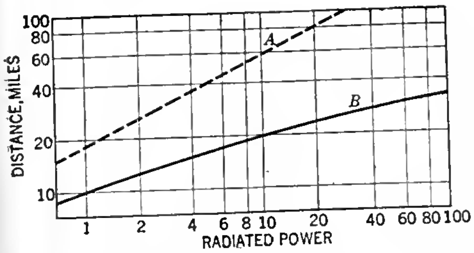
The energy one wishes to receive speeds from the broadcasting station with the velocity of light, so fast that it may be heard from the loud speaker before it is heard in the rear of an auditorium in which the broadcasting may occur. This is because sound travels through air at 1100 feet a second and radio waves through the ether at 186,000 miles a second.

The receiving antenna is almost as intimately connected with the transmitter as if a wire joined them metallically, although less efficiently to be sure. What comes out of the transmitter sets up a voltage across the receiving antenna. Naturally, the stronger the transmitter, the nearer to the receiver, or the higher the receiving antenna the greater is the received voltage.

Here is where we start on our measuring expedition. How can we measure the relative strength of a transmitter at a given locality?

HOW RECEIVED ENERGY IS MEASURED

IN THEORY the problem is about as follows. The actual voltage across a given antenna is measured by the substitution method. That is, a given deflection on a meter is secured from the distant station. Then a voltage which can be read on another meter is substituted for the distant transmitter and when the proper deflection is secured the voltages are equal. The process may be changed as follows. The given deflection is secured. Then a much greater voltage, which



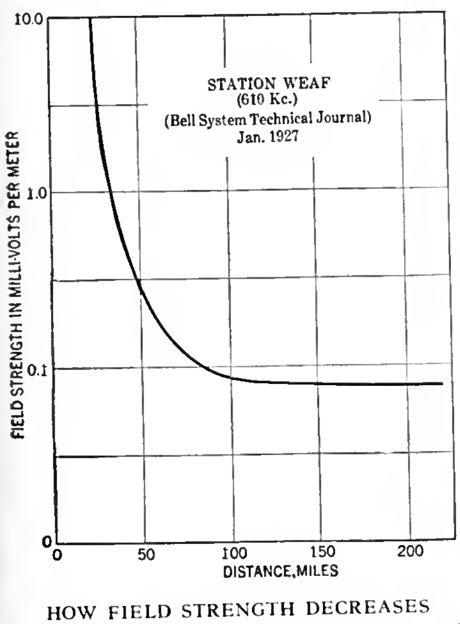
CONDITIONS UNDER WHICH SETS WORK

Estimates agree that a radio set must have delivered to its antenna a signal strength of between one and ten millivolts per meter for "good" service. This means that the received signal will then be strong enough to over-ride ordinary static and local electrical disturbances. This curve shows the increase in power necessary at the broadcasting station to increase the range at which a field strength of ten millivolts per meter is delivered. Curve A shows the power required to lay down this field strength *without* any absorption of the wave; Curve B shows the unit power needed to lay down an equivalent field strength *with* all sources of absorption included. Note that at a distance of about 20 miles from the station, only about 1.1 units power is required for ten millivolts while, with absorption, ten units are required to produce the equivalent signal

can be easily measured, is cut down in known steps until the same deflection is noted. In this manner the field strength of a given station may be definitely measured.

Since the field strength at a given receiver varies with the antenna height, the usual basis of comparison is field strength per meter height. It is merely the actual voltage measured divided by the effective height of the receiving antenna. This is expressed in millivolts per meter and is a factor which is a measure of the effectiveness of a given transmitter at a given locality at a given time of day.

A given number of millivolts per meter will produce a certain loud speaker response with a given receiver. The more sensitive the receiver the greater loud speaker signal will be secured from a given field strength, or conversely, a given



HOW FIELD STRENGTH DECREASES

This curve, from the *Bell System Technical Journal* graphically shows how the field strength of WEAF falls off with distance from the station. Any receiver, to be subject to tests which indicate anything, must operate under standard conditions, which are gradually being agreed upon

signal may be produced by a weaker field strength the more sensitive the receiver.

What, then, may be considered a good signal? Here we are talking dimensions or magnitude. What we want to know is the field strength that will override static and other interference to produce a good lusty loud speaker signal, one that will be good, day or night, rain or shine.

The following table is taken from Dr. Alfred N. Goldsmith's paper in the *I. R. E. Proceedings* for October 1926 and shows what may be expected from various field strengths.

Signal Field Strength	Nature of Service
0.1 millivolt per meter	poor service
1.0 " " "	fair service
10.0 " " "	very good service
100.0 " " "	excellent service
1000.0 " " "	extremely strong

So far so good. Let us see how powerful a station must be to deliver such a field strength over a certain distance. Again quoting from Doctor Goldsmith's paper we have the following data.

Antenna Power	Service Range
5 watts	1 mile
50 "	3 miles
500 "	10 "
5000 "	30 "
50,000 "	100 "

There seems to be some regular progression here between the power and the range of station —in fact a law exists stating that the range of the station varies with the square of the power of the station. That is, to double the range we must quadruple the power. To increase the service range three times we actually increase the power the square of three or approximately ten times.

Now quoting Lloyd Espenschied in the *Bell System Technical Journal* (January 1927), we find:

Fields between 5 and 10 millivolts per meter represent a very desirable operating level, one which is ordinarily free from interference and which may be expected to give reliable year-round reception, except for occasional interference from nearby thunder storms.

From 0.10 to 1 millivolt per meter, the results may be said to run from good to fair and even poor at times.

Below 0.1 millivolt per meter, reception becomes distinctly unreliable and is generally poor in summer.

Fields as low as 0.1 millivolt per meter appear to be practically out of the picture as far as reliable, high quality entertainment is concerned.

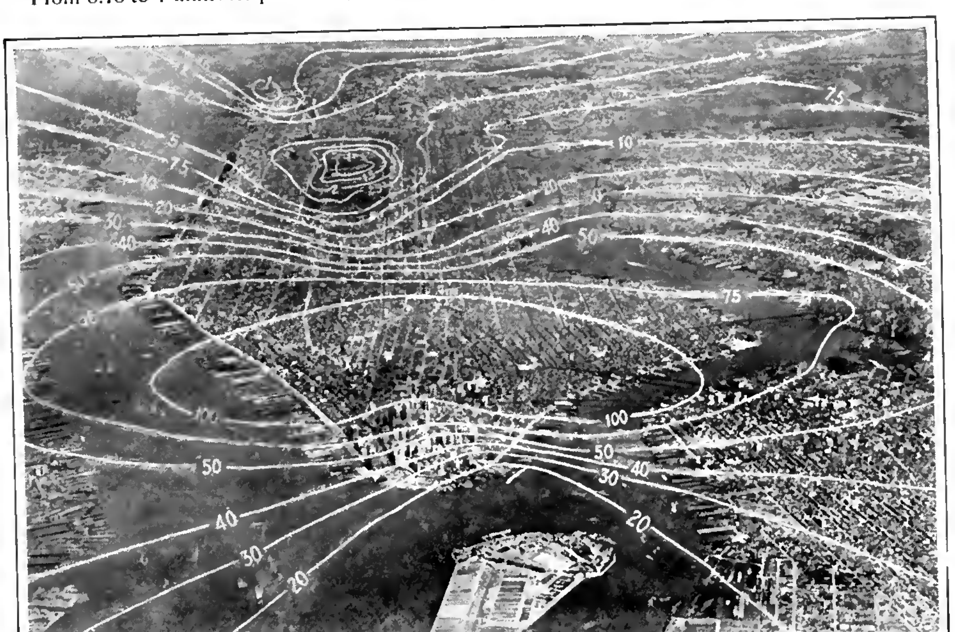
WHAT POWER DO STATIONS DELIVER?

FROM a given station the field strength falls off according to an inverse law, that is, if we double the distance we shall halve the field strength: "a 5 kw. station may be expected to deliver a field of 10 millivolts from 10 to 20 miles away and a 1.0 millivolt field not more than 50 miles away."

In a Bureau of Standards paper, "General Report on Progress of Radio Measurements," (April, 1924) the following data were published. When WEAF was transmitting with 3 kw., its field strength at 10 miles was 32 millivolts per meter. When KDKA has a nominal power of 10 kw. its field at 10 miles was 43 millivolts.

All of these statements may be expressed graphically and the curves on these pages contain much meat for thought. What everyone wants is good lusty signals from a high quality station, day and night, without resorting to regenerative receivers to boost the volume at the cost of fidelity, without being forced to listen to nearby poor quality stations riding in on an adjacent channel, or without having his program more than liberally punctuated with static or extraneous noises. It is up to broadcasting stations to produce a field strength that will insure programs and transmission of this desirable quality. It is up to design engineers to produce receivers that will serve their owners with loud speaker signals from the field strengths laid down by high quality stations. Mathematics alone is not infallible; some experiment and laboratory work must go with it to make certain all the factors have been considered.

Subsequent articles will deal with methods by which engineers check up on the soundness of their design; methods by which sensitivity, selectivity, and fidelity may be measured.



Fairchild Aerial Camera Corp'n

A RADIO "MAP" OF WEAF'S SIGNALS

Although made some time ago when WEAF was transmitting from Walker Street, New York, this illustration shows that in various parts of New York City WEAF signals were very faint indeed. A receiver, no matter how good, could not successfully "pull in" this station. The answer is greater power and location of broadcasting stations away from areas of great absorption

Do You Own a Battery-Operated Set?

Many Fine Types of A-Power Supply Units Are Now Available to Convert Your Battery-Operated Set to One Which Requires Almost No Attention

By HOWARD E. RHODES

NOT so long ago, the only way to heat the filaments of your tubes was to use a battery. And practically everyone who had a radio set had a storage battery; few indeed, even in the olden days, used dry cells to light their tube filaments unless that was a necessity. Then the storage battery passed through a cycle of development. The crude battery which radio borrowed from the automobile industry was dressed up. The case became polished wood or even glass and special precautions were taken by the makers to keep the acid electrolyte where it should be, for this battery was not to be housed in the interior regions of a motor car but in the parlor of high society. And now, to compete with the steady old battery come socket A-power units. What are they? How much do they cost? How many tubes will they supply? Do they need regular attention? Can a socket A-power unit be installed and be depended upon to light the filaments of the tubes "when, as, and if wanted"? These and goodness knows how many other questions are being asked by technical and non-technical radio folk these days as the offerings of 1927 are more and more widely announced.

The owner of a good radio set of some years back realizes that the tempting new 1927 models, operated directly from the light socket, probably are as superior to his outfit in convenience and performance as Whiskery is to Dobbin. But for one reason or another our loyal owner decides to keep his receiver. Can't he buy gadgets to turn his set into a light-socket outfit? Why not, for there are plenty of good B socket-power units and a goodly number of A socket-power units advertised? Well, so he can. He can buy a reliable A socket-power unit, a good B socket-power unit, a relay switch, and there you are—complete light-socket operation! He has achieved convenience which he seems to be pursuing strenuously. The economics of the change is another matter. Of the convenience and reliability there is no question.

Take the case of a set owner who bought a receiver a year ago. He may not be quite ready to buy a new outfit, but complete light-socket operation tempts him. His receiver must be operated by these A and B power units without any sacrifice in tone quality or volume. If the power units cannot accomplish this—and for a reasonable length of time, without renewal of parts—they are not worth purchasing. There are, fortunately, many A-power units capable of giving as satisfactory reception as can be obtained from the unadorned storage battery.

The storage battery as a source of filament power is in many ways an almost ideal device. The current it supplies is perfectly steady. Its voltage is practically constant during a greater part of its discharge, and the slight decrease in voltage that does take place as the battery becomes discharged does not affect the operation of the receiver adversely because tubes of present-day design will operate satisfactorily at slightly lower than rated filament voltage. Automatic A-power units have been developed because the public demands convenience. The necessity of charging A batteries is a serious annoyance to many radio users.

THE BALKITE A-POWER SUPPLY

This device will supply filament current to receivers having up to eight tubes and it requires practically no attention. Inside the case is a transformer and electrolytic rectifier and an electrolytic condenser. The list price is $32.50

TABLE I

Name of Unit	Price	Type of Rectifier	Max. Number of ¼ Amp. Tubes Unit Can Supply	Power Input from Line	Size of Container L x W x H
Abox	$32.50	Electrolytic	8	—	
Balkite A	32.50	Electrolytic	8	100	$11\frac{1}{8}$ x $6\frac{17}{32}$ x $8\frac{15}{16}$
Electron Electric A					
Regular	45.00	Tube	7	—	$12\frac{1}{4}$ x $7\frac{3}{4}$ x 9
Giant	49.50	Tube	12	32	
Marco A Socket Power No. 500	60.00	Tube	10	47	$11\frac{1}{2}$ x $7\frac{3}{4}$ x 9
Sterling A Supply	42.50	Tube	8	—	7 x 11 x 8
Valley Socket A	39.50	Tube	12	36	$9\frac{1}{2}$ x $5\frac{3}{4}$ x 11
White A Socket Power	43.50	Tube	9	39	$11\frac{1}{2}$ x 7 x $6\frac{1}{2}$

TWO GENERAL TYPES OF A UNITS

THE radio set can be operated from the light socket by the use of A and B power units, or by designing the receiver to operate with special a.c. tubes, receiving their filament current from the power mains. The purchaser of a new set finds his problem largely solved, for the makers of light-socket sets have engineered their sets beforehand. It is to the owner of a battery-operated set that this article is addressed.

A power units fall into two classes:

(a) units using a rectifier and filter system connected through a transformer to the a.c. line. (See Table I).
(b) units using a special storage battery in conjunction with a trickle charger. (See Table II).

The various A-power units listed in Table I are all essentially similar in design but they differ in minor ways that are of interest. All A-power units in Table I must contain (1) a step-down transformer (to lower the voltage of the line to the proper value required by the rectifier unit); (2) a rectifying unit (to change the reduced a.c. to a sort of d.c.); and (3) a filter system (to smooth out the product of the transformer-rectifier circuit). The filter must eliminate the "hum" which is always present in unfiltered, rectified a.c.

Enormous capacity in the filter condenser is necessary to remove this troublesome hum. With electrolytic condensers a capacity of 30,000 mfd. can be attained in a reasonable space and at reasonable cost, and such a large capacity as this is necessary for adequate filtration. The electrolytic condensers are shipped dry and when they are put into service, distilled water is gradually added to the condenser container. The contained chemical, which in some cases is potassium hydroxide, dissolves in the water. When it completely dissolves, the unit is ready for use.

These electrolytic condensers require practically no upkeep. Every six months or so a small amount of distilled water must be added. If the user is absent minded and lets the water get too low, the unit is not damaged, but indicates its need of attention by causing the unit to produce an audible hum which is heard in the loud speaker. If, "by a set of curious chances," too much water is put into the condenser unit, it will fail to function properly. Excess liquid can and must be removed with a syringe. When the water is first put into the condenser can some heat will be generated for a short time.

The Balkite and Abox units both use the form of electrolytic condenser discussed above. An interesting feature of each of these two outfits is that the chemical rectifier electrode is immersed in the same electrolyte used for the condenser. The outer plates of the condenser act as the second electrode of the electrolytic rectifier. This ingenious scheme achieves very compact construction. Both these units are supplied with external taps which insert resistance in the secondary circuit to control the output voltage. It is always advisable to use the lowest resistance tap that gives satisfactory results. In the Abox unit, there is a film of oil on top of the electrolyte which prevents excessive evaporation of the fluid. Both units require the addition of a small amount of water every six months but do not require any other attention.

Another interesting A-power unit uses the Raytheon "A" cartridge—a new type of dry rectifier. Units of this type are made by Electron, Marco, Valley, and Sterling. Some of these use one Raytheon cartridge, others two. The Marco product, for example, boasts two cartridge rectifiers. A rheostat in the primary circuit allows regulation for different loads. A meter on the front of the panel simplifies proper adjustment. Inside the box is a relay with silver contacts—to avoid sticking—so that the power unit can be controlled by the filament switch in the receiver.

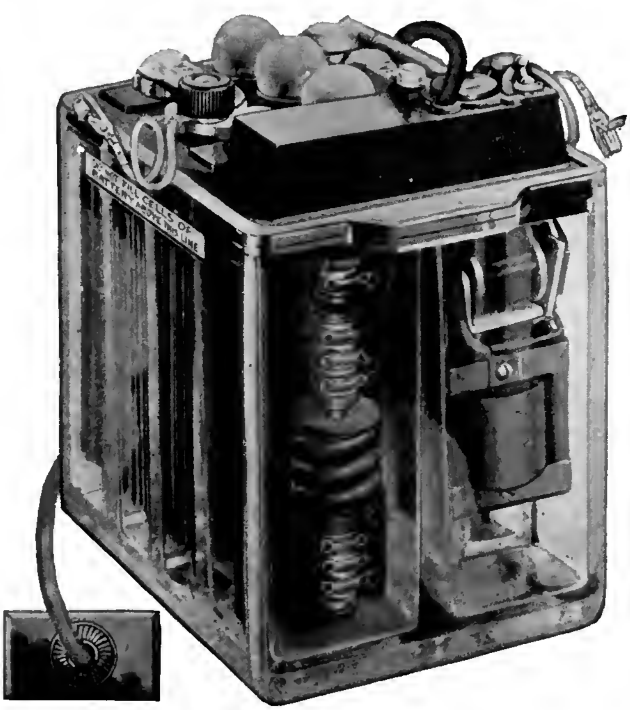
Either one or two Raytheon "A" cartridges may be used in the Valley A-power unit, depending on the number of tubes in the receiver to be supplied. Full-wave rectification obtains with the use of two cartridges. Valley suggests using the full complement of two cartridges for receivers with seven or more tubes. A single cartridge will suffice for more modest receivers. This Valley device also uses an electrolytic condenser to smooth the output of the cartridge rectifiers. Since it is shipped without liquid, the dry chemical may rattle in the condenser can and excite some curiosity on the part of the purchaser. The addition of water, according to directions, makes all things as they should be. Between the rectifier and filter system is the control rheostat which provides sufficient regulation for various loads imposed by the receiver.

The A-power unit from Sterling uses a single Raytheon cartridge, is equipped with an automatic filament circuit relay, a control rheostat, and a meter to facilitate the correct voltage adjustment.

The White unit among those listed in Table I is the only one on which we have information which uses a Tungar or Rectigon tube as a rectifier. The transformer in this device delivers about 8 volts to the plate and about 2 volts to the filament of the rectifier tube. The rectifier tube has a rating of 2 amperes, which, according to its manufacturers, is conservative; the unit, when operating under normal loads, should therefore have a long life. The filter circuit in this device, besides the usual electrolytic condenser, contains a 4-henry choke to assure complete elimination of hum. A calibrated rheostat to control the output is connected between the tube and filter system and the meter scale on the front panel enables the user to adjust the unit accurately and with ease. A six-foot cord with a pendant switch is supplied to control the a.c. input.

YOU WON'T RECOGNIZE THE STORAGE BATTERY

ALL the units listed in Table I are grouped there because they provide a source of A supply by utilizing a rectifier and filter system, while those of Table II combine a storage battery and trickle charger. There are many radio users who are convinced that the ideal A-socket power unit is one that is innocent of liquid of any sort. An unfortunate experience with the old storage battery may have instilled this dislike of an A-supply involving liquids. But as radio has developed and the inevitable and fortunate process of refinement has occurred, ingenious ways have been found to mould the storage battery into a highly desirable product indeed. Another school of manufacturing thought therefore has worked along these lines. They have taken the storage battery, designed it exactly to fit modern radio needs, and in the process have succeeded in producing a unit which has none of the disadvantages always quoted against it. Since any of the two distinct types of socket-power A units listed in Tables I and II supply satisfactory A potential to the receiver, and differ largely in the electrical means used to produce the direct current for the tube filaments, whether one chooses one type or the other is entirely a matter of personal preference.



THE VESTA GLASS ENCASED A-POWER UNIT

This is a combination storage battery and trickle charger combined with a relay so that its operation is entirely automatic. A distinctive feature is that the entire unit is enclosed in a moulded glass case so that all the parts are visible. The list price is $47.50

Storage battery makers, since radio became popular, have sought to reduce the routine attention demanded by the storage battery. Today's battery requires only the occasional addition of distilled water. Keeping the battery "up" is automatically accomplished by a trickle charger. By a study of the demands on storage batteries used by a wide variety of radio owners, sufficient data have been collected to accomplish a storage battery-trickle charger combination which needs only slight attention.

The principles of operation of this type of device have not been changed, but this year many important improvements have been made which insure satisfactory service and almost entire freedom from user attention. Unusually thick plates, especially designed vent caps, built-in "state of charge" indicators, conveniently located controls to vary the charging rate, and special cell construction to insure long life in trickle-charging service—all contribute to make the combination trickle charger and storage battery a convenient and satisfactory A socket-power unit.

Let us discuss some of the points of interest in these devices. The Acme A-power unit, type APU-6, is designed to supply 8 to 10 tubes. The battery unit can be charged at two rates: $\frac{1}{2}$ and $1\frac{1}{2}$ amperes. This wise provision permits adjustment of the unit to take care of the demands of a receiver with many tubes, or the lesser current requirements of a set with fewer tubes.

The Westinghouse "Autopower" has much to commend it. Our friends in East Pittsburgh have combined in a compact unit both a storage battery and an efficient trickle charging device, the latter developed during the last year. This rectifier, which is the heart of the charger, is interesting enough to merit a slight digression. Several years ago, it was found possible to make a solid body of matter conduct electricity more freely in one direction than in the opposite one. This was the origin of Rectox, the trade name of the rectifier used in the "Autopower" and some units by other makers, operating under Westinghouse licenses. The first materials to show this property offered three times as much resistance to the passage of electric current in one direction as in the other. The present Rectox units, developed after considerable research, have increased this resistance ratio of 3 to 1 to as high as 20,000 to 1 in the final units. The life of this rectifier unit is said to be indefinite.

A special clip on the front of the "Autopower" makes it possible to obtain three different rates of trickle charging. In addition, a "booster" rate can be used to revivify the battery if the receiver has been used for an excessive length of time. (One thinks of the $11\frac{1}{2}$- hour continuous Lindbergh broadcast of last June!) The unit contains a relay, which, when the set is turned on, automatically disconnects the a.c. from the trickle charger and connects it instead to two leads terminating in a plug on the side of the "Autopower" unit into which the connecting cord of a B-power unit is connected. When the radio receiver is turned off, the relay automatically closes the trickle-charger circuit and the battery begins to charge. At the same time, the relay opens the

TABLE II

NAME OF UNIT	WATTS INPUT	PRICE	MAX. NUMBER OF TUBES UNIT CAN SUPPLY	TYPE RECTIFIER USED IN CHARGER	SIZE L x W x H
Acme A power	—	$35.00	10	Tube	11 1/8 x 7 x 9 1/2
Autopower	22	35.00	10	Copper oxide	11 x 6 5/8 x 9 1/4
Basco A power	35	40.00	12	Tube	12 1/2 x 5 1/2 x 10
Compo	26	42.50	8	Tube	10 1/2 x 5 1/2 x 8 1/2
Exide Radio Power	17	31.90	10	Tube	11 x 5 6/16 x 9
Philco A Socket Power (603)	—	32.50	6	Electrolytic	12 7/8 x 9 1/2 x 7 7/8
Unipower—AC-6-K	24	39.50	10	Electrolytic	11 7/8 x 7 5/16 x 10
Universal	—	32.50	8	Dry disk	8 3/16 x 8 x 7 1/2
Vesta A Power	—	37.50	—	Dry rectifier or electrolytic	9 1/2 x 7 1/8 x 9 1/2
Greene-Brown	29	30.00	10	Tube	8 5/8 x 3 7/8 x 10 1/4

circuit to the B-power unit so that this unit is automatically disconnected. The "Autopower" requires no attention except the occasional addition of distilled water to the battery.

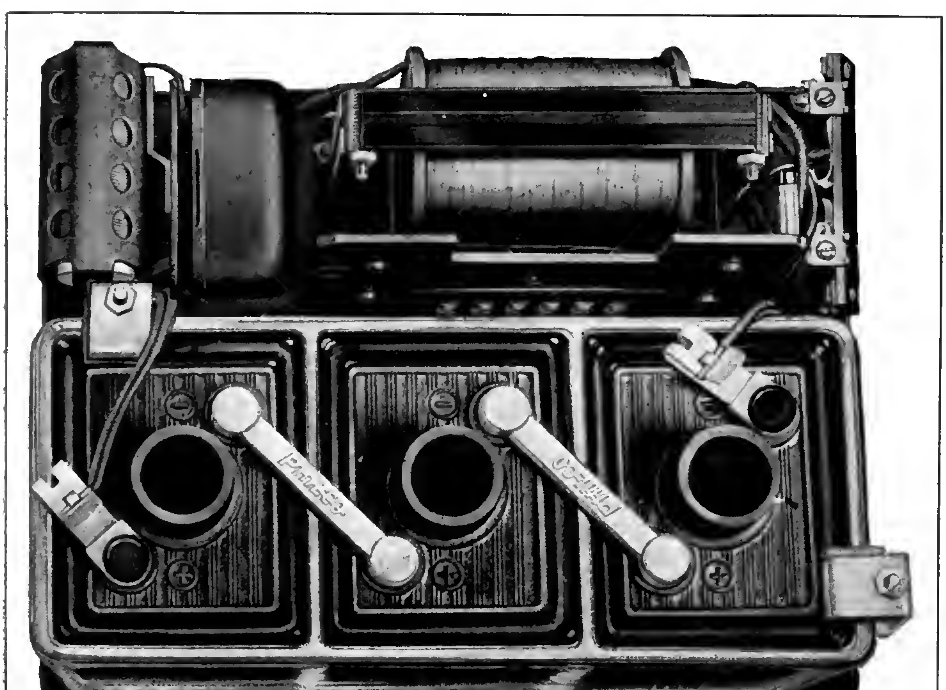
WHAT THE UNITS CONTAIN

THE Basco A-power unit contains in a single case the storage battery, the rectifier, an automatic relay (similar to the type just described above), an emergency switch, transformer, fuses, and a terminal board. The battery is an all-glass Exide unit with a capacity of 45 ampere hours. It is equipped with colored indicator balls to show the condition of charge. A thin film of oil on the surface of the electrolyte prevents undue evaporation and also prevents spraying and corroding of battery terminals. This battery has a large water space and the ordinary user will not have to add distilled water oftener than every half year. The Basco A unit is connected to the receiver just as if it were an ordinary battery and when the receiver is turned on, the current from the battery flows to the tubes and at the same time passes through an automatic relay which closes a circuit and makes 110 volts (for your B-power unit) available at a plug on the side. When you are through using the set, turn off the switch. The relay automatically opens the B-power unit circuit and puts the battery on charge. A Raytheon "A" rectifier is used as the charging rectifier. This rectifier has the advantage that its rate of charge automatically decreases as the battery becomes charged. Danger of overcharging is decreased. The "emergency" switch mentioned above is used to recondition the battery after it has stood idle for some time. Turning this switch recharges the battery at a high rate and inconvenience is reduced to a minimum.

A 35-ampere hour battery in a composition jar with a special cellulose moisture-proof pad on top of the plates and a paste electrolyte are features of the Compo A-unit. An eye-dropper full of distilled water in each cell about every four months is all the attention the unit requires. Three rates of trickle charging are available: 0.2, 0.4, and 0.6 amperes.

The Exide model 3A 6-volt A-power unit is designed to supply constant voltage direct current for the operation of the filaments of the tubes in any standard radio set. It comprises a storage battery and trickle charger with three taps, each affording a different charging rate. This rate depends, of course, on the number of tubes in the receiver and the number of hours the set is used. The battery is a standard Exide unit of excellent design and construction and contains ample space for excess electrolyte over the tops of the plates, thus making necessary the addition of distilled water only once or twice a year. The makers recommend it be used with the Exide master control switch which contains an extra plug for the a.c. supply for a B-power unit. The unit has a visible charge indicator consisting of two small colored balls so that the condition of the battery can be told at a glance. The entire unit is contained in a nicely finished sheet steel enameled case, fitted with two carrying handles.

The Philco A socket-power unit also affords a dependable source of filament potential. Philco has refined this unit in many ways during the last year to make it entirely fool-proof and economical in operation. The model 603A power unit, listed in Table II, consists of a high-efficiency transformer and rectifier with a battery especially designed for trickle charging service. The battery has unusually thick plates and separators. Spray-proof construction, preventing the leakage of electrolyte from the battery, and the built-in state-of-charge indicator, are two important improvements. These heavy plates and separators insure long life and freedom from the danger of internal short-circuit. Without the built-in Philco indicator there would be no simple means of determining the condition of the battery except through the use of a hydrometer and when it is used there is always the possibility that some acid will be spilled, incurring the righteous wrath of the housewife. Special vent-caps have been incorporated in the Philco units which make possible the addition of water to the battery without removing them. And water need not be added to these cells oftener than twice a year. Water will flow down these vent-caps, but it is impossible for any of the enclosed acid to leak out. In normal operation the vent-caps need never be removed. Philco units employ an "economizer" which permits the user to adjust the charging rate to the lowest current consumption which will, at the same time, keep the battery properly charged as shown by the visual indicators. By using the lowest possible rate, gassing of the electrolyte is prevented, and this reduces the frequency with which water need be added. Three charging rates are available with a "booster" rate for emergency use. The batteries are in a glass container. Philco units can be had for operation on 25- 30- 40- 50- or 60- cycle a.c. Type A603 is designed to supply up to six tubes and type A-36 is designed to supply up to ten tubes. The latter type contains a dry trickle charger which provides three rates: 0.25, 0.5, 0.26 amperes and a 1.0-ampere rate for booster service.



A PHILCO UNIT

This Philco unit incorporates several interesting features among which are a visible indicator of the state of charge of the battery and special vent caps on the battery which absolutely prevent any acid from leaking out of the battery. These vent caps do not have to be removed in order to add water to the battery

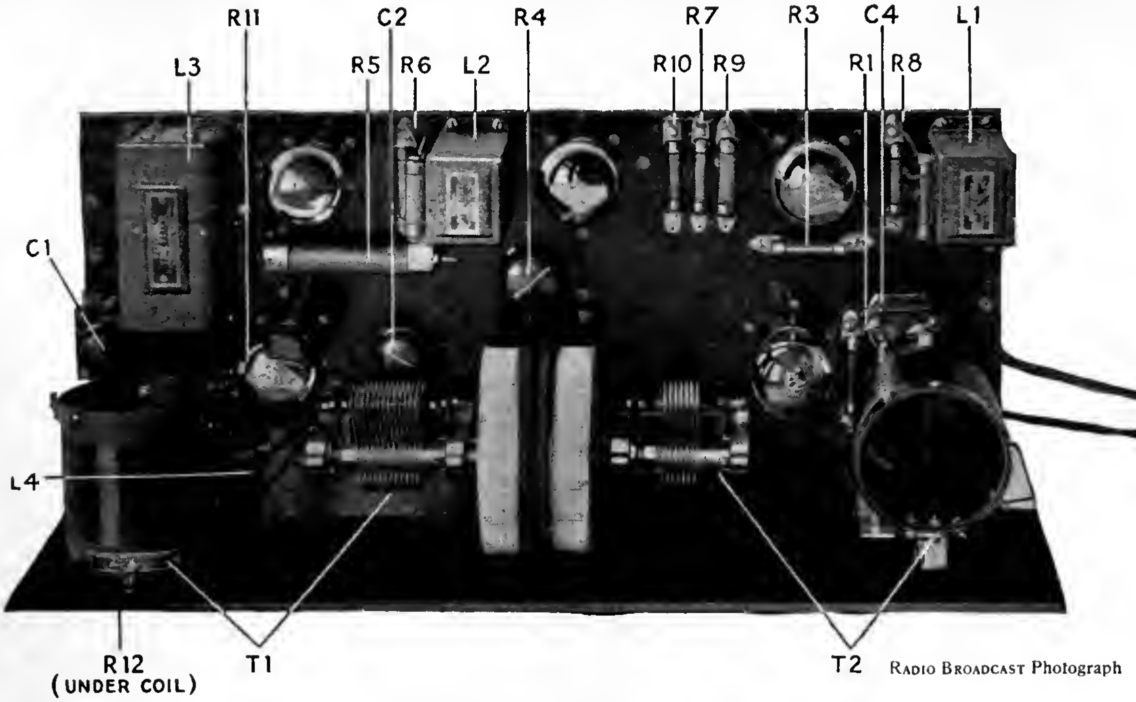
The Unipower type Ac-6K provides, according to its makers, three unique features. First, a "Kathanode" cell construction which insures long battery life; secondly, an automatic cut-off in the rectifier cell which suspends charging if the user fails to add water when necessary, and third, five charging rates with a high rate of 1½ amperes—meeting the requirements of all grades of receivers.

In the "Kathanode" design, porous glass wool mats are fitted against the positive plates to prevent the shedding of active material which frequently occurs if the battery is overcharged. The glass mats, by capillary action, draw fresh acid to the plates, increasing efficiency. The Unipower, cased in rubber, contains three "Kathanode" constructed battery cells, a rectifier cell, a transformer, as well as the essential switches, terminals, and connections. All these cells are watered at once and the rectifier is designed so that when the level of electrolyte exposes the tops of the cell plates, the charging current is automatically cut off until water is added. The makers feel this safeguard is essential to the proper operation of the battery. On the front of the unit, a dial regulates the charging rate, which ranges from 0.25 to 1.5 amperes in five steps.

A Rectox dry disk rectifier is used in the Universal A-power unit. The 36-ampere-hour battery is assembled in a three-compartment glass jar with mounted hard rubber covers. This A-power unit has a visible state-of-charge indicator, and the whole device is supplied in a steel container.

One of the first battery-trickle charger combinations received in the Laboratory in which glass was the container was the handsome Vesta A-power unit. Vesta now makes two A-power units, one containing an electrolytic trickle charger and the other a dry trickle charger. A visible charge indicator shows the state of the battery; when the three colored balls float at the top of a small compartment, the battery is fully charged and as the charge decreases, one ball after another gradually sinks to the bottom of the compartment. The Vesta unit has a socket into which the a.c. plug for the B socket-power unit may be plugged.

So the A-power devices of 1927 look and perform very differently from the indiscriminate units with which the radio user of some years ago was content. If a variety of A-power devices are offered the purchaser and he does not know what type to use, he should ask his local dealer to install them in his home so he can easily choose the one which best fits his own needs and his local conditions.



Radio Broadcast Photograph

A NEW BROWNING-DRAKE RECEIVER

The new Browning-Drake receiver shown above is to be described constructionally next month. It has been designed for complete a.c. operation although batteries may be used if desired. This first article discusses the various a.c. tubes suitable for the purpose

Electrifying the Browning-Drake

A Discussion of the New A. C. Tubes and How They May Be Incorporated in a New Design Browning-Drake Receiver

By JAMES MILLEN

WITH the availability of really good a.c. tubes, another and important step toward the ideal radio set is made. With the a.c. tube, no storage battery or A-power unit is required. All that is necessary is merely a compact little transformer for decreasing the line voltage to a suitable operating value. As far as actual performance is concerned, the new a.c. tubes are essentially the same as the well-known 201-A or 301-A type tubes. The person with a set equipped with standard tubes will not improve the performance of his set by changing it over for a.c. tube operation. If his storage battery, charger, and tubes are in good condition, there is nothing to be gained by such a change. If, however, the batteries have about run their useful life, or if the charger has died of old age, the new tubes offer a number of worthwhile attractions to the home constructor. First, they open new fields for experiment; second, they enable him to build a completely lamp-socket operated receiver for less money than a battery operated receiver with its associated storage battery and charger, and at the same time there results a receiver somewhat simpler to maintain.

Once a few of the little tricks of the use of a.c. tubes are acquired one will have no difficulty in constructing any of the popular circuits for a.c. operation or in replacing old tubes in any standard receiver with new a.c. tubes. Perhaps the best way of acquiring this knowledge is to carefully follow the details in connection with the construction of some popular circuit for use with the new tubes. With this in mind, we have selected the Browning-Drake as one of the most popular receivers which has been described in past issues of Radio Broadcast, and have redesigned it not only for complete a.c. operation, but also to incorporate the latest ideas on layout, audio amplification, and other slight modifications of the original Browning-Drake circuit. Furthermore, the set has been so designed that it may, if desired, be wired for battery operation where the constructor is not so fortunately situated as to have a.c. on tap. The photograph gives an idea of how the completed receiver looks. Complete construction data on this set will be given in the next article. In this article we will consider some of the general problems involved in the use of a.c. tubes. First of all let us consider the different a.c. tubes available for all but the last audio stage. The last audio, or power tube, be it of the 112, 171, or 210 variety, may be operated on raw a.c. just as well as on batteries. No special a.c. tube is required, therefore, in the last audio stage.

It will be seen from the table on the next page that the a.c. tubes may be divided into two general types, *i. e.*, those using a low-voltage high-current filament, and those having a separate heater element. The heater type tubes are better suited as detectors than the filament type, but either type are about equally well suited as radio and audio amplifiers. Since the heater tubes are, in general, more expensive and have shorter lives, it is advisable to restrict their use to the detector socket.

The different filament heating transformers available are mostly designed for direct operation with the RCA-Cunningham tubes without the use of rheostats or other resistors. The voltage taps on some of the transformers available at present are:

Manufacturer	Taps (in Volts)
Amertran	1.5, 2.5, 5.0
Dongan	1.5, 2.5, 5.0
General Radio	2, 3.5, 5.0, 7.5
Modern	1.5, 2.5, 5.0
National	1.5, 2.5, 5.0
Silver-Marshall	1.5, 2.5, 5.0
Thordarson	1.5, 2.5, 5.0

When a.c. tubes of other manufacturers are used with transformers having the proper taps for the RCA-Cunningham tubes, special rheostats made by General Radio and Carter should be used in the low-voltage transformer leads. When tubes of the Armour-Van Horne type are used throughout, then two short lengths of resistance wire with a total resistance of about 0.1 ohms should be inserted in the leads to the detector and audio amplifier tubes so that they operate at a slightly lower voltage than the radio-frequency amplifier tube. Several manufacturers make special resistors for just this use.

Where the Kellogg tube is used only as a detector, the 2.5-volt filament transformer winding will be found just right. Where Kellogg tubes are used throughout, then the 1.5- and 2.5-volt windings should be connected in series (that is, so that their voltages add rather than subtract) to give 4 volts which may be dropped down to the desired 3 volts with a suitable rheostat or fixed resistor. The filament voltages required by any of the tubes are far from critical and the tubes will be found to perform excellently with voltages considerably below the rated values. Operating the detector at a lower voltage often results in almost complete elimination of any hum. If the heater voltage of a UY-227 detector is excessive, the set will cease to regenerate, and, in fact, practically stop operating. Generally, about 2.2. volts seems to work best with the 227's when used as detectors and a six-inch length of wire from an old-ten ohm rheostat, in series with one of the 2.5-volt transformer leads, will give this lower voltage.

The 1.5- and 2.5-volt transformer windings should not be center-tapped as potentiometers located close to the tube sockets are necessary for the best results. The 5-volt winding for the 171 or the 7.5-volt winding for the 210, however, may just as well have a center tap and thus eliminate the need for one potentiometer. The detector and the power-tube filament circuits should be wired with No. 18 equivalent rubber covered twisted wire. The proper size wire for the radio and first audio stages, containing high-current tubes, may be determined by estimating the total current drawn by these tubes from the table of characteristics and then selecting a wire that will carry such a current from the table below. In the case of the Browning-Drake receiver using RCA tubes, No. 18 may be used, but if the Van Horne-Armour type tubes are used, then No. 16 will be necessary. The following table gives the current-carrying capacity of rubber covered copper wire:

Wire Size	Current
14	11 amperes
16	6 "
18	3 "
20	1.5 "

THE R. F. AMPLIFIER

EITHER the heater or the filament type of tube will work well in the radio stages, but because of its longer life, lower cost, and simpler connections, the filament type is generally to be preferred. There is, however, one real advantage that the heater types have over the filament types when used with some circuits, and that is lower inter-electrode capacity, which often facilitates neutralization. The filament type a.c. tube may be employed in the r.f. stage of a Browning-Drake receiver with materially improved results over those obtained with the customary 199 type tube.

While frequently no negative grid bias is employed on the r.f. tubes in a battery operated receiver, the use of this bias is essential with the a.c. filament type tube. This biasing voltage may be obtained from a C battery or by utilizing the voltage drop across a suitable resistor which can also provide the bias for the first and second audio-frequency stages.

The optimum r.f. tube plate voltage for minimum hum does not seem to be at all critical and the 67½-volt tap on the average B supply unit gives as good results as any, with less tendency for the radio-frequency stage to oscillate than when the 90-volt terminal is used. The C bias on the r.f. tube should be a little more negative, for a given plate voltage, than on the a.f. stages. The use of a somewhat lower plate voltage on the r.f. tube than on the a.f. tubes permits the use of the same C voltage on both the audio- and radio-frequency tubes.

The use of a.c. tubes and a B power unit make two of the forms of volume controls considered more or less standard with battery operated receivers—the r.f. filament rheostat and the variable series resistor in the r.f. plate circuit—unsuited for the electric receiver. There are, however, at least two other systems of volume control which will give satisfactory results. One is a variable antenna coupling coil, and the other is a variable resistor across the primary of the r.f. transformer. By this means it is possible to control the volume by varying the r.f. input to the detector circuit.

A potentiometer across the filament circuits of both the radio and first audio stages must be employed. As the voltage is low, this unit may be a 30-ohm rheostat with a third connection made to the "open" end of the winding. As this potentiometer may, from time to time, require a minute change of adjustment, it is well to locate it in some convenient place on the sub-panel. The potentiometer should not in general be mounted on the front of the panel, as for best results it must be hung directly across the filament leads at about an equal electrical distance from all the tubes. The adjustment of this potentiometer is quite critical, and a very slightly different setting is frequently required at night than during the day in order almost completely to eliminate all the hum—and the hum can certainly be reduced to a very low order if the receiver is carefully constructed and adjusted.

A. C. TUBES IN THE AUDIO AMPLIFIER

AS THERE is nothing to be gained by the use of the more expensive heater type tube in the first audio stages, the filament type is to be recommended. As already mentioned, the one potentiometer and grid bias resistor serves both the radio and the audio stages. In the case of the UX-226 (CX-326) tubes with 90 volts on the plate, the grid bias should be adjusted until the drop across its terminals, as measured with a high-resistance voltmeter, is about 6 volts. In the case of the Browning-Drake receiver to be described in detail next month, a fixed 500-ohm wire-wound resistor is used to obtain C bias and this value of resistance is just right. Any of the several different forms of audio amplification may be employed with excellent results.

Where the grid bias for several stages is obtained by taking the voltage drop across one resistor, as in this case, then the use of a "grid return filter" in each stage is recommended and such filters have been used in the a.c. Browning-Drake receiver. These filters merely consist of a 0.1-megohm resistance and a 1-mfd. condenser connected so as to prevent any of the audio-frequency currents from flowing through the grid bias resistance. In the last or power stage, the 171 is recommended as the tube best suited for home use. A 2000-ohm wire-wound resistor will automatically provide the proper grid bias for this tube regardless of the plate voltage, within reasonable limits. A loud speaker protective device to eliminate the direct current from the loud speaker windings should be employed.

THE DETECTOR

WHILE either form of a.c. tube may be used as a detector, the UY-227 type of heater type tube has several advantages over the filament type. First, the a.c. hum can be, for all practical purposes, entirely eliminated. The hum from a filament type a.c. tube is not what could in any way be termed objectionable, yet, it is there. The heater tube may be used with either a grid-leak condenser arrangement or with C bias, whereas, the 226 type of tube, while it will function quite well with a grid-leak condenser, is better suited for plate rectification. Plate rectification, however, is not as sensitive as the grid-leak condenser arrangement and its use in connection with an all a.c. operated receiver also leads to other complications. The Kellogg a.c. tube may be used as a detector with excellent results.

In using the heater type tube as a detector, either a negative or a positive bias of about 40 volts or so should be applied to the heater element by means of a potentiometer. In some instances a positive bias seems best and in others, a negative, and either of these biases are readily obtainable from the 40-volt tap supplying C bias to the power tube or the plus 45-volt tap for the detector. The adjustment of this bias voltage is not at all critical, and once set, will require no further attention. In fact, a fixed resistor with center tap, such as the type 438 General Radio, will serve the purpose excellently. This resistor is so designed as to mount directly on the terminals of the detector tube socket.

In a second article which will appear next month, constructional details and adjustment suggestions on the a.c. Browning-Drake receiver will be given.

A. C. Tubes

Name	E_f	I_f	I_p	R_p	M_u	G_m	E_p	E_g
Heater Type								
C-327	2.5	1.75	4.2	8600	7.8	905	90	−4.5
UY-227	2.5	1.65	3.5	10350	8.7	860	90	−4.5
McCullough	3.0	1.0	4.2	9400	8.6	870	90	−4.5
Sovereign	3.0	1.5	4.6	9100	8.5	935	90	−4.5
Marathon	5.5	1.0	4.2	9500	7.3	775	90	−4.5
Arcturus	15.0	0.35	3.1	12150	10.5	870	90	−4.5
Magnatron	2.5	1.50	4.6	8700	9.3	1070	90	−4.5
Filament Type								
CX-326	1.5	1.05	4.6	9000	8.5	935	90	−4.5
UX-226	1.5	1.05	4.4	9150	8.7	950	90	−4.5
Armor	1.0	2.4	3.8	11200	7.8	690	90	−4.5
Van Horne	1.0	2.0	4.4	9000	9.0	1000	90	−4.5
CeCo	1.5	1.05	2.8	14200	9.2	730	90	−4.5
Magnatron	1.5	1.05	4.0	10800	8.8	830	90	−4.5

E_f = Filament Volts I_p = Plate Current
E_p = Plate Volts R_p = Plate Resistance
E_g = Grid Volts M_u = Amplification Factor
I_f = Filament Current G_m = Mutual Conductance

"Our Readers Suggest—"

THESE two pages are reserved for the many interesting contributions from our readers, some of whom may have run across many ingenious ideas in the operation of broadcast receivers and accessories. These pages will appear regularly in RADIO BROADCAST *and all contributions accepted will be paid for at our regular rates. In addition, each month, a prize of $10 will be paid for the best contribution published.*

Contributions are especially desired about changes and simple adaptations dealing with ready-made receiving sets and accessories. Those who have made their own receivers are, in a sense, experts, and are usually well aware of the possible improvements in the use of their own equipment. Each contribution will be published as the writer prepares it, telling how he solved his problem, to which will be added some comments from the staff. Address all contributions to The Complete Set Editor, RADIO BROADCAST, *Garden City, New York.*—THE EDITOR.

Rewiring an Atwater Kent Receiver for A. C. Tubes

THERE seems little doubt in the minds of engineers that the alternating-current tube will eventually find a place in the majority of radio receivers. It is in anticipation of this eventuality that RADIO BROADCAST has already devoted considerable space to the problems of A battery elimination and the characteristics of a. c. tubes. We are interested in the following description of how a reader, Henry March, of New York, altered a popular type of receiver for a. c. operation, necessitating few and simple circuit changes. He writes:

"It has been my pleasure to discover that the Atwater Kent Model 35 receiver can be easily adapted to a. c. operation through the use of a. c. tubes. I presume that the same simplicity of conversion holds true for many other receivers—a fact that may interest your readers.

"I rewired my receiver for Arcturus tubes (type 28 amplifier, type 26 detector, and type 30 power tube), choosing these tubes because of the fact that they plug into the four-prong socket which is standard equipment on practically all receivers wired for storage battery tubes. Thus no additional filament wiring or special sockets are required—greatly simplifying the necessary changes, which are illustrated clearly in the accompanying diagrams. Fig. 1 shows the original wiring in the receiver. The parts of the circuit to be changed have been drawn in heavy lines. Fig. 2 shows the circuit with the changes made.

"All grounds have been eliminated from the filament circuit. The lower terminals of all r. f. and a. f. secondaries, excepting that of the power tube, have been grounded. The detector grid return to the potentiometer has been eliminated, and the return is now effected through a 4.5-to 9.0-volt C battery, *positive to the grid.* Detector C minus is connected to the B minus post. The plus terminal of the main C battery also connects to B minus. Minus 1.5 C battery is grounded (supplying the r.f. tubes), while 22.5 minus runs to the power tube in the usual manner. A Centralab modulator is connected across the secondary of the first audio transformer as a volume control.

"The a. c. filaments are operated from an Ives step-down 'toy' transformer (type 204) at the 14.5 volt tap. All plate voltages remain the same as in the d.c. set, excepting that 180 volts is applied to the output power tube, increasing the possible undistorted power output of the receiver."

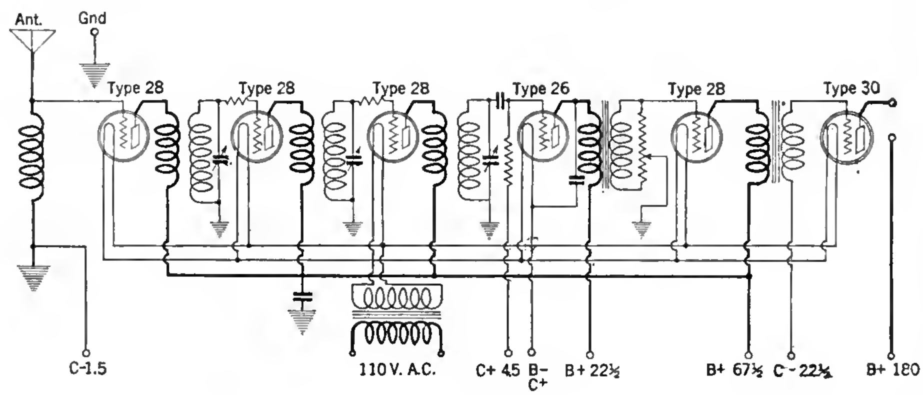


FIG. 2

STAFF COMMENT

AS OUR contributor suggests, a. c. tubes of this type (the characteristics of the Arcturus tubes are given on page 34) may be used in many receivers after relatively simple changes have been made. However, the operation of alternating-current tubes is essentially a complicated proposition, and it is recommended that readers secure specific information on the changes required in their particular receivers before proceeding with the alteration. This information can generally be secured from the manufacturers of the tubes selected, and from the technical department of this magazine.

However, a few generalities may be laid down for the adaptation of d. c. receivers to a. c. operation. Much of this is covered diagramatically in the accompanying circuits.

All grounds must be eliminated from the filament circuit. Ground all secondaries (filament side) having the same negative bias. A bias of minus 1.5 to 3 volts is generally applied to all r. f. grids.

Run the two filament wires as close together as possible, lacing or twisting them when convenient. Be sure that all plus filament posts are connected together. Connect minus B to what previously were the positive posts. Connect the r. f. and the a. f. C plus and the detector C minus to B minus.

Eliminate all filament rheostats and potentiometer r. f. controls. It is not practicable to use these forms of volume and sensitivity control with a. c. tubes. With the potentiometer device, sensitivity is governed by varying the bias on the r. f. tubes which, with a. c. tubes, would introduce hum at certain adjustments. A 250,000-ohm variable resistor connected across the r.f. secondary preceding the detector tube is a preferred volume control.

Receivers wired for four-prong base a. c. tubes can be used with d. c. tubes at any time, merely by substituting an A battery for the transformer. No other changes are necessary for d.c. operation of such a receiver.

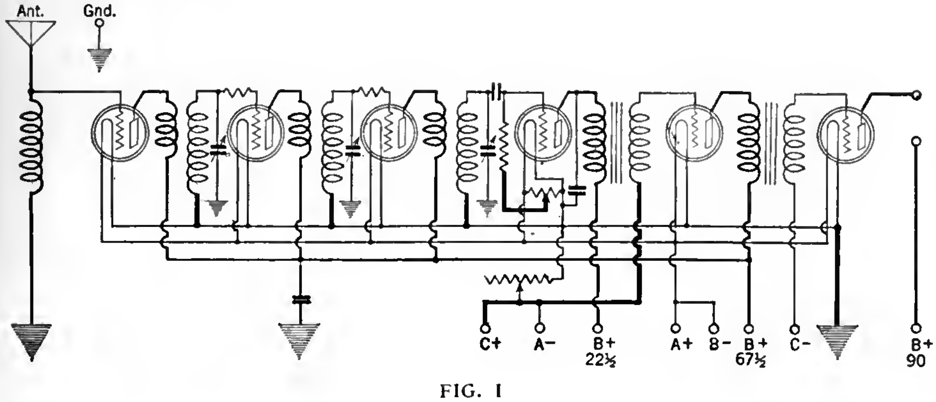


FIG. 1

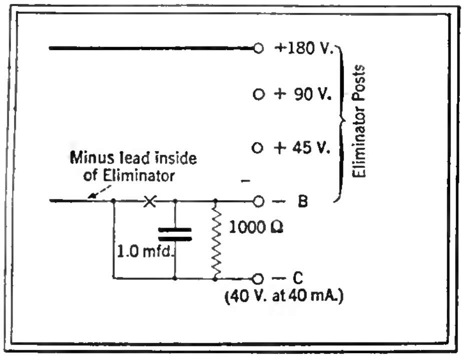


FIG. 3

C Bias from a Mayolian Socket Power Unit

B-SOCKET power units in the future will undoubtedly incorporate extra resistors making it possible to secure C bias for at least the power tube. It is not difficult to incorporate this feature in the average power unit along the lines described by a contributing reader, James J. Corrigan, of Des Moines, Iowa:

"I have a Mayolian B power unit, the utility of which I have doubled by adding an extra resistance and bypass condenser. The drop across the resistance supplies the C voltage to my power tube.

"The lead to the negative binding post is broken at 'X' inside the case (Fig. 3). A 1000-ohm, two-watt resistor is connected in the break and by passed with a 1.0-mfd. condenser. The post marked B minus connects as usual to the receiver, while the C bias voltage is tapped in the eliminator side of the resistor. A forty-volt C battery is supplanted by this means.

STAFF COMMENT

THIS is a simple and practical method of C battery elimination, readily applicable to all eliminators giving voltages, under load, in excess of 180. The C voltage is necessarily subtracted from the B voltage, and the compromise is sometimes undesirable. If your eliminator has a no-load potential of about 250 volts, C elimination is quite worth while. Many B-socket power units fill the bill. Among them are: Kodel, Burns, Greene-Browne, Kellogg, and General Radio.

However, the use of a fixed resistor is not recommended as it is almost impossible to secure the right bias. It is suggested that a variable resistor, connected as shown in Fig. 4, be used instead. Amsco Products manufacture a zero to 2000-ohm variable resistor known as a Duostat, made especially for this purpose. It is equipped with two variable arms, making it possible to secure two C bias potentials, one for the power tube and one for the other a. f. tubes. Each arm of the Duostat must be bypassed with a 1.0-mfd. condenser. Other variable 2000-ohm C bias resistors are made by Carter and Electrad.

A rough adjustment of the bias potentials can be made by ear. However, a much more scientific job can be done with the aid of a small milliampere meter, reading up to 25 milliamperes. This should be placed in the plate circuit of the tube on which the bias is being adjusted. The variable arm is moved until, on a loud signal, the needle is motionless, or practically so. Any movement of the needle is an indication of distortion. If the needle kicks up, turn down the resistance (lowering the C bias); if the needle kicks down, increase the resistance.

This careful adjustment is generally made only on the output tube. The meter is connected in series with the loud speaker, or the primary winding of the output device if such is used. As the power handled in the preceding tubes is generally small, a rough adjustment by ear is adequate.

Getting High Notes from the Resistance-Coupled Set

I HAVE a Ferguson Model 12 receiver, in which were incorporated three stages of resistance-coupled amplification. I operated this set in conjunction with a Western Electric 540 AW cone loud speaker. While the tone quality of this combination was distinctly superior to that of the average set, there was, at times, a disconcerting rumble on low notes, which quite counteracted my pleasure in the unusual reproduction of these

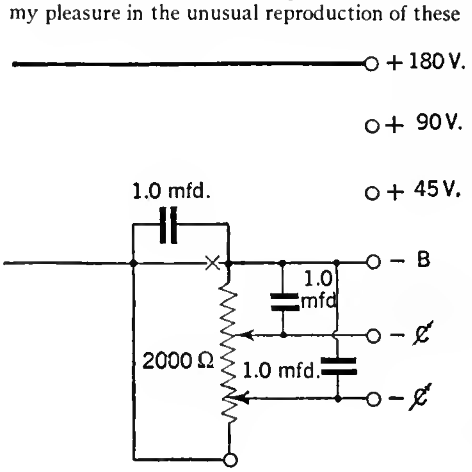


FIG. 4

low frequencies. There seemed to be a resonance point in the output system in the neighborhood of fifty cycles. A friend of mine has an impedance-coupled set, which, while quite free from the particular disturbance I mention, is distinctly partial to higher notes. It occurred to me that a compromise between resistance and impedance coupling might be ideal in my particular case.

Upon the advice of an experienced fan, I removed the coupling resistor from the second audio stage, and ran two wires from the prongs to the primary of an old audio-frequency transformer. I left the grid leak exactly the same as when resistance coupling was used (See Fig. 5).

The result is most gratifying. There is no longer any rumble on the troublesome notes, and it seems to me that the speaking voice is cleared up a bit . . . it is more natural. Also there is a slight improvement on the higher notes such as are occasionally reached by sopranos and violins. A certain vague sense of muffled sound has altogether disappeared.

STAFF COMMENT

THE experimenter writing the above experience, Frank Wendell, of Los Angeles, has accomplished what is being done nightly in the large broadcasting stations, where the process of balancing the scale of frequencies is known as "equalization."[1] With outside or "nemo" pickups, transmitted over landline to the broadcasting station, certain frequencies are transmitted with less fidelity than others, and the boosting up of the delinquent tones is accomplished in much the same manner as our correspondent brought up his high notes.

The average cone loud speaker in comparison with the average horn, is much better on the low notes. The same holds true of the resistance-coupled amplifier as compared with other amplifying systems; but this type of amplifier also has a distinct cut-off on high frequencies. The combination, therefore, is one that favors the low frequencies—often to such an extent that there exists the low-frequency rattle referred to.

In the case under consideration, the high notes have been boosted by substituting a reactance in place of the resistance. It is probable that the response curve of the reproducing system has been leveled out a bit. That is, all frequencies reach the ear with a closer approach to their relative amplitudes or volumes.

Taking out a coupling resistor and substituting a comparatively low inductance choke coil will always increase the amplification of the higher notes more than it increases the amplification of the low notes. The lower the inductance of the choke coil, the more will be the difference. There is no reason why the average broadcast fan should not improve reception by "equalizing" his receiver in this manner. A resistance-coupled amplifier (in any receiver) most easily lends itself to changes of this nature.

VARYING THE AMOUNT OF EQUALIZATION

AN ORDINARY amplifying transformer is probably the most readily available form of inductance or choke coil. The primary, in the case of the average transformer which may be on hand, should be used.

The high notes will be brought up most if only the primary of the transformer is used. There will be less difference from straight resistance coupling if the secondary is used. Different degrees of equalization will be obtained if the primary and secondary are connected in series, with, first, the grid and plate posts strapped (using the B and F posts as terminals) and, secondly, with the grid and B posts strapped.

The grid leak of the tube outputting to the choke coil is not touched but the bias applied through the leak should be increased by about 4.5 volts.

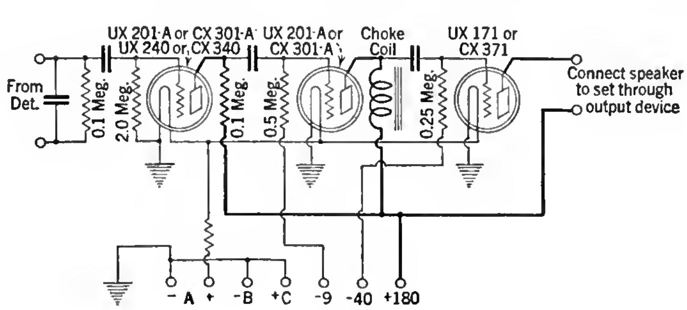


FIG. 5

The Listener's Point of View

LISTENERS—GUESTS OR CUSTOMERS?

By John Wallace

A READER at Long Beach, California, addressed us not long ago as follows:

SIR:

May I be permitted to call to your attention the excellent and timely article appearing on page 15 of *Radio News* for July, 1927, entitled "The Fly in the Ointment," by one Nellie Barnard Parker?

A great many listeners hereabouts were struck by the miserably poor taste displayed by the writers of the "can't-the-announcer-be-choked" and the "sprayed-with-petroleum" telegrams to which the writer refers; and one of us, at least, was equally impressed by the sportsmanship displayed by the announcer in reading such telegrams to us at all. I think that you will agree with the author of the article in question that '. . . when a company has spent thousands of dollars to broadcast a program, it has bought the right to let you know who your host is and what it has to sell.'

I, for one, would like to see a similar stand taken by RADIO BROADCAST; and I believe that such a stand, in your columns, would more nearly present the average "Listener's Point of View" than does much that now appears there.

G. I. RHODES.

Here, indeed, was an invitation for your department editor to adopt a policy—and if there is anything an editor, of any variety, keeps an eagle eye out for, it is "policies." Policies are what enable him to get his stuff written. So we swam into the article, a most entertaining one.

The specific fly in the ointment complained of was an incident in connection with the broadcasting of opera by KFI and KPO last season, as the indirect advertising donation of a certain petroleum corporation.

The opera broadcast was unquestionably one of the outstanding musical treats afforded West Coast listeners that season. In the intervals between the acts the announcer read a number of telegrams of commendation and explained, with some precision, just who was financing the broadcast. "And then," says the author of the article referred to, "right out of the sky, came the fly in the ointment! A man wired in: 'We are enjoying the program but can't the announcer be choked off and let us have opera without telegrams and advertising?' And pretty soon another 'guest' wired his objections against being 'sprayed with petroleum' while he listened. Clever, yes, but it struck one listener at least that when a company has spent thousands of dollars to broadcast a program, it has bought the right to let you know who your host is and what it has to sell."

That was the case in question. We are hardly fitted to pass on its merits since we didn't hear the broadcast. It is quite possible that the number of telegrams read and the amount of advertising dished out were entirely within the bounds of reason. In fact this seems probable if there were but two unfavorable comments on it. As the writer points out with some show of logic, the reading of a telegram of commendation suggests the sending of them to other listeners, and if a large number is received "they are permanently bound and the next time there seems a possibility of interesting some firm in paying the fiddler for an expensive program, this bulky volume is brought forth." Thus the telegram reading may in some cases react finally to the listeners' benefit.

But departing from this particular instance wherein the adverse criticism may not have been entirely warranted, the writer goes on to generalize and takes the stand that adverse and destructive criticism of a better-than-average program is never justifiable. This, it seems to us, is stretching the point to absurdity. She says:

> You are free to steer your airship where you please, casting out your line knowing that there are just as good tunes on the air as ever were caught. Such being the case, why send in thoughtless messages to mar the perfect pleasure of your host? Let him sing his little solo without having the anvil chorus crab the act!
>
> It is only fair to say that those who criticise the big programs are in the minority, but there are just enough of them to destroy that fine edge of joy and what-a-good-boy-am-I feeling the sponsors and operators have.
>
> Every graduate operator of a radio is a supercritic of the air. Like an insect of the ether, the true radio bug goes sniffing through the air with his little feeler; when he "contacts" with something he likes, he settles upon it with a pleasant little hum. But if it pleases him not, he is liable to plant a sting, if he is that kind of a bug. How much nicer it would be if he would remember that the sponsors and announcers are just big boys trying to get along! They are not inoculated against praise. It takes on them beautifully and they break out with brighter and better programs. They invite and welcome constructive criticism and helpful suggestions, but mere "razzing" and discourtesy never fanned a generous impulse into flame. Just be human, kindly and courteous, remembering that the announcer, like the fiddler, is doing the best he can.
>
> And don't be the fly in the ointment!

We quote this writer at such length because hers is a point of view that is all too widely held, namely: that the purveyor of radio programs is your host and that all the rules for polite drawing room conduct should operate in your attitude toward him.

When a man invites you to his home for dinner he does so as a private individual, and however burnt the potatoes may be, it is not common politeness for you to throw them at him. But if the same man sets up a restaurant and you happen in there to eat, you are perfectly justified in calling him all sorts of names if his chef has too highly seasoned the lobster *thermidor*. He has removed himself from the rôle of private individual and become a purveyor to the public. He has become, to use the word loosely, an artist, and by universal assent any and all of the products of the artist are open to criticism and he may not protest. By his very act of setting himself up as an artist he tacitly agrees to submit to any opprobriums that the citizenry feels inclined to hurl at him. This is true of every sort of artist—chef, singer, movie producer, poet, electric refrigerator manufacturer, sculptor, street cleaner, painter or sponsor of broadcast programs.

If a man wants to buy himself a box of paints and surreptitiously records on canvas his impression of the cherry tree in the back yard or sunset on the drainage canal no one has a right to comment on the way he does it. It is entirely his own affair as long as he keeps it his own affair by contenting himself with hanging the finished works on his own wall. But if he starts sending his pictures to the exhibition galleries he, by that gesture, professes himself to be an artist, and his work to be art; and he automatically becomes perfectly legitimate meat for anyone to pounce upon who cares to.

If what he exhibits as art is inexcusably bad, the good name of Art is threatened. And since Art is not his own private possession but is held by common consent to be in the custody of the great unwashed public, it is incumbent upon that public to weed out with vituperatives anything that threatens to cast a smirch upon it. The commentary that the public makes is known as Criticism. Criticism may be of many kinds, favorable or unfavorable, constructive or destructive, gentle or splenetic, competent or incompetent. The writer of the article discussed, and those of the same misguided frame of mind, would object to any criticism that does not fall into the category of favorable or constructive. This is obviously silly and results from a complete misconstruction of the function of criticism. Gentle-spirited sentimentalists get all hot and bothered

THE SANKA AFTER DINNER COFFEE HOUR AT WEAF

Heard over this station on Tuesday evenings at 7:30. They should receive some kind of reward for getting the maximum number of words into the title. Anyhow, here are the performers and are filled with great sympathetic aches when some public performer gets it in the neck from a sharp tongued critic. They decry the critic as mean and lacking in human qualities. But in the case of a genuine artist their sympathy is wasted. A true artist doesn't mind adverse criticism—much; he is his own best judge of whether his work is good or bad. On the contrary he is rather stimulated by it. Splenetic or strongly biased criticism may be far more effective in egging him on to do better work than soporific boquets. The only criticism to which he is likely to object is the incompetent kind—and of this there is, of course, plenty.

The two critics of the KFI-KPO opera broadcast may have been incompetent; they may not have been aware of all the facts, viz.: that a certain amount of advertising was necessary if the broadcast was to pay for itself. As we have said, we did not hear the program and do not know whether this reading of telegrams was carried to excess or not. But not all criticism of radio programs by minority calamity howlers is incompetent. A great deal of it is very much to the point (including, of course, all our own sage pronunciamentos.)

The fact that a majority of the listeners are perfectly satisfied with the way any given radio program is presented does not mean that any criticism on the part of a few of the minority is worthless. The oft-repeated phrase about *giving the public what it wants* is, at best, just a phrase. True, some effort is made in this direction, but the public is not at all sure what it does want, seldom expresses itself on the subject, and finally, finds it the course of least resistance to *take what it gets*.

The masses continue to be satisfied with what they are getting until something better comes along. Then they accept the improvement with the same placid satisfaction—perhaps wonder why they were so easily pleased with the old—but make not the slightest effort to secure further betterment. It is up to the minority kickers and mud slingers to secure for them these improvements.

Your average radio listener was perfectly satisfied with broadcasting as it existed in 1923. His unimaginative and uncritical mind could conceive of nothing better. He was getting programs made up largely of cheap jazz and cheaper talks. To live up to their views, the advocates of "throw-away-your-hammer-and-get-a-horn" would have to argue that things should have been left for him just as they were. He was satisfied; his cup of joy was full; why attempt to overfill it?

BOB CASON AND REBER BOULT

Artists at station WLAC, pianist and baritone respectively. They call themselves the "Thrift Twins" for some reason not apparent in the photograph

But what has happened since then? Programs have improved and his taste has improved with them. He has thrown away the cup and has graduated to the mug, which also is filled to the brim. Having a mug, will he now demand a schooner? He will not.

The conclusion that we have been laboring, somewhat heavily, to reach, is that it is to the mud slingers and knockers, the minority critics—or "Flies In the Ointment"—that most of the credit is due for the rapid strides that radio has made. Back in radio's dark ages at least fifty per cent. of every station's time was devoted to unendurable tin pan jazz. The passive listeners stood for it. The knockers objected. It was eliminated and the passive listeners found themselves with fifty per cent. more entertainment for their money and all through no effort of their own.

Radio has grown up considerably but it still has a few bad habits hanging over from its infancy. It is up to the knockers to knock these out. If radio is to be a Bigger and Better man than it was a boy it is up to the knockers to pummel it into this new shape. The soft soapers and dispensers of ointment can do no more for it than to make it a self satisfied mollycoddle. Let there be more flies in the ointment!

The British Broadcasting Company Gets Razzed

WE ARE unable to give any very valuable dissertation on broadcasting conditions in England, at this distance. But from what we read there seem to be continual rumblings in the tight little isle, and most of them to the effect that the British Broadcasting Company is too highbrow. We have just received a copy of a thirty-eight page pamphlet by one Corbett-Smith flaying the administration of the B.B.C. A decidedly long-winded affair, it gets down to points occasionally:

> When one sets out to give a radio entertainment, whether music, poetry, drama, speech, "variety," or anything else, one visualizes (or should visualize) not the few who are already educated in some measure to appreciate the best in these various forms of art, but the vast many of our people to whom beauty has hitherto been a closed book—the great mass of our folk who have never heard good music or noble poetry or any of our incomparable English literature—and so who pretend impatiently to disdain these niceties of civilization, as they would call them. . . . *Every single radio program should be so built and presented as to form a perfect fusion of art, education and popular entertainment.*
>
> The type of mind which is usually associated with scholastic education is hopelessly out of place in radio work. And there is another cause of the B. B. C.'s failure. It is the born showman of a very special quality that is needed. The man with the widest possible range of interests, with "an accute sense of the inter-relationship of every kind of activity." Radio entertainment demands not the depth of the scholar but the breadth of the sensitive man of the world.
>
> Showmanship, in varying degree, is needed for every single feature of radio entertainment. The "superior person" may sometimes scoff; but that person does not interest us. We have to compel and to rivet attention. We need, also, strong and vivid personality. The personality of the leader of men, not of a cold-blooded corporation. And we need absolute sincerity, both of purpose and utterance.
>
> Now the B. B. C. have not begun to appreciate anything of this. Instead of making a Charles Dickens their director of programs they have put in a Matthew Arnold, the apostle of culture. Dickens enjoyed everybody and everything, even Fagin and Mr. Murdstone. That was the secret of his art and of his success. The B. B. C. seem to enjoy nothing, not even themselves.
>
> It is necessary to emphasize this total lack of sympathy with the people at large, because it strikes at the root of the matter. The B. B. C. are forever vaunting the intensely democratic character of their service when, in fact, it is about the most aristocratic business in the country. The House of Lords is an assembly of plebs beside it.

Wherein, if Mr. Corbett-Smith's words are to be taken as true—and he certainly sounds convincing—we see that a government-controlled monopoly is not one of the best ways of providing satisfactory radio programs. The point that the writer pounds in throughout the length of his diatribe is one which, we think, is well worth making, namely: that radio's principal service is, after all, for the masses. The so-called intellectual class is not interested in radio at all. Its members do not own receiving sets nor would they listen to one if it were given them. This is not due merely to snobbishness; their time is otherwise occupied, and of other means of entertainment they have more at their hand than they can make use of.

But we in the United States have no reason to fear such a state of affairs as Mr. Corbett-Smith complains of. Radio stations in this country are operated essentially for the masses. This is the natural result of a competitive system which depends for its reimbursement on advertising, direct or indirect. A maximum number of listeners must be the aim of every station which is not endowed or privately financed. In fact, here, a condition exactly the opposite of that alleged to exist in England is likely to obtain. A majority of stations, in their devotion to the masses, quite neglect the upper fringe of listeners. This is not true of the two score or so better stations. Careful and intelligent planning has enabled them to present programs appealing to the widest possible range of tastes. Their procedure is, first, to arrange a program that definitely appeals to the great mass of listeners, and secondly, to further manipulate it so as to effect a compromise with the upper crust of listeners.

We, from viewing the subject too closely, are likely to forget how exceedingly well this has been done. Take, as an example, the Atwater Kent Hour. A straight appeal to the masses is made in the making up of these programs. While the selections are limited to the classics and to the opera, it is almost exclusively the sure-fire hits and tried and true tunes that finally find their way on to the program. But while the highbrow may think some of the tunes are banal and overworked, they've got him on another score: he cannot afford to ignore the importance and artistry of the performers Atwater Kent employs to put them over.

ANITA DEWITTE HALL OF KOIL

She is the versatile program director, organist, pianist, and "Mother Hubbard" of the staff

The R. G. S. "Octamonic" Circuit

How Laboratory Discoveries Were Moulded to Produce the Commercial Design of a Sensitive and Selective Set—Details of a Striking 1928 Development

By DAVID GRIMES

THE first article in this series (Radio Broadcast for October) described the conception and theory of the fundamental "Octamonic" principle, which obtains a high degree of selectivity by a function of the vacuum tube rather than by any special circuit contraptions. It was shown that the super-selectivity did not impair the tone quality as is the experience in tuned radio-frequency circuits. The high frequency of the second harmonic current permits a very sharp resonance curve without unduly compromising the side band amplification which is absolutely necessary for the proper reproduction of the high-frequency audio tones.

Other points of invention were also discussed, but it is a long road from invention to commercial design. It is one thing to build a laboratory model which proves the principle of an idea and quite another thing to plan the construction of a radio receiver which will meet all of the commercial conditions encountered in the field without a great many operating controls.

The purpose of this article is to reveal the design and constructional information which have been found necessary. These data have been acquired only after a great amount of original investigations, for there appeared to be little or no information available on the subject of second harmonic generation, tuning, amplification, and detection. The subjects will be discussed in the order in which they occur in our laboratory notebook. While the order may appear to be unusual, the facts were accumulated in just that sequence.

The first study was confined to the harmonic generating tube. The proper operation of this tube insures the success of the entire receiver. The first article showed a C potential bias on the grid of the harmonic generator—this bias causing the tube to operate on the lower knee of the grid voltage-plate current characteristics. This point of the characteristic gives the greatest amount of second harmonic energy as the unequal amplification between the two halves of the carrier wave is greatest at this point. However, with the standard commercial types of vacuum tubes operating on standard units of B potential such as 22 volts, 45 volts, or 90 volts, the amounts of negative C bias required for harmonic generation do not correspond with the commercial units of C potential available with the standard C battery. For instance, the maximum amount of second harmonic energy appeared to be generated by a standard CX-301-A tube operating on 45 volts plate potential with about 2 volts minus grid potential. Such a C bias cannot be obtained conveniently from dry batteries.

Of course, the easiest way to obtain a 2-volt negative bias on the grid of the harmonic generating tube is to utilize the principle of an IR drop. By running the filament return of the tube through a fixed 6-ohm resistance, a 2-volt drop may be obtained and if this fixed resistance is placed on the negative filament lead a negative 2-volt bias is available for the grid. Fortunately the operation of the second harmonic tube was not affected by running its filament on 4 volts, the remaining A battery potential available for the filament after 2 volts had been extracted by the fixed resistance for the grid bias. In fact, it was found that the filament of the harmonic tube could be run much lower than this without in any way impairing its second harmonic generating properties. This is explained graphically by Fig. 1 which shows the grid voltage-plate current characteristic of a vacuum tube which is operated at various filament voltages. The various filament temperatures materially affect the upper portions of the characteristic but have

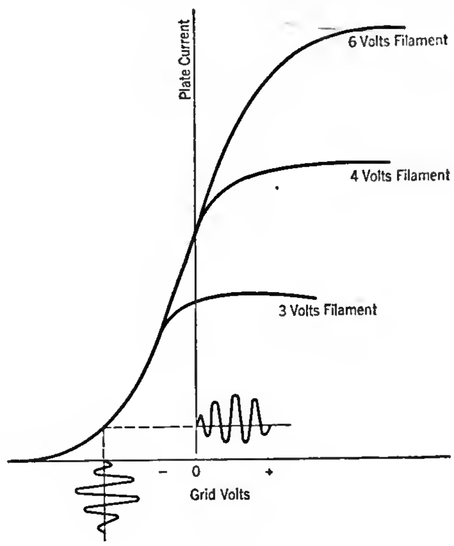


FIG. 1

little or no effect on the lower knee of the curve. The filament voltages only affect the saturation point of the tube.

In the vernacular, this is a fortunate "break" in design work as it affords a very simple arrangement for the harmonic generator which is very stable in its performance and exceedingly inexpensive. As a matter of fact, a series of tests shows that the filament voltage of the tube could be cut down as low as $2\frac{1}{2}$ volts before the second harmonic currents were affected, and the C bias could vary from $1\frac{1}{2}$ to 2 volts. This more than covers the variation in A battery potential during the period between full charge and discharge of the A battery. The 45 volt B battery on the harmonic generator was also found to be a non-critical factor. Fairly large amounts of second harmonic currents were generated by this tube when the voltage had dropped as low as 34 volts or was raised as high as 50 volts.

PROBLEMS IN THE HARMONIC GENERATOR

EXCESSIVE B potentials on the harmonic generator created an unusual and peculiar difficulty. There existed a tendency toward oscillation on the short wavelengths of the input tuning condenser to this harmonic generator when the plate voltage was boosted too high. The source of this oscillation is not obvious and evaded detection for some little time. One is accustomed to expect oscillation in a tube only when there is a deliberate external feed back circuit or through the internal electrode capacities only when the plate circuit is tuned to the same frequency as the grid circuit—such as occurs in a tuned radio-frequency system. As seen in Fig. 2, the plate circuit of the harmonic generator is tuned an octave higher in frequency than the grid circuit and under these conditions the well known ordinary oscillation cannot occur. As a matter of fact the primary of the second harmonic transformer possesses considerable effective inductance as the result of the tuning to the higher octave. The number of turns in the harmonic transformer primary alone is insufficient to cause oscillation in the harmonic tube unless the secondary is tuned to the higher octave. When this is done, there is an increase in effective inductance over and above the actual inductance which causes the oscillatory difficulties mentioned, with excessive plate voltages on the harmonic tube.

The remedy for the difficulty outlined above

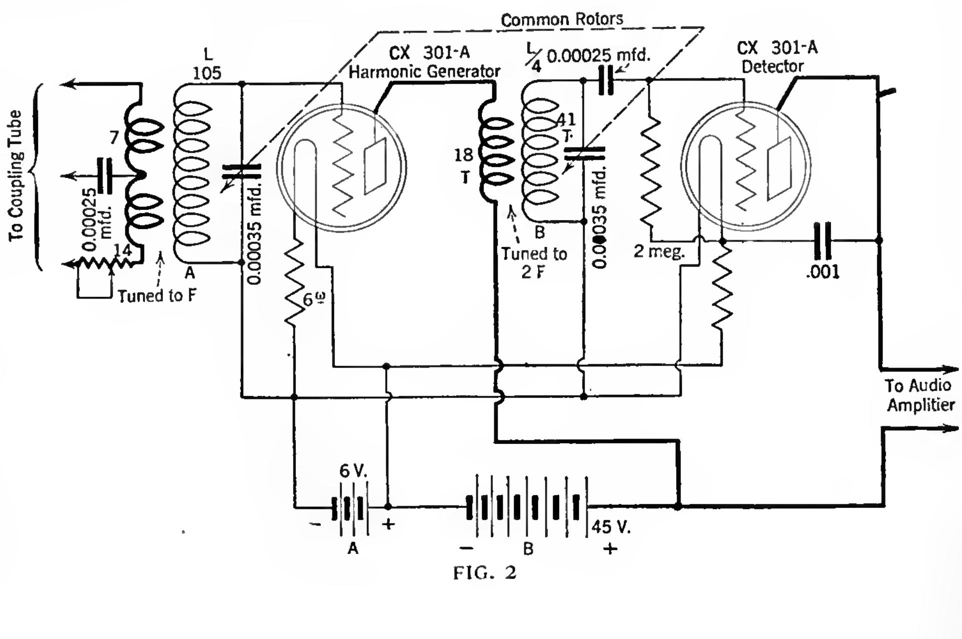


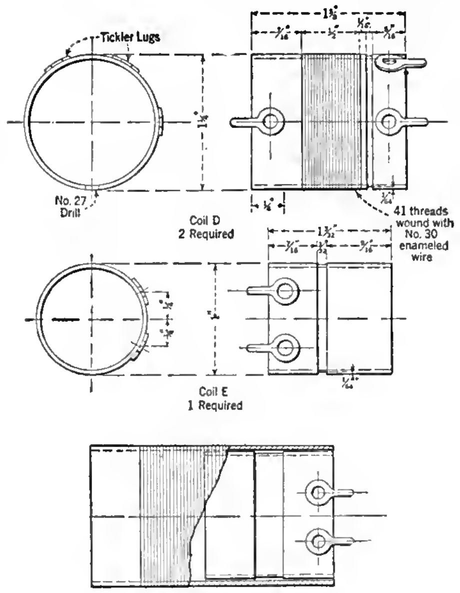
FIG. 2

lies in reducing the number of primary turns in the harmonic transformer to such a point that the effective inductance at the highest commercial voltage will not produce the oscillation described at the short broadcast wavelengths. Fig. 3 shows the design details of the tuned harmonic transformer used for connecting the output of the harmonic generator to the input of the detector tube. It will be noted that the secondary of this transformer has been made unusually small—much smaller than would be expected for merely tuning the double frequency involved. Commercial considerations have controlled the design of this transformer as well. The general tendency in the modern design of the radio receiver is to combine as many of the tuning condensers as possible on one shaft—exercising the proper care in the balancing of the condensers and coils so that they will tune alike for all the broadcast wavelengths. In the R. G. S. "Octamonic" design, it seemed desirable to combine the tuning condenser on the secondary of the harmonic transformer with the tuning condenser on the input to the harmonic generator. The problem is not as simple as the combining of condensers controlling similar circuits. The harmonic condenser must always tune to half the wavelength of the fundamental tuning condenser in the input of the harmonic generator. Furthermore, another limitation is imposed because all available gang condensers have been designed for tuned radio-frequency circuits and have therefore equal capacity in all the individual members of the gang.

This means that the second harmonic transformer must be so designed that a standard 0.00035-mfd. tuning condenser must tune the half wavelength band from 100 to 275 meters at exactly the same settings on the dial as a similar condenser tunes the fundamental coil for the respective corresponding fundamental wave between the 200 and 550 meter broadcast band. A consideration tuning formula shows that this can easily be accomplished if the inductance of the secondary of the harmonic transformer is made exactly equal to $\frac{1}{4}$ of the inductance of the fundamental tuned secondary on the input to the harmonic generator tube.

SOURCES OF SELECTIVITY

ANOTHER fortunate "break" aids in the ganging of these two condensers, as one of them is extremely sharp in tuning while the other is relatively broad. The real selectivity of the receiver is obtained by the tuning condenser on the input to the harmonic generator as the harmonic currents generated in this tube are proportional to the square of the resonant input carrier voltages resulting from this tuning condenser. The tuning condenser across the secondary of the harmonic transformer is no sharper than the ordinary tuning circuit on the input to a detector tube. Slight variations are therefore permissible in the coils and condensers without jeopardizing the performance of the receiver.



TYPICAL ASSEMBLY OF COILS

FIG. 3

The two gang condensers may have the same grounded rotor shaft as there is no need for any special insulating between these circuits. It is true that there are different grid biases on the two tubes to be tuned, but the positive bias on the grid of the detector tube may be supplied by the grid leak connecting from the plus filament of the detector tube directly to the grid, while the negative C bias on the harmonic generator is supplied through the common rotor and the secondary of the fundamental transformer in the grid circuit of the harmonic generator. The blocking condenser in the grid circuit of the detector effectively separates the positive potential on the grid of the detector and the negative C bias which exists in the rest of the harmonic secondary by virtue of the common grounded rotor shaft. As the negative potential is obtained by a resistance drop, as previously described, it is obvious that both the high-frequency currents in the detector grid circuit and the broadcast frequency currents in the harmonic grid circuit must return to their respective filaments through this resistance. Feed-back difficulties and oscillation would absolutely occur at this point in a tuned radio-frequency system, but no difficulties are encountered in the R. G. S. "Octamonic" because these two carrier currents are of different frequency and cannot, therefore, interfere with one another.

One thing should be made very clear at this point of the discussion. There is a fundamental difference between detection as such, and the generation of second harmonics. As discussed in the first article of the series the operation of a tube on the knee of its characteristic curve will produce not only second harmonic but audio currents as well. In this circuit the tube is acting not only as a harmonic generator but, incidentally, as a detector. No method is known at present for the efficient generation of second harmonics without the incidental detector action occurring simultaneously. However, in the detector stage, two possibilities are present. Either the grid leak system of detection or the C battery system of detection may be used. The grid leak system is slightly more sensitive on very weak signals while the C battery system will deliver more audio energy on local reception without distortion. A study of these two types reveals some interesting facts. There is present, along with the detector action, some incidental generation of second harmonics, when the C battery detector is employed. This would be expected from the considerations already discussed in connection with the harmonic generator. However, second harmonic currents are almost wholly absent in a detector tube employing the grid leak system. This means, that detector action cannot be confused with harmonic generation. They may or may not occur simultaneously. The grid leak detector simply cannot be used in the generator stage for the creation of second harmonics. The harmonic generator is not a detector.

WHAT TYPE OF DETECTOR CIRCUIT?

IT NOW remains to determine which type of circuit should be used in the detector stage. Both the C battery and grid leak circuits were subjected to an extensive series of tests. The grid leak system was found to be much more satisfactory and much more stable. The tone quality was not impaired by the grid leak system and the distortion which occurred on local reception when using the C battery system, entirely disappeared when the grid leak system was substituted. The results were so consistently contrary to those anticipated that considerable data was gathered in an effort to explain the cause. Fig. 4 shows graphically just what occurred and why it is desirable to employ the grid leak system in the bona fide detector. It will be noted that the incidental detection occurring in the plate circuit of the harmonic generator is represented by an increase in the plate current—the increase being proportional to the modulation on the incoming carrier waves. Quite the reverse takes place in the detector circuit. Here the plate current decreases upon detection due to the choking action of the grid leak and condenser in the grid circuit. The decrease in plate current is proportional to the modulation on the incoming carrier waves. The rectified or audio currents existing in the plate of the harmonic generator are not utilized but, in turn, flow through the B battery circuit. The detected or audio currents in the plate circuit of the detector go through the primary of the first audio transformer and then flow through the B battery circuit. With these two audio currents opposing each other in the B battery at all times there is no audio voltage drop occurring therein. If a C-battery detector were employed the two audio currents would increase and decrease simultaneously, causing excessive audio voltage drops in the common B battery.

As brought out in the previous article, the R. G. S. "Octamonic" receiver obtains its super-selectivity through the sacrifice of some of the radio-frequency energy. But as radio-frequency energy is very easily obtained by any number of r.f. amplifying circuits and selectivity is not so easily obtained, the sacrifice is well worth while. However, some form of r.f. amplification must be placed ahead of the "selectivity" circuits just discussed. Various r.f. arrangements have been investigated and the one shown in Fig. 5 is

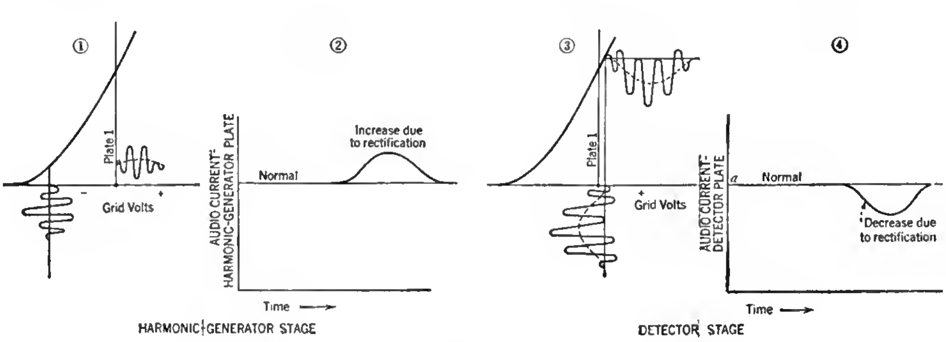


FIG. 4

recommended. This shows one stage of radio-frequency amplification only as one stage has been found to be more than ample for operating the harmonic generator on even the most distant stations. The antenna is very closely coupled to a tuning circuit which serves mainly to bring the antenna circuit to resonance at the frequency desired. The carrier wave is then amplified and applied to the harmonic generator through a special equalizing coupling circuit which is designed to pass all of the broadcast frequencies with approximately undiminished amplitude on to the harmonic generator. The theory of the operation of this unusual coupling is rather simple. The total winding consists of 21 turns which is the proper primary for the longest wavelength of 550 meters. Then a tap is taken off at 7 turns which is approximately the proper primary for the shortest wavelength of 200 meters. A 0.00025-mfd. fixed condenser is connected between the tap and the filament of this amplifying or coupling tube. A variable non-inductive 250-ohm equalizing resistance is placed in series with the total winding. The short waves pass readily through the fixed condenser to the filament while the longer waves tend to pass more and more through the entire winding because of the increasing reactance of the fixed condenser to the lower frequencies of the longer waves.

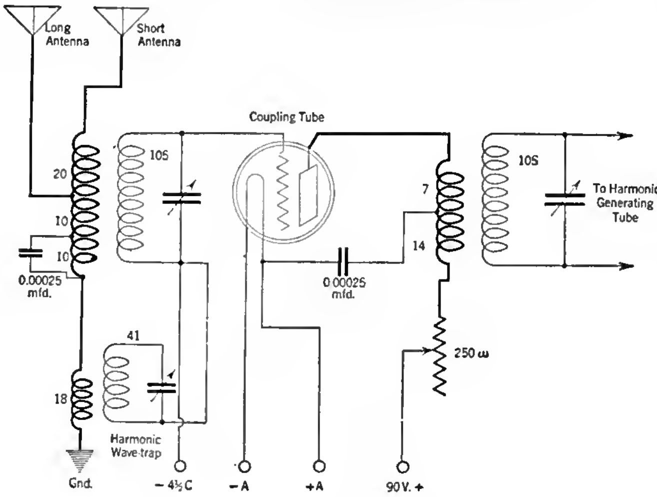


FIG. 5

This first amplifying tube has been designated a coupling tube since its main function is purely a coupling and amplifying action rather than any aid to the tuning. The coupling to the antenna is made as close as possible so as to derive the maximum amount of energy therefrom throughout the broadcast band. Such close coupling makes the tuning very broad and non-critical—the real super-selectivity of the receiver being created by the tuning condenser on the input to the harmonic generator. In actual operation, this antenna condenser appears to be sharper in its tuning than it really is because, after all, it has an indirect effect, though broad, on the amount of energy being transformed into second harmonic currents by the generating tube. This action gives it an apparent sharpness greater than that which is really occurring in the antenna circuit.

CURIOUS MODULATION EFFECTS

ONE very important factor in the design of the coupling tube circuit is *modulation.* Great care must be exercised in the design of this circuit to avoid any possibility of rectification action even on the louder signals. Otherwise, the extreme selectivity of the harmonic generator will be somewhat modified by a cross-talk or modulating action between a near-by high-powered local station and a distant station operating on an adjacent carrier channel. The action is as follows: The receiver in New York City is tuned to a weak station such as WOO in Philadelphia operating on 508 meters. It is found that several dial degrees of silence are obtained between this Philadelphia station and WEAF, New York City, operating on 492 meters. However, WEAF is coming in with considerable field strength impressing considerable 492 meter energy on the grid of the coupling tube along with the energy from the Philadelphia station. If any rectification occurs on the strong signals from WEAF, audio currents will be set up in the plate circuit of this radio coupling tube which correspond to the program being sent out by WEAF. It must be remembered here that the first circuit is broad—its function being amplification and not tuning. As a result, more WEAF energy may be present than the energy coming from Philadelphia even though the antenna tuning condenser has been set in favor of the Philadelphia station.

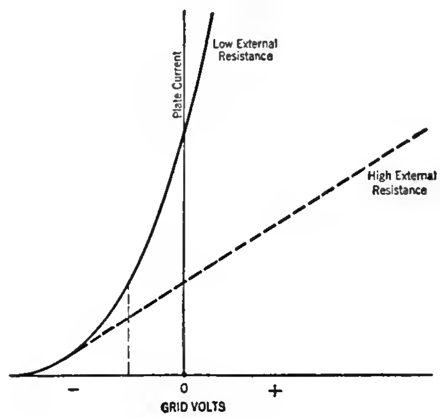


FIG. 6

Now, the audio currents occurring in the plate circuit of the coupling tube as a result of the rectification of the WEAF carrier wave, will cause a plate voltage variation in this tube which corresponds to the program on the carrier wave of WEAF. This action will, in turn, affect and vary the amplification of any other carrier wave coming through the tube at the time, such as the Philadelphia station which is desired. The audio modulation or WEAF's program will then impress itself on the carrier wave of the Philadelphia station in the same manner that the original audio currents at the studio of WEAF impressed themselves on the original carrier wave being sent out from WEAF on 492 meters. The result is that, while several dial degrees of silence are obtained between WEAF and WOO, as soon as the Philadelphia station is tuned-in, the program from WEAF is found also to exist thereon in the form of cross-talk or cross-modulation.

The remedy is to operate the coupling tube on the straightest portion of the grid-voltage plate-current characteristic curve. For the standard CX-301-A tube, this requires 90 volts on the plate and 4½ volts negative bias on the grid. This point is very essential. In addition, it is desirable to have the maximum of coupling to the harmonic generating tube, not only from the standpoint of energy transfer, but also for the purpose of obtaining a fairly high effective resistance in the plate circuit of the coupling tube at the particular frequency for which the input to the harmonic generating tube is tuned. It is a well known fact that the resistance of a primary winding increases considerably at the resonant frequency of the secondary. At the same time the reactance passes through zero, of course. The closer the coupling the greater is the effective resistance of the plate circuit and resistance in the plate circuit tends to flatten out the characteristic curve of the coupling tube. This is shown in Fig. 6. This flattening of the characteristic curve still further reduces any tendency toward rectification in the coupling tube.

A detailed discussion on the audio amplifier as well as a full explanation of the theory and operation of the harmonic wave-trap shown in the antenna circuit will be taken up in the next article of the series. The next article will also describe in further detail the best wiring arrangements.

The "Equaphase"

Better Control of Oscillation Is a Feature of This New Receiver—The Story of Some of the Difficulties Surmounted in Its Design

By J. O. MESA

ANY radio engineer can make a single receiver work in the laboratory but when a factory turns out five hundred a day, each of which must be thoroughly tested, the problem becomes somewhat more complex. It becomes one not only of manufacturing small mechanical parts to a high degree of precision and of simplified assembly so that mistakes are difficult to make, but one of following a circuit that is electrically sound and as foolproof as possible.

Circuits that are highly sensitive are often highly critical in their adjustment, necessitating that they pass through the hands of a well trained tester before they can be released. What every set manufacturer wants is a receiver design such that manufacturing costs and assembly problems are reduced to the bone, that testing methods are neither complicated nor expensive in point of time, and that adjustments are few. Simplicity of design is not the controlling factor, for the simplest circuit must embody the same trouble producing elements as the most complex. For example, every engineer knows that inductance in the plate circuit of a radio-frequency amplifier is necessary to transfer energy from one circuit to the following tube; but he knows too well that including this inductance tends to make the previous tube oscillate. One method of preventing oscillation is to feed back to the input circuit some of the energy that appears in the output circuit in such magnitude and phase that the tube is no longer unstable. Owing to the fact that unity coupling is necessary to obtain complete prevention of oscillation (neutralization) at all frequencies, it is impossible to neutralize the amplifier over more than a narrow band at one time. Often the circuits are balanced at the shortest wavelengths, for the tendency to oscillate is greatest there; but this is apt to result in poor transfer of energy on the longer waves.

If it were possible to neutralize a receiver completely throughout its tuning range and to include sufficient primary inductance with close enough coupling to the secondary to produce proper amplification on the longer waves, the design engineer's problem would be simple. Unfortunately, in spite of the neutralization process, it is often impossible to utilize the utmost desirable amount of primary inductance and coupling, and the longer waves suffer.

A method that has been used to maintain the circuits in a two-or three-stage radio-frequency amplifier free from oscillations is that of including resistances in the grid circuits of the amplifying tubes. It was found in the Freshman laboratories that, with sufficiently large primary coils, the resistances became rather large, of the order of 500 ohms. This method of "holding down" an amplifier is shown in Fig. 1, and in Fig. 2 is the equivalent circuit.

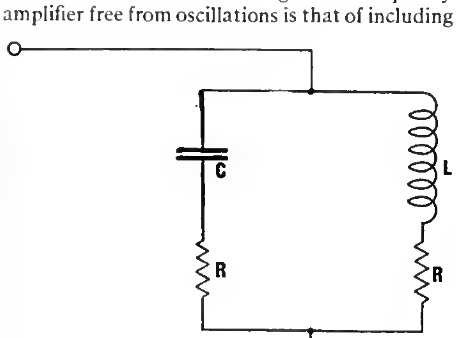


FIG. 3.

Mathematics will show that for every resistance, another, smaller in actual value, can be substituted, as in Fig. 2, in the tuned circuit itself to accomplish the same end, namely, cessation of troublesome oscillations. In fact, when such external resistances are used, the selectivity of the circuit suffers, and at the same time the amplification falls off, showing conclusively that this external resistance has in effect added considerable damping to the tuned circuit itself.

There is a very serious objection to the use of resistances as in Fig. 1. Under the usual conditions obtaining in a high-amplification circuit, the value of the stabilizing resistance is somewhat critical. If the correct value is exceeded, the overall voltage gain of the radio-frequency amplifier is considerably reduced, while if the resistance is too small, the circuit oscillates violently. Furthermore, any slight variations in the component parts which make up the radio-frequency amplifier change the value of resistances needed for best operation.

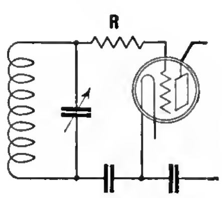


FIG. 1

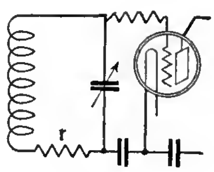


FIG. 2

The solution, naturally, lies in very close manufacturing limits on the values of inductance, capacity, and resistance, and for some time receivers employing the resistance arrangement of Fig. 1 were built in the Freshman plant. In spite of the fact that the resistances were held accurate to within plus or minus 1.25 per cent., difficulty occurred from oscillation or poor selectivity and lack of amplification too frequently for comfort. It became necessary to develop another stablizing system.

The new method of overcoming oscillations without the disadvantages previously mentioned was found by Mr. W. L. Dunn, Jr., and was developed by the engineers of the Freshman laboratory. This method is based on a principle which has been used for a long time in telephone equalizing circuits, and has been discussed mathematically by K. S. Johnson in his *Transmission Circuits for Telephonic Communication* and by Morecroft on page 92 of the new edition of his well known *Principles of Radio Communication.*

The circuit which has been utilized is shown in Fig. 3, and it may be seen to consist of a coil and condenser in parallel with a resistance in each branch of the parallel circuit. If the resistances in the two paths are equal to each other and equal to the square root of the inductance divided by the capacity, or:

$$R_L = R_c = \sqrt{L/C}$$

the impedance of the circuit looked at from the standpoint of the previous tube is a pure resistance at all frequencies.

Therefore, the plate circuit of the previous amplifier has no inductive reactance in it and so the tube cannot oscillate, provided the values of inductance, capacity, and resistance are properly adjusted.

Limiting the magnetic feed back in the circuit by using small diameter coils and placing them at right angles to each other, and by using proper bypass condensers across impedances which are common to more than one stage, naturally aid in keeping the amplifier performing its required tasks.

The method of applying this interesting case of parallel resonance is shown in Fig. 4. Owing to the fact that some resistance is reflected into the circuit when a secondary coil is coupled to it and is tuned to resonance, the actual values of resistance used are different, 380 ohms being used in the condenser, or plate branch, and 350 ohms in the inductance branch. The capacity used is about 100 micro-microfarads and is of the fixed-variable type, that is, a fixed condenser having attached to it a small variable capacity which may be adjusted in the factory so that the receiver does not oscillate.

When it is realized that closer coupling and greater primary inductance may be used when such a circuit is employed, the gain over the grid resistance method of stabilization is evident. Nearly double the coefficient of coupling may be used between primary and secondary in this new system.

THE RECEIVER

THE schematic diagram of a battery operated receiver using this principle is shown in Fig. 5. This receiver is now being manufactured with large quantity production methods. It has been found that it is not subject to the difficulties encountered in the case of the grid resistances method of preventing oscillation. The condenser in the plate circuit of the radio-frequency tubes consists of curved spring plates with mica dielectric which can be flattened by means of a screw which is accessible to the inside of the cabinet. This condenser is adjusted at the factory

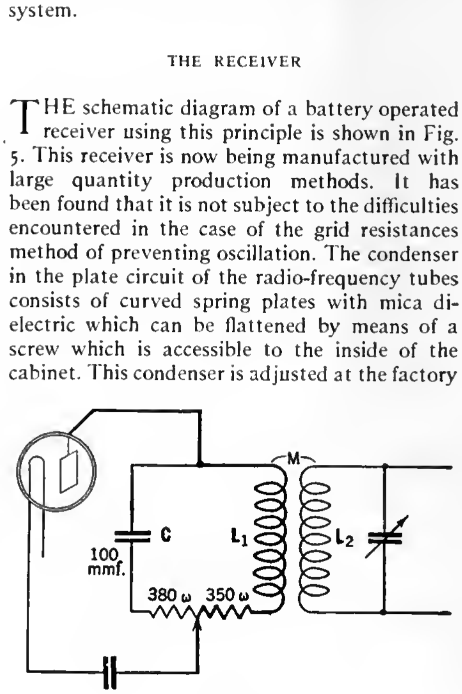


FIG. 4.

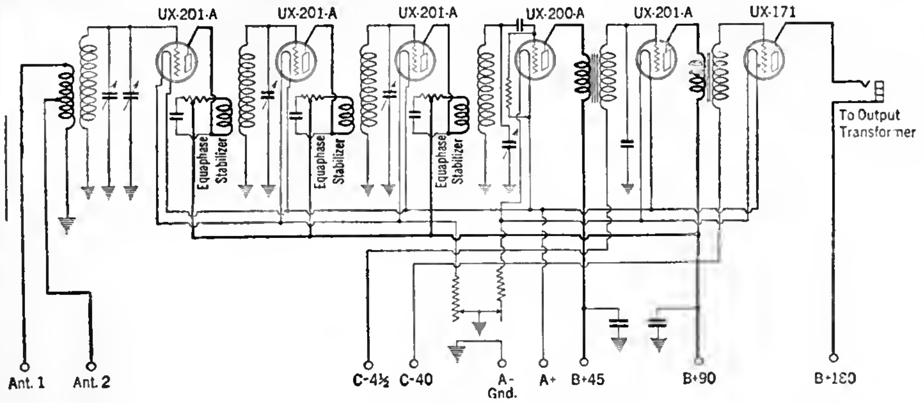


FIG. 5

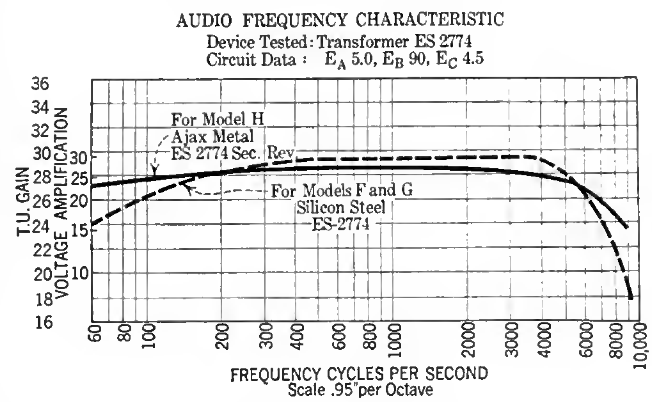
so that the amplifier does not oscillate and does not require readjustment thereafter so long as tubes having the same plate impedance are used in the radio-frequency amplifier. When a.c. tubes are used a smaller capacity is needed owing to the high low impedance of these tubes compared with the average d.c. tube.

The radio-frequency transformers have secondaries which are wound on a small bakelite tubing and have individual turns slightly spaced. It has been found that this type of winding can be controlled so that the inductance of the coil may be held to within about 0.5 per cent. of accuracy when manufactured in large quantities. The primary of the radio-frequency transformer is a spiral wound on a wooden form, and is placed at the ground end of the secondary, thus having the advantage of a comparatively large coupling and at the same time small capacity between the primary and secondary.

The audio transformers are mounted on the tube shelf and have a 4 to 1 turn ratio. The secondary windings are of the split or balanced type which have very low distributed capacity and very low capacity between windings, with the result that a quite uniform amplification is obtained between 100 and 5000 cycles per second.

The radio-frequency inductances and audio-frequency transformers as well as all the other apparatus which is not accessible to the controls on the front panel, are mounted on a spring suspended metal shelf. This shelf carries the tubes and is provided with rubber dampers so that there is no microphonic feed back.

The variable condensers used are selected so that their capacities are equal to within 0.25 per cent. at two points. Since the plates are of heavy construction and have rather wide spacing, the capacities of the condensers in any receiver are practically identical throughout their entire range. The arrangement of the front panel of the "Equaphase" may be seen in the photograph of this receiver which appears on page twenty.



INTERESTING CURVES

Showing the characteristics of the audio transformers used in the "Equaphase"

The volume control of the battery operated receivers is obtained by means of a rheostat in series with the filaments of the radio-frequency tubes. This method has been used for several years on Freshman Masterpiece receivers and has left nothing to be desired.

As mentioned before, a slight modification of the constants of the elements used in the plate circuit of the radio-frequency amplifiers is necessary to adapt the circuit to the use of the alternating current tubes of the UX-226 (CX-326) type. Since the circuit does not oscillate and has high amplification throughout the broadcast range, the volume control can be obtained by means of a potentiometer across the secondary of the first audio-frequency transformer. This potentiometer has the so-called logarithmic scale, that is, its resistance varies so that equal angular increments on the control produce equal increments of volume. A schematic diagram of the house current operated "Equaphase" receiver and its power supply is shown in Fig. 6. The plate supply is of the conventional type using a UX-280 full-wave rectifier tube and having a two-section filter. Various plate voltages are obtained from taps on a resistor connected across the output of the filter. The grid bias for the various tubes is obtained from the drop across the resistance in the plate circuit of the tubes.

Two independent tests are made on the sensitivity of each receiver before it is packed. These tests are made by two men who check each other's work without either knowing the other's. Around the laboratory is fed a continuous 1000-cycle tone of a certain amplitude which is maintained constant. This is available at each test bench, and is used to modulate a small radio-frequency oscillator. A very small part of this energy is picked up on a dummy antenna whence it goes through the receiver just as a radio signal would. The test man listens to it comparing it with the standard input 1000-cycle tone by means of an attenuation box which is placed in the receiver output. In this way he reads the relative amplification of the receivers, and after fixing a certain standard he can reject any which fall below the required limit. Phonograph music is also fed around the test benches so that the test man can listen to music as well as his standard 1000-cycle signal.

Any slight error in a component part is discovered in this way before the receiver leaves the factory, in which case it can be sent back to the repair bench for final adjustment.

It can easily be appreciated that this method of preventing oscillation is one which does not affect the selectivity of the receiver once it is properly adjusted. The selectivity of the "Equaphase" is quite satisfactory enough for congested districts.

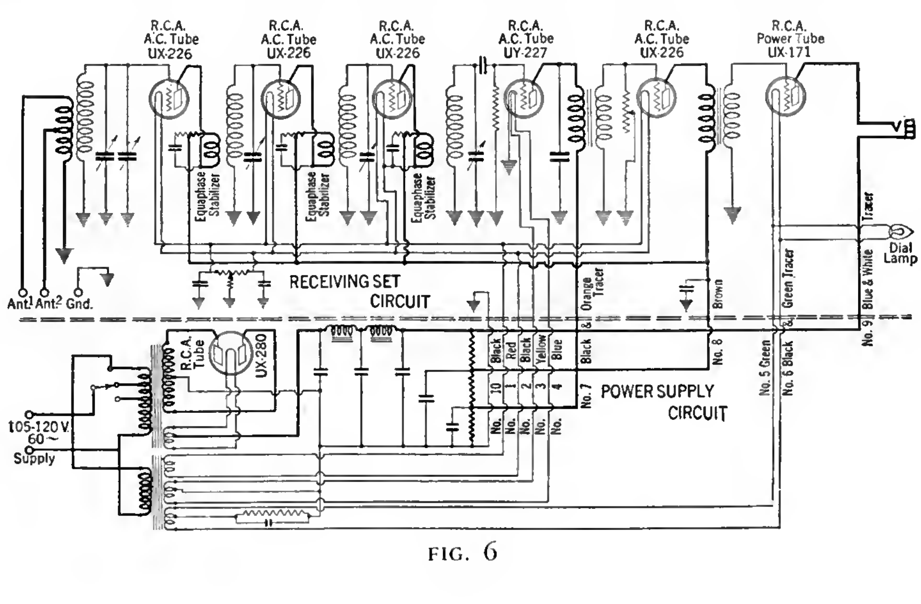


FIG. 6

The Improved "Shielded Six"

By JOHN E. McCLURE

IT IS seldom that a radio receiver design, or kit, outlives a single season's popularity, and when the exception comes along, it gives assurance that it must be an unusually fine set. Such is the "Shielded Six." During this last year certain refinements of design have been developed, and the new improved model is now ready for the 1927–28 season.

Mechanically, the design of the receiver is one of the prettiest of kit jobs, and the "Shielded Six" looks more like a carefully worked-out assembly for quantity production in a modern factory than a kit receiver. The whole set builds up progressively on a die-formed and pierced steel chassis, which is a radical departure from the often makeshift packing-case baseboards to which the home constructor is accustomed. The panel also is of metal, bronze, attractively decorated in the fashion of the new expensive factory-built sets, being utilized for this purpose.

Electrically, the circuit design involves three stages of tuned radio-frequency amplification with controlled regeneration, a grid-biased detector tube, and two stages of transformer-coupled audio-frequency amplification. In these respects the improved model is very like the original, and the only really startling improvements found in the set are circuit changes resulting in greatly increased selectivity, and the addition of vernier tuning dials found necessary because of the greatly increased sharpness of tuning.

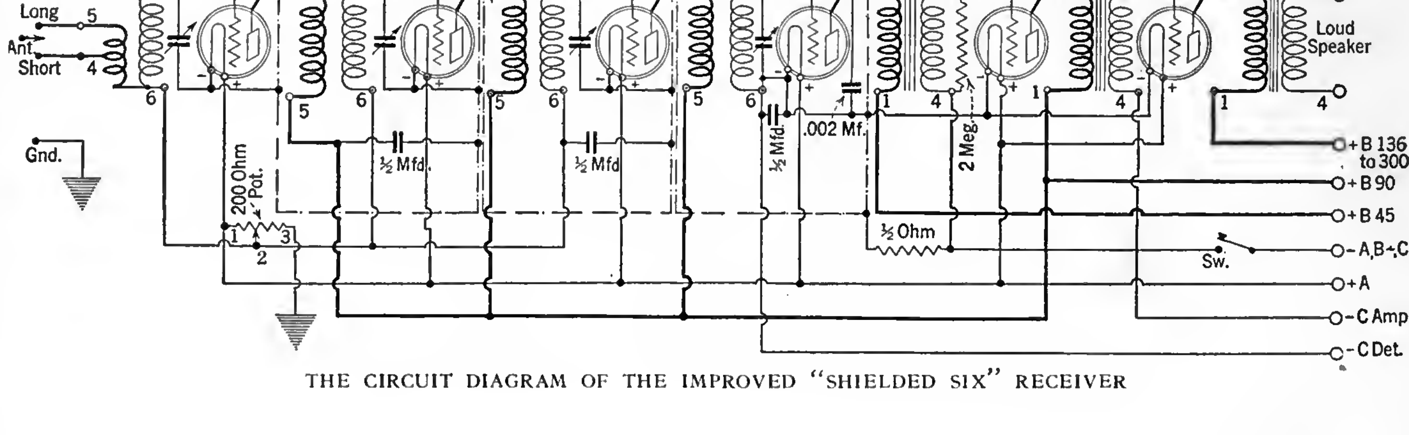
The antenna stage, or first radio-frequency amplifier, is left unshielded in the new model to increase the coil pick-up to a point where the receiver may be operated in apartment houses with no antenna at all, and yet give adequate loud speaker volume on powerful local stations. If the second, third, or fourth coils were unshielded, selectivity would be affected, for energy pick-up on these coils would affect the selective tuning action of the tuned circuits. Shielding not only prevents pick-up of external interference, but possibly more important, entirely prevents extraneous interstage coupling.

Losses in the r.f. circuits have been reduced to a minimum through the use of quite low resistance inductances, wound on threaded ribs of bakelite coil forms in such a fashion that they are practically air-supported. These inductances are tuned by means of newly designed, very rugged, condensers providing a semi-straight-frequency, straight-wavelength tuning curve which gives most satisfactory spacing of stations over the tuning dial scales. The set may be adapted for loop reception without a single change except to pull out the antenna coil and clip on two loop leads to coil socket posts 3 and 6. The new set seems amply selective for present broadcasting conditions, for, in Chicago, it will cut through a mass of thirty local stations and bring in out-of-town stations.

While four tuned circuits are employed, only two tuning controls are used, this being made possible through extremely accurate matching of condensers and coils. All coils for a set are matched to within a quarter of one per cent. and the condensers are all checked and held within one per cent. of each other. Since the tuning of the three right-hand circuits is substantially identical, a mechanical link serves to turn all three condensers as the right-hand dial is turned. The antenna stage condenser is tuned separately.

The audio-frequency amplifier has a highly desirable characteristic in that it amplifies practically uniformly all frequencies between 30 and 5000 cycles, above which frequency there is practically no amplification. The highest fundamental note of any musical instrument is 4192 cycles and the 5000-cycle upper limit allows plenty of leeway for the handling of the highest fundamental frequency in music, and it has been proved that frequencies above 5000 cycles do not contribute, in any measure, to fidelity of reproduction. Thus the interference caused by heterodyne squeals developed between transmitting stations, by atmospheric noise and by the tube and battery noises, all of which are generally above 5000 cycles, are almost entirely absent.

A group of people listening to the improved "Shielded Six" receiver operating in conjunction with a good cone loud speaker and receiving an organ program, will actually feel the vibration of the room in which the receiver is located, as



THE CIRCUIT DIAGRAM OF THE IMPROVED "SHIELDED SIX" RECEIVER

PREPARATORY TO PLACING THE STAGE SHIELDS IN POSITION

The arrangement of the Silver-Marshall triple link motion is distinctly shown in this photograph. The transformers are, from left to right, output, second audio, and first audio

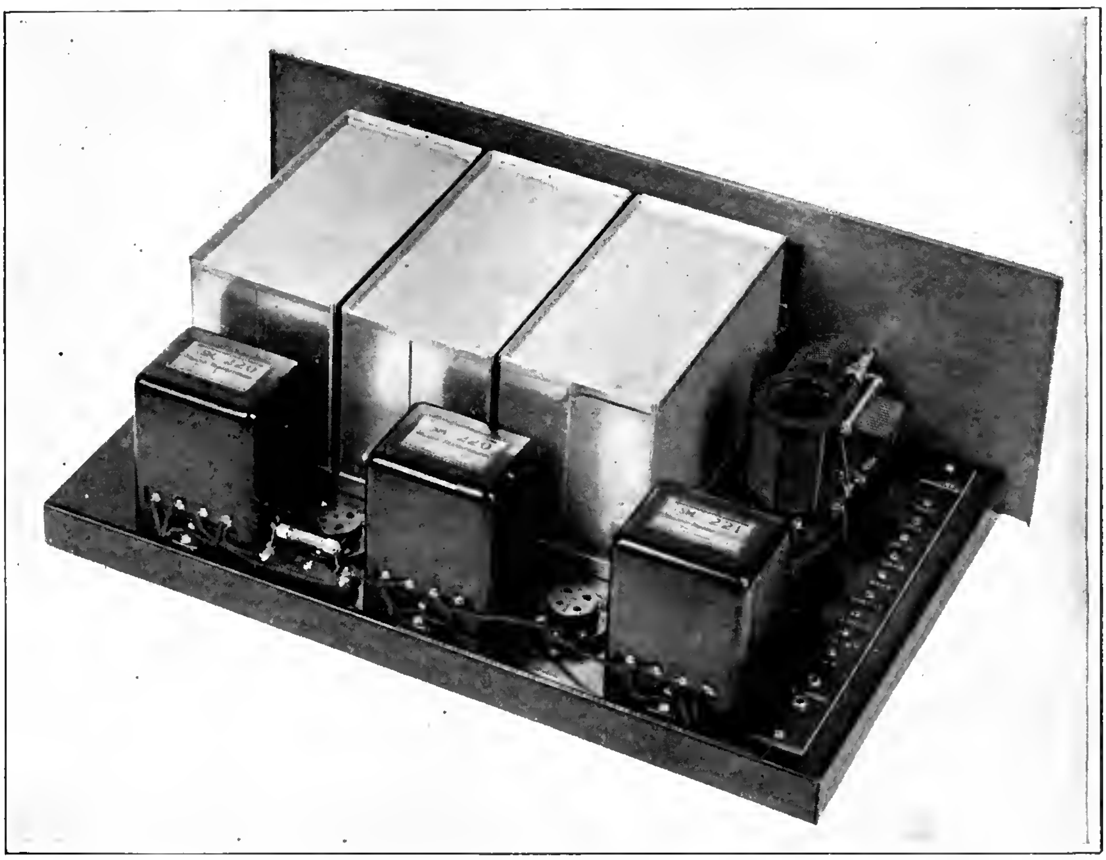
they would were they in the original building in which the organ itself was located.

A. C. OPERATION

A. C. OPERATION is so ridiculously simple with the "Shielded Six" as to require little description and if Sovereign or equivalent heater tubes are used, lighted from a filament transformer, only minor changes need be made in the wiring. The standard Sovereign tubes have the heater leads coming out on top and all tubes should have their heater elements connected in parallel and to the 2½-volt winding of a filament heating transformer. It is also well to ground one side of this winding. The F—terminal of each tube socket should be connected to the receiver chassis while the F+ terminal of each tube socket should be ignored. The 200-ohm potentiometer should be eliminated and in its place a Carter 6000-ohm potentiometer used (the two center shields will have to have their corners clipped away to accommodate the new 6000-ohm potentiometer). Terminals 6 of the three left-hand r.f. transformers, which previously connected to the center arm of the potentiometer, should ground to the chassis. The 0.5-mfd. potentiometer bypass condenser is eliminated. The new potentiometer should be connected with one end to the chassis, the other end to the +90 binding post, and the arm connecting to one end of the B-90 bypass condenser and to terminals 5 of the three right-hand r.f. transformers. Five Sovereign a.c. tubes are used, with a CX-371 (UX-171) type tube in the last audio stage. The two filament leads from this latter power tube socket are run directly to the 5-volt terminals of the filament transformer. The center tap of a Frost FT 64 resistance shunting the power tube filament connects through a 2000-ohm Carter fixed resistance to the chassis of the receiver or ground. A regular B supply, such as the Silver-Marshall 652A (which will also supply A potential to the tubes) will then furnish B potential to the entire receiver, and A, B, and C potential to the second audio stage, while a 4½-volt C battery will have to be used for the detector and the first audio stage (terminal 4 of the first audio transformer should connect to the C—Det. binding post of the receiver).

The parts needed for the Improved Model are listed below. They total exactly $95.00. While this price may seem a bit high in that fifty-dollar six-tube sets, completely constructed, are available, it must be remembered that the "Shielded Six" has been designed with unusual care and that all the parts have been very carefully matched to insure satisfactory operation.

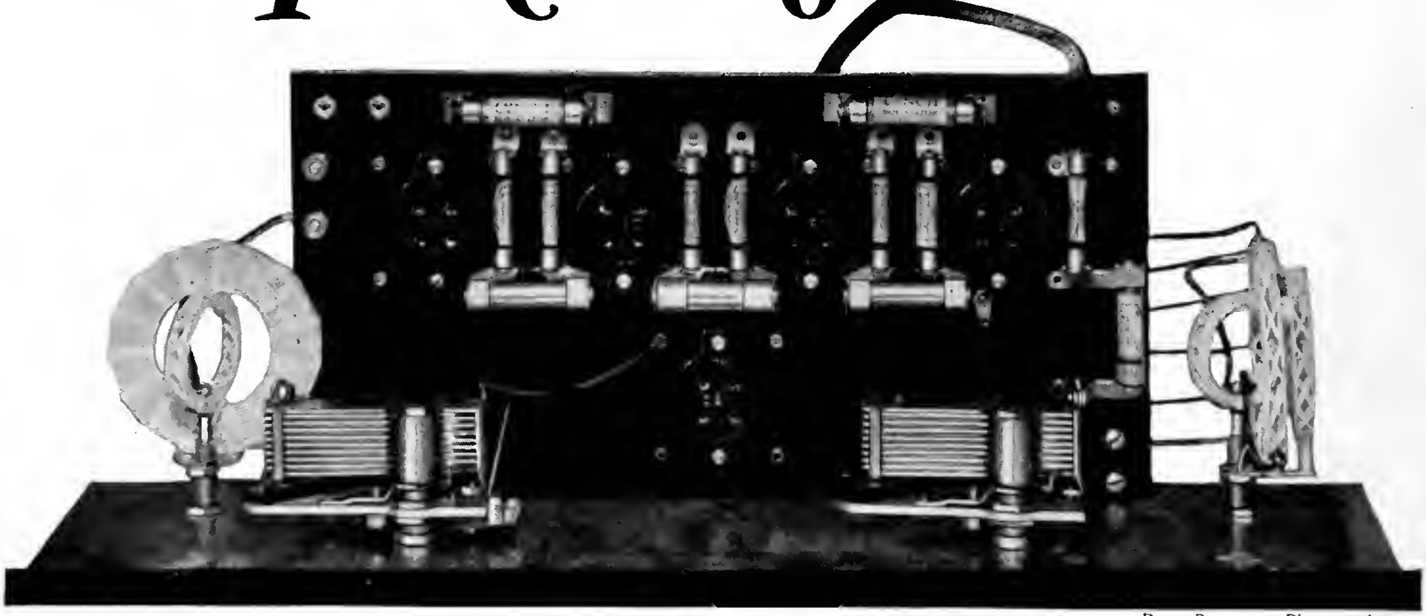
3—S-M 631 Stage Shields	$ 6.00
2—S-M 316A Matched Condensers .	9.00
2—S-M 316B Matched Condensers .	9.00
4—S-M 515 Coil Sockets	4.00
3—S-M 118A Matched Coils . . .	7.50
1—S-M 116A Coil, Matched with Above	2.50
6—S-M 511 Tube Sockets	3.00
2—S-M 220 Audio Transformers . .	16.00
1—S-M 221 Output Transformer . .	7.50
1—S-M 632 Triple Link Motion . .	2.50
1—Polymet 0.25-Meg. Grid Leak . .	.25
1—Polymet Resistor Mounting . .	.50
1—Carter 0.002-Mfd. Condenser . .	.50
3—Carter 105 or Polymet Condensers, 0.5 Mfd.	2.70
1—Carter M-200 Potentiometer (200 Ohms)	.75
2—Carter No. 10 Tip Jacks . . .	.20
1—Carter H-½ Resistor	.25
2—Marco Walnut Vernier Dials . .	5.00
1—636 Terminal Strip, 1⅛ x 11 inches .	2.00
1—Crowe 633 Drilled and Engraved Metal Panel, Size 7 x 21 Inches .	8.50
1—Crowe 634 Steel Chassis, Size 12 x 19¼ x 1¼ Inches	6.00
1—Carter No. 12 Antenna Switch .	.60
1—Carter "Imp" Battery Switch . .	.50
1—Coil Kellogg Fabricated Hook-up Wire, Screws, Nuts, Lugs, and Complete Building Instructions .	.25
Total	$95.00



THERE IS AN ADVANTAGE IN LEAVING ONE TUNED STAGE UNSHIELDED

The antenna tuning stage, the only one of the four tuned stages not shielded, has purposely been left in this condition. By so doing, the coil pick-up is increased to a point where the receiver may be operated in apartment houses with no antenna at all, and adequate volume obtained on the loud speaker when receiving powerful local stations

The IMPROVED Aristocrat



Radio Broadcast Photograph

A SUITABLE LAYOUT THAT MAKES FOR SIMPLICITY OF CONSTRUCTION

There are many possible variations of design for the new "Aristocrat," the layout here, in fact, not being exactly similar to that described in the text. The "deck," for example, is mounted away from the front panel in the model described, and one variable rheostat takes the place of the two ballasts shown in the photograph. New Eby sockets have been substituted for the older pattern ones shown, and binding posts are used for Antenna, Ground, and Loud Speaker

By ARTHUR H. LYNCH

EXACTLY two years ago Radio Broadcast first described the "Aristocrat" receiver. This receiver became unusually popular and many interesting letters were received telling of the good results that were obtained. It was a five-tube affair consisting of a stage of tuned radio frequency followed by a regenerative detector, and the audio circuit comprised a three-stage resistance-coupled amplifier. Correspondence is still received from many readers regarding the receiver and evidently many "Aristocrats" are still giving good service. We do not intend in this article to describe a radically new "Aristocrat" receiver. The original circuit was carefully thought out and even though two years have elapsed since it was first described there are only minor ways in which it can be improved. An "Aristocrat" receiver carefully constructed in accordance with the original description would be found selective, sensitive, and capable of giving good quality reproduction in the majority of cases; there are, however, a few rearrangements that might be made in the mechanical design which will make the construction of this receiver simpler and better looking.

Before going into the details concerning these suggested changes, a very brief description of the circuit in its revised form, with special reference to the ways in which it differs from the original, will be given. The circuit diagram of the new "Aristocrat" is given in Fig. 1. An important difference between the new and the old set is immediately evident to those who are familiar with the original circuit, *i. e.*, that the antenna stage now uses a variocoupler instead of a tapped coil. Antenna tuning in the original receiver was accomplished by means of the taps on the primary of the antenna coil and by proper use of this adjustment it was possible to obtain high efficiency from the receiver with various lengths of antennas. The new antenna coil of the "Aristocrat" contains a secondary with primary inside it, variable coupling between the two coils accomplishing the same results as did the taps in the original coil; with the new arrangement the adjustment can be made more readily and more accurately. The variable antenna coil is a distinct improvement and should be incorporated in the new "Aristocrat" receiver and might also be used to advantage in receivers constructed according to the original circuit.

The detector stage of the new "Aristocrat" remains the same as the original circuit. The audio amplifier is arranged so that somewhat greater voltage is placed on the plate circuits of the first two stages than was originally used. The new high-mu tubes should be operated with at least 135 volts on their plates.

Simplicity of construction is the keynote of the new receiver. The improvements that have been made in the constructional features of the "Aristocrat" are, first, the use of a metal panel of special design and, secondly, a new and unique type of sub-panel construction. The special metal panel is designed to accommodate two variable condensers of the single-hole mounting type and the panel is also made for use with illuminated dials. There are three additional holes in the panel, the one at the left being for the antenna rotor control, the center one for the rheostat knob, and another hole at the right is for the regeneration control. This panel and dial combination can be used in constructing any number of circuit combinations where there are only two tuning controls and its use in the "Aristocrat" is a good example of its utility. The panel measures seven by eighteen inches and is a product of the Wireless Radio Company, of Brooklyn, New York.

The new special sub-panel, or "deck" as it is called, has five Eby DeLuxe sockets mounted on it and audio amplifying equipment for a five-tube receiver. It is made of Westinghouse Micarta, and is built to accommodate ten binding posts. In the model illustrated the six-wire cable obviates the use of six of these binding posts, connection for the batteries being made directly to the wiring of the receiver by means of this six-wire cable. The audio amplifier is a three-stage resistance-coupled affair and both the resistances and condensers are held in place on the "deck" by clips so that constructors may use any values which they may prefer. The person who wishes to experiment can procure additional values of resistance and condensers than those which come with the deck and substitute them when desired.

Plate Voltage	Negative C Battery Voltage Required			
	Power	Semi-power	Audio	Radio
45	—	—	—	0
90	16.5	6.0	—	3
135	27	9.0	1.5	—
180	40.5	12.0	3.0	—

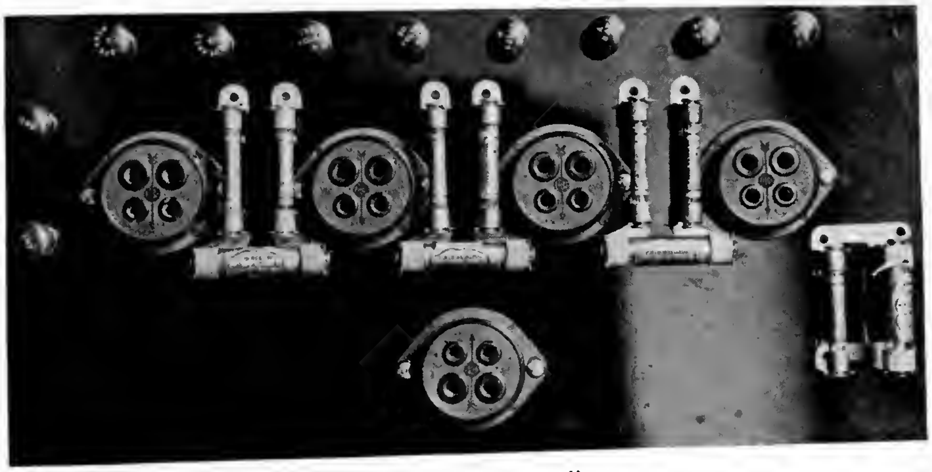
There are available many different antenna couplers and three-circuit tuners that may be used in the "Aristocrat." In the particular receiver illustrated in the photographs accompanying this article, Sickles "Aristocrat" coils have been used in conjunction with Cogswell condensers. The Cogswell antenna tuning condenser has been made in a very ingenious fashion. Its stator plates form one side of the neutralizing condenser, while the other plate of the latter is mounted on a pair of hinges and is adjusted by turning a small screw which pushes against an eccentric cam. It is all very small, very simple, convenient, and very effective, as well as being cheap. At the end of this article there is given a list of those parts used in the model that is illustrated, and the photographs and the circuit diagram should enable experienced constructors to build the receiver with little difficulty.

NEW TUBES

IT IS possible to procure an improvement in results from either an old or new "Aristocrat" by making proper use of the several new types of tubes that have become available since the "Aristocrat" first made its bow. A special detector tube, for example, may be used in the receiver instead of a 201-A type and it will increase the sensitivity and volume very considerably. In this case the detector grid return should go to negative A instead of to positive as indicated in Fig. 1, unless a special Ceco type H detector tube is used, when no change is necessary. Ceco type G high-mu tubes should be used in the first and second stages of the audio amplifier. High-mu tubes of other manufacturers should not be used unless the condenser and resistor values are changed to comply with the specifications of the individual makers. The output tube should be of the semi-power type with proper C and B voltages. Ceco makes special radio-frequency amplifier tubes which will give slightly increased gain in the r. f. stage. They are known as the type K tubes. These new tubes, without regard to any other improvements that might be made, will give greater distance, sharper tuning, and more volume than can be obtained when ordinary tubes are used.

In the table accompanying this article there are given data on the C and B voltages that should be used on the various tubes. The column headed "Power" gives the voltages when a UX-171, CX-371, or Ceco J-71, is used in the output stage. The column head "Semi-Power" gives the required voltages when a UX-112, CX-112, or Ceco type F is used in the output. The voltages given under the column headed "Audio" refer to the high-mu tubes in the audio amplifier. The values given under the column headed "Radio" apply to either 201-A's or special radio-frequency amplifier tubes. If a 171, 371, or J-71 power tube is used in the output of the receiver, an output filter or output transformer should be used in the plate circuit of the tube to protect the windings of the loud speaker from the high plate current. As shown, the circuit is wired for a 112 or Ceco F type tube. C bias for the first two audio tubes is obtained by inserting a battery in the common grid lead at the point marked "X," the positive terminal of the grid battery connecting to negative A.

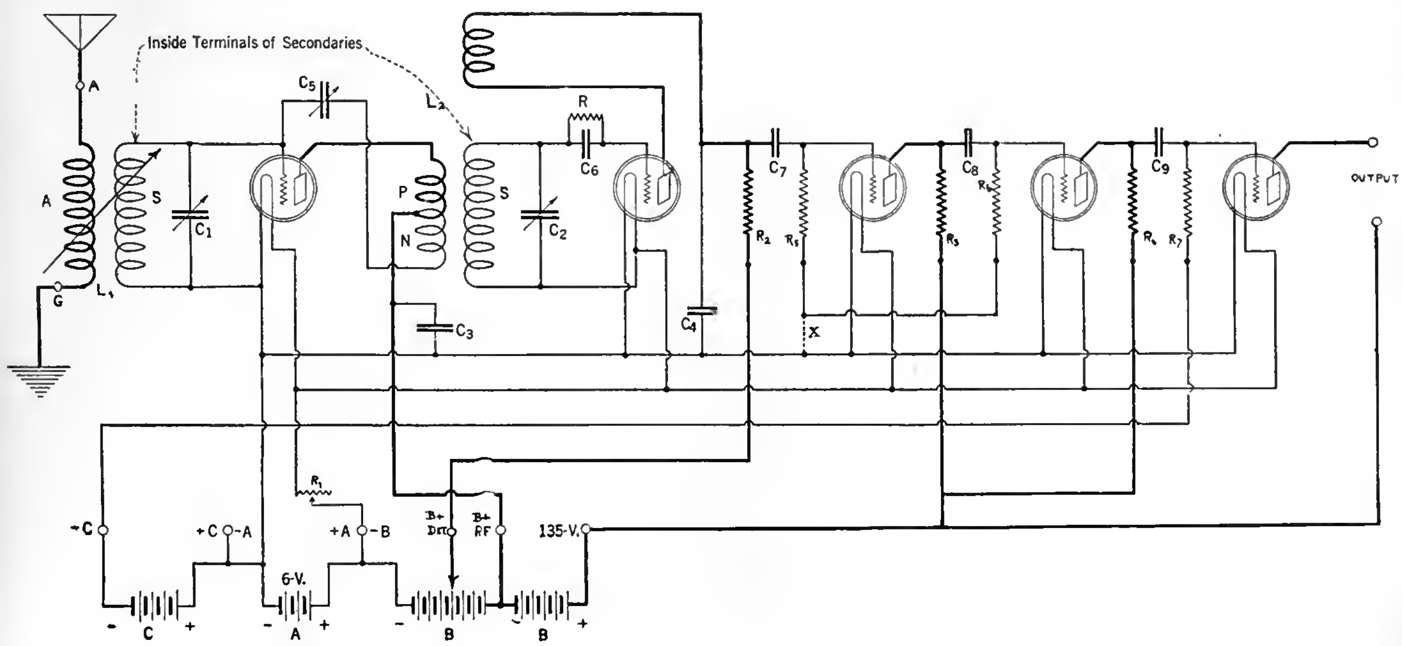
The results obtainable from the improved "Aristocrat" receiver do not suffer at all in comparison with the original set, while the total cost of building the receiver has been materially reduced. The automobile business is not the only one in which the honest claim that production methods enable you to purchase a better product for a lower price. In the case of the improved "Aristocrat," production methods have been applied to radio.



THE LYNCH "DECK"

Its utilization considerably simplifies receiver construction. The list of parts below tells just what the "deck" comprises

L_1, L_2—Sickles "Aristocrat" Coils	$ 4.50
C_1—Cogswell Variable Condenser, Type A, 0.00035 Mfd.	2.25
C_2—Cogswell Variable Condenser, Type B, 0.00035 Mfd., Neutralizing Condenser (C_5) Attached	2.75
C_3, C_4—Sangamo 0.004 Mfd. Fixed Condensers	1.20
Four Eby Binding Posts	.60
Six-Wire Cable	.60
Wireless Radio Company's Panel, 7 x 18 Inches, with Mounting Brackets, Illuminated Dials, and Filament Rheostat (R_1)	4.50
Two Kurz-Kasch Knobs	.50
Lynch Deck, Including the Following Parts, Mounted and Ready for Wiring: Westinghouse Micarta Panel; Seven Resistor-Condenser Mounts; R_2, R_3, R_4—0.1-Meg. Metallized Resistors; R_5, R_6, R_7—0.5-Meg. Metallized Resistors; R—2-Meg. Metallized Resistor; C_7, C_8, C_9—0.006-Mfd. Tubular Condensers; C_6—0.00025-Mfd. Tubular Condenser; Five Eby DeLuxe Sockets	12.50
Total	$29.40



THE CIRCUIT DIAGRAM OF THE "ARISTOCRAT" RECEIVER

Suppressing Radio Interference

Interference from Motion Picture Theatres, Telephone Exchanges, Arc Lamps, Incandescent Street Lamps, Flour Mills, Factory Belts, Electric Warming Pads, Precipitators, Etc., Is Discussed, and Remedies Are Suggested

By A. T. LAWTON

Although this article is really the second of a series, the first of which appeared in the September Radio Broadcast, it is nevertheless complete in itself, and the reader who is suffering from interference of any of the forms outlined here will profit considerably from a study of this paper. The data presented here result from a two-and-a-half-year study conducted by the author in more than 132 cities. The forms of interference covered in the September article were those due to oil-burning furnaces, perhaps the most common source of man-made static, X-ray equipment, and dental motors. The first kind of interference to be considered here is that originating at motion picture theatres.

MOTION PICTURE THEATRES

The radius of interference from this source is ordinarily about 200 yards, occasionally greater, depending on exterior wiring. In the great majority of cases the direct-current generator is responsible for the trouble. Contrary to popular belief, the arc lamps themselves cause practically no interference; in fact, there is often less disturbance with the arcs lighted than before they are "struck," *i. e.*, with the generator running unloaded. The difference in certain cases is decided, absorption of the interference occurring as soon as the arcs are put on.

Fig. 1 shows a method used to eliminate this interference with success in actual practice. Five-ampere fuses are used. If the commutator is badly worn, it should be turned down in a lathe, and we might remark here that the quality of the carbon brushes used have a noticeable effect on the intensity of commutation interference.

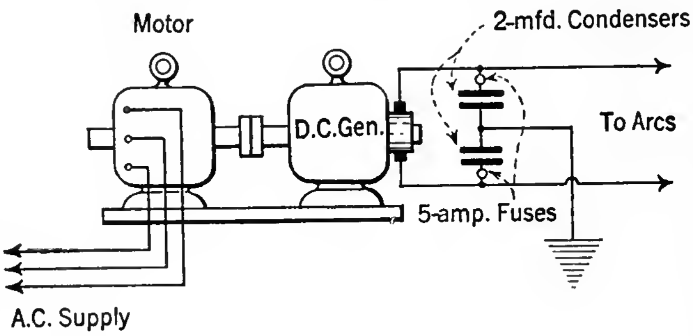


FIG. 1

Squirrel cage induction motors are in common use for driving these generators and, ordinarily, give no trouble unless some defect is present.

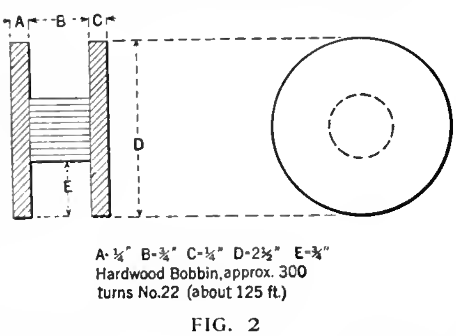


FIG. 2

Constructional details for the choke coils recommended for elimination of interference originating in telephone exchanges

TELEPHONE EXCHANGES

It is probable that in most cities interference from this source has been cleared up. The larger operating companies have been active in this regard, but in smaller towns and rural communities much trouble exists. On the larger type motor ringers, high-tone and low-tone (sometimes referred to as trouble tone and howler) circuits are mainly responsible. Complete elimination is secured by inserting a choke coil in each of the two brush leads, close up to the machine. Details of the coil required are shown in Fig. 2.

Complications arise if connection is made at a distance of more than four inches from the brushes—incomplete elimination resulting.

The greatest offenders in the category of telephone ringing apparatus are pole changers and frequency converters. These constitute standard equipment in thousands of small exchanges; in some larger exchanges they are operated only after 10 P. M. when the rush hours have passed. The interference is of a rapid clicking nature and may carry half a mile or more, depending on the proximity and layout of the city distribution and telephone wiring.

For pole changers, definite and conclusive results are obtained by inserting the coils described in Fig. 2 in the ringing leads and at least 95 per cent. of the trouble disappears. Up to the present we know of only one instance where this method failed—and peculiarly enough, a simpler method cleared up the trouble. A single one-half microfarad condenser bridged across the contacts gave 100 per cent. elimination.

Frequency converters are a different proposition, operating off a. c. instead of d. c. as in the case of pole changers. The surge trap applicable to pole changers gives only 50 or 60 per cent. reduction.

A special surge trap is made up for this source by companies manufacturing the frequency converter, and it will be found more economical in the long run to purchase this complete rather than endeavor to make it up locally. For all practical purposes, complete elimination is obtained through the installation of the special surge trap.

Automatic telephones, now coming into such general use, contribute their little quota of disturbance. Usually they affect radio receivers only in the same residence where the dialing operation is being carried out, although several cases are on record where radio sets of next-door neighbors were also affected.

A single condenser of one microfarad capacity placed across the dialing circuit will cut out the clicking noise and does not appear to have any detrimental effect on the speech transmission or proper functioning of the line. However, permission of the telephone company should be obtained before making any attachments.

ARC LAMPS

Strange as it may seem, flickering arc lamps cause practically no radio interference. If the arc is jumping violently, however, then clicks are recorded on radio receivers in the vicinity; a short distance away interference is not material. This doesn't mean that arc lamps cause no disturbance. On the contrary, during a recent investigation one arc lamp practically killed radio reception for eleven city blocks along one street. It was burning perfectly steadily and showed no sign whatever of defect.

The characteristics were slow clicking in dry weather, fast clicking in moist atmosphere, and rapid clicking during rainy weather. On a five-tube set with loud speaker, the noise was violent, resembling very much the operating of a pneumatic hammer. The source of trouble here was a minute fissure in the composition head ring which, filling up with moisture, caused a high-resistance short across the 4000-volt lines. Evidently the spark dried up the moisture at each crossover, and time was required for the path to reform, otherwise we should have gotten steady buzzing here.

During all the days this case was under observation not once did it come on coincident with the lighting of the arcs, but always twenty minutes or twenty-five minutes afterward. It took time to develop, possibly a slight heating and consequent expansion of the parts being involved.

If arc lamp interference comes on directly the lamps are lighted the source is very likely to be line trouble, such as wires scraping on iron bracket arms, loose splices, etc.

In many localities where it is prevalent arc lamp circuit interference starts up before the lamps are lighted, perhaps twenty-five or thirty minutes previous to lighting, and it is quite regular every evening.

This is caused by the rectifying tubes in the power house or sub-station. These tubes are "warmed up" for service prior to the line being switched in; the operation takes twenty-five minutes or so, and radio-frequency surges pass out on the line despite the open switch, so even before the lamps are actually lighted interference starts. Intensity of the interference is increased when the lights come on and continues all night, until the daylight shut-down. Generally speaking, new rectifying tubes do not give trouble, nor older ones, paralleled. Overloaded tubes, however, or those which have become hard through long usage, are liable to set up interfering surges that will travel long distances over the system.

The obvious thing to do with a defective lamp is to have it repaired; the same thing applies to line defects. Rectifying tube disturbance, by far the worst trouble because of its continuous nature and wide range, can be cleared up by putting a choke coil as described in Fig. 3, in each outgoing d. c. feeder.

Two hundred turns of No. 16 d. c. c. wire are required on a wooden cylinder $3\frac{1}{2}$ inches diameter and about 12 inches long. Longitudinal slots are cut in the cylinder for insertion of fibre strips which keep the wire off the wood and provide adequate heat radiation facilities. This is for 4-ampere arcs; for 6-ampere arcs it may be as well to use No. 14 wire.

It seems that in certain instances of this nature, seventy-turn chokes were large enough to give satisfactory elimination; in the particular case in mind they were ineffective.

INCANDESCENT STREET LAMPS

IT MAY come as a little surprise when we say that, given any city where the street lighting system consists of, say two thousand series arcs and two thousand series incandescent lamps, on various circuits, more radio interference will be caused by the incandescent lamp circuits than by the arc system.

This is due to less careful installation in the case of the incandescent system—not because of any inherent defect. The condition is general.

Of one hundred cases of radio interference due to faults on series incandescent lighting systems:

- 42 were caused by down-lead wires scraping on the iron brackets.
- 15 by loose connections of the wires at the lamps.
- 10 by internal defects in the lamp fixture proper.
- 10 by partial shorting of the wires in conduit prior to connection at the lamp.
- 9 by poor line splices.
- 5 by leakage or spitting at the disc fuses in the lamp head.
- 5 by lamps loose in their sockets.
- 4 by defective mercury or other type automatic time switches.

It may be remarked here that sources on a series lighting system giving rise to radio interference are most difficult to locate. What occurs at a defective lamp seems to be duplicated in many lamps either side of the faulty one; intensity values of the interference are misleading and very careful observation is required.

FLOUR MILLS

IN PRACTICALLY every flour mill the chlorine process of bleaching has been superseded by the electrical method. This consists of a twenty-thousand volt spark oscillating directly in the path of a blast of air, the latter becoming ozonated, passes on to the grain in process of crushing.

Direct radiation is confined to a few hundred feet. The source, however, is a vigorous one and distribution wiring carries the disturbance to great distances; it is capable of mutilating radio reception practically all over the average small town.

Methods of elimination are simple and definite. One hundred-and-fifty turn choke coils wound on three or three and a half inch tubing will kill at least 85 per cent. of the noise and will not interfere in the least with normal operation.

Operating current here is 12 to 15 amperes; if the coils are not banked, No. 10 wire will be suitable. To conform to Electrical Inspections requirements, enclosure of the coils in a standard outlet box is recommended, the knockout holes of which have been opened and covered with fine wire gauze. This latter affords good ventilation while preventing grain dust accumulating on the coils.

Self-contained bleachers of the arc type cause no trouble. They are, however, being rapidly displaced by the more efficient spark type.

FACTORY BELTS

HIGH-SPEED belts are a fruitful source of radio interference, especially noticeable in cold, dry weather. Friction between the pulleys and belting causes a static charge to form on the belt and this, after rising to a high potential, will spark to nearby metal objects, setting up a "crackling" noise in the receiver.

As most heavy rotary machines are well connected to ground one would imagine that this static charge would filter away gradually, and fail to build up to any material potential. The fact is, and it can be demonstrated, that the film of oil in the machine bearings is sufficient to insulate the rotating parts from ground.

A "static collector" is used to get rid of this trouble. It consists of a wiping contact of springy metal, at all times resting on the belt in motion and permanently connected to earth.

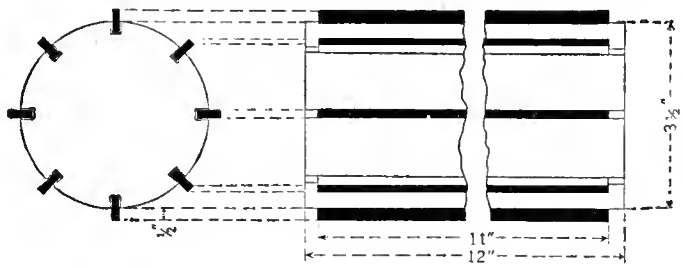


FIG. 3

A metal laced belt can set up quite a loud clicking interference. Every time the metal lacing passes over an iron pulley the click is heard. No such effect is noted, of course, where wooden pulleys are used, but in the cases cleared up we simply removed the metal lacing and substituted rawhide.

ELECTRIC WARMING PADS

WHETHER interference from this source is to be regarded as serious or not depends on how far away you live from the offending pad. The radius is about two dwellings either side of the one in which the pad is being used, assuming that the houses are close together.

Little thermostats inside the pad automatically break the supply current when the pad becomes sufficiently heated and switch it on again when the elements cool sufficiently. This alternate opening and closing of the 110-volt supply line sets up clicks which are extremely annoying to broadcast listeners in the immediate vicinity.

Intensity of the trouble varies with the make of pad and also with length of service. It seems that corroded or burned contacts are responsible for most of the trouble and before going to the expense of purchasing condensers, etc., it is usual to open the warming pad and readjust the thermostat contacts after cleaning them up properly.

A different problem is presented in the case of hospitals. Take a literal, specific example: Two hundred patients, two hundred pairs of telephones (no loud speaker allowed) and, incidentally, two hundred warming pads (one for each cot), were in use. Every time a patient gets restless and kicks out his feet he jars the pad thermostats and treats the other hundred and ninety-nine to a series of sharp clicks usually resulting in reciprocation.

Substitution of quiet types for the noisy ones and condenser absorption would seem to be the best recommendation.

PRECIPITATORS

THIS apparatus is used in the treatment of various ores as well as for the purpose of smoke and dust precipitation. Its radio interference can be heard ten miles; at five miles it hurts reception and in the vicinity of the plant, normal reception is impossible.

As in the case of the notorious oil-burning furnace, methods of elimination which clear up the trouble in one installation fail to give the desired results when applied to another plant.

Several cases have been cleared up using high-frequency chokes, *i.e.*, placed in the high-tension circuit. The coils consist of 500 turns of No. 18 or No. 20 bare or covered wire on a tube three and one half inches in diameter. Individual turns should be spaced about one eighth inch apart except at the ends, where one-quarter inch spacing is recommended.

Fig. 4 shows an arrangement which has given satisfactory results. It may be necessary in other cases to split this 500 turn choke, *i.e.*, putting 250 turns near the rectifier and 250 near the treater.

In the types where the high-tension energy for the rectifier is obtained through transformer action direct from a transmission line, interference is naturally heavier than that experienced from the more or less self-contained motor generator type although the actual energy in the former is less than in the case of the latter. Average energy values will be about 70 milliamps. at 30,000 volts and 80 milliamps. at 50,000 volts, respectively.

Considerable experimental work has been carried out by different precipitation plants in this connection and while special treatment was found necessary in several instances practically all cases investigated have been cleared up.

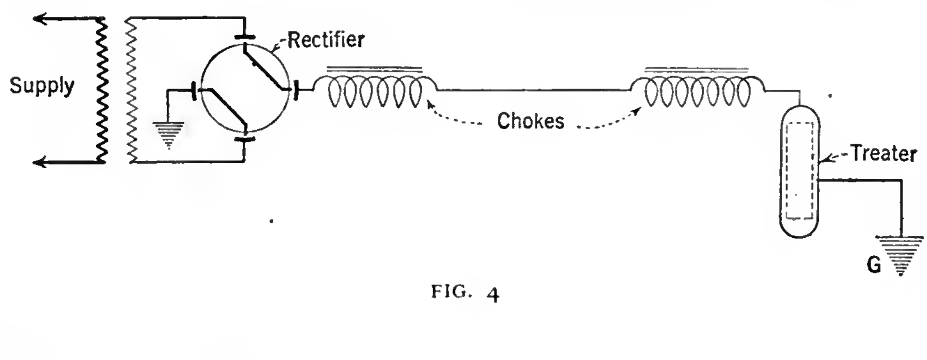


FIG. 4

AS THE BROADCASTER SEES IT

BY CARL DREHER

Drawing by Franklyn F. Stratford

Putting Freak Broadcasting in Its Place

IN ALL human affairs the tendency is toward quiescence and boredom. Among vigorous peoples this drift toward monotony is resisted by a constant seeking for innovations. Now and then some fruitful bit of originality rewards the quest. In the main, however, the innovations are failures. They have no deep roots in human desires or interests, and, after the first glance, they amuse the normal spectator even less than the old shows he is weary of. The spirit is praiseworthy, but the results are dreadful, especially in the arts. Consider the poets, for example. Here and there one of them, distressed by his inability to convince the world that he is another Shelley, decides to be entirely original by printing a magazine of verse with a fake Nujol advertisement on the cover, no capital letters, and half the words upsidedown. His originality is hard on the compositors. To be original, in the sense of doing something that is not commonly done, is very easy. To that degree you can be an exponent of novelty, by entering the nearest drug store and ordering a pineapple soda with chocolate cream. But to be fruitfully original requires more than twenty cents.

We are similarly beset in the art of broadcast entertainment. The innovations are many, but most of them are of the twenty-cent variety. I do not intend to itemize all the varieties of freak broadcasting; it would be impossible, and, besides, a certain portion of this department is consecrated to sensible subjects. A few samples will suffice.

The broadcasting of alleged disembodied spirits seems to me to fall into the category of futilities politely hinted at above. I have no animus against the spirits as such. It is true that I have never seen one, and, since studying psychopathology, have doubted their existence. Nevertheless, as I have not seen everything in the universe, and don't expect to, I acknowledge that such things as ghosts may exist. But why broadcast them? If a ghost wants to see me, let him or her call on me at my office, or in the dark reaches of the night. But as a broadcast listener, I like to be entertained. As a broadcast listener, I also object to the imputation that I am a total ass. No doubt I am an ass in some respects, but not to the extent that I can be kidded, on hearing the tinkling of glass, a noise like a $6 saxophone, and some mumbling through my loud speaker, into believing that authentic goblins are disporting themselves in the studio of the puissant broadcaster who is striving to instruct me. And, when a committee of spiritualist investigators assure me that everything is aboveboard, I guffaw openly at their discourse. Who are they to tell me so? What do they know about the tricks of broadcast transmission?

The method used in broadcasting the shades is to turn on the microphone and, with the studio doors locked and no one in the room, to listen for mysterious sounds on the station carrier, which is assumed to be quiet. The investigating committee watches the studio doors and snoops around otherwise at their discretion. But can they assert with any semblance of plausibility that they know all the sources of input to the speech amplifiers of the transmitter? Nothing could be simpler than to rig up an additional microphone somewhere in the building and, paralleling it with the transmitter in the empty studio, to broadcast any sounds one cares to. Not even that is necessary. One of the operators can tap a tube in the speech amplifier and make noises which will seem inexplicable to the ghost-chasers. The business of spiritualistic investigation is at best full of complications, and to complicate it further by adding the technical intricacies of a broadcast transmitter is beyond all sense. Whether there is fraud or not—and certainly in connection with struggling stations avidly bent on cadging every possible square inch of newspaper space the possibility of deception is not remote—the pretence of scientific investigation under such conditions is simply silly. The broadcast listeners may not be Newtons, Goethes, and Mommsens, but they are not voodoo worshippers either. The studio manager who first conceived the idea of broadcasting spirits may have been original, but he omitted to mix a few brains with his originality.

Even more infantile is the menagerie broadcasting stunt. The only justification I can see for it is in connection with a children's hour. The noises made by sea lions and rhinoceroses are neither agreeable nor intellectual, and, being full of steep wave fronts and tones outside the band of transmittable frequencies, they don't get over anyway. If a man roared into the transmitter it would sound as much like a lion when it got through the loud speakers as if a lion did the roaring.

As one listener, I ask to be spared such buffooneries. I respect the urge for originality, but it must take a more convincing shape than in such procedures, which have no other use than to get some station's publicity matter a transient hearing. If there is nothing interesting left to say, and nothing beautiful left to play, my counsel is to shut down the transmitter and economize on electricity at the rate of three cents per kilowatt hour.

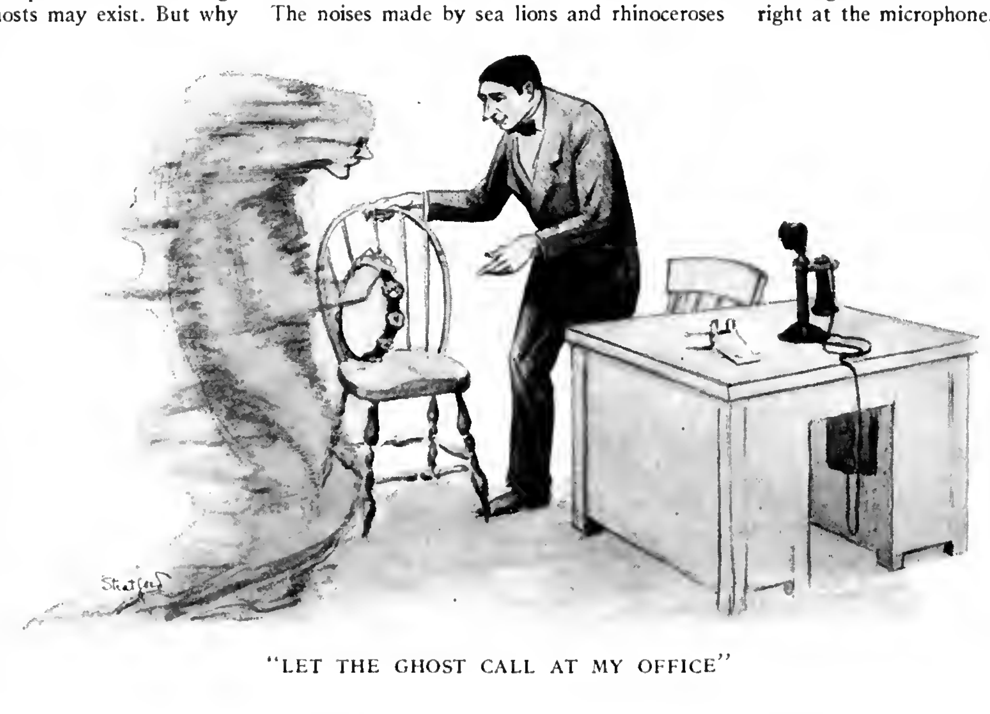
Background Noises

MR. A. S. DANA of Seymour, Connecticut, writes us as follows:

> The better grade of broadcasters have made such improvement in their quality that there is but one factor which could be improved in so far as my ability to judge quality goes.
>
> Is it not possible for them to reduce or eliminate the noise background which accompanies the transmission? In other words, cannot the equipment be improved so that it is not possible to tell when a station is on the air unless speech or music enters the microphone? According to present standards, it is easy to locate and tune-in a station when they are not broadcasting simply by the racket which occurs when the station is in tune.

Mr. Dana seems to think that the noise in question is all generated at the transmitter. Actually there are three possible sources. In some cases all are in evidence, and in others none.

Background noise may have its inception right at the microphone. The transmitter itself has a degree of internal hiss caused by current passing through the carbon in the case of a microphone, and by tube irregularities in the first stages of the amplifier associated with a condenser transmitter. But if the microphone is well designed and the carbon of high quality, and not too old, the sensitivity to external sounds is so great that the hiss is seldom audible. In the case of speech input some slight hiss is usually observable, and occasionally during pianissimo passages of musical performances, but with proper microphone care the internal



"LET THE GHOST CALL AT MY OFFICE"

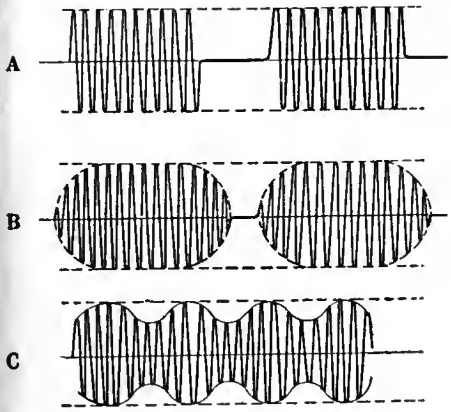


FIG. 1

noise level is negligible. If the tubes in the associated amplifier of a condenser transmitter are carefully picked this instrument is practically noiseless with normal inputs. Of course any type of transmitter will pick up room noises, and broadcasters cannot always secure their material in perfectly quiet places. But in general we may say that most well regulated stations transmit practically noise-free modulation. By that I mean that at a distance of a few feet from the monitoring cone in the station, which is assumed to emit a loud signal during modulation, no sound is audible in the intervals. Of course, by placing one's ear on the cone one can hear plenty of rustle, but that is going out of one's way. It is like saying that the alarm clock in my house, which I can hear ticking 33 feet away if I listen hard enough, is causing a disturbance which should be eliminated.

But after leaving the transmitting antenna, the modulated wave must run the gauntlet of electromagnetic disturbances in the medium between transmitter and receiver. The metaphor I have used here may be an unfortunate one, if it confirms the popular supposition that the carrier, in some mysterious way, picks up noises on its journey through space. People jump to this conclusion because they find, in tuning their receivers, with the sensitivity control well down, that they hear nothing over a certain section of the broadcast frequency range, and then, running across a blank carrier, they get a more or less audible background. The actual sequence here is more along the following lines, however: The receiver has been picking up slight disturbances—static, distant violet-ray machines, transmission lines, bells, and the like, right along, but at a level below audibility, when the receiver sensitivity is low. But the carrier coming in increases the receiver sensitivity through its heterodyne amplification, hence the noises come up when the receiver is tuned to a carrier. Of course neighborhoods vary in the relative strength of external disturbances, and anywhere there is a variation with time; normally the atmosphere may be quiet, but when there is local lightning plenty of crashes and rumbles will be picked up by all receivers. However, Mr. Dana's question probably does not include these relatively rare periods of acute disturbance.

Finally we must take into account the internal noises of the receiver itself. There is a tendency for slight gaseous irregularities in the radio frequency tubes to be amplified through each successive stage until quite a noticeable rustle results in the loud speaker. But if the tubes are properly exhausted there should be no trouble from this source. I have an eight-tube receiver, and, in testing it as I write with the sensitivity control all the way up and the loop removed to eliminate r.f. input, I am unable to hear any sound whatsoever. With the loop in position I can hear the elevator motors in nearby apartments and a medley of undifferentiated noises, but then in practice I should never think of using the receiver in this state of excessive sensitivity. The receiver may also develop internal noises through regeneration at radio or audio frequency, or through an impure plate or filament supply. When at a low level, many such sources of disturbance manifest themselves as rustling or murmuring sounds which may be ascribed to the broadcast transmitter.

The increase of transmitting power has undoubtedly reduced background noise in radio reception, by permitting the use of less stages of amplification and lower sensitivity at the receiver, for the same signal volume. But the factor of modulation depth comes into the problem forcefully. A weakly modulated carrier simply amplifies static and interference at the expense of its intelligence-bearing side bands. Deep modulation is highly desirable on this account, and limitations on adequate modulation—which means 80-90 per cent. peaks, are as bad as inadequate field strength. Of course the best thing is to get rid of the carrier altogether, but that is a technical step feasible, at this stage, only in radio circuits professionally operated at both ends.

Abstract of Technical Article. *VII*

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 A. I. E. E. on October 17, 1923. Reprinted May, 1924 by Bell Telephone Laboratories, Inc.

(*Continued from October* Radio Broadcast)

IN A carrier-current telegraph system free of capacity and inductance, a series of dashes made at the transmitting key will be reproduced accurately as oscillations of the carrier frequency within a rectangular envelope, as

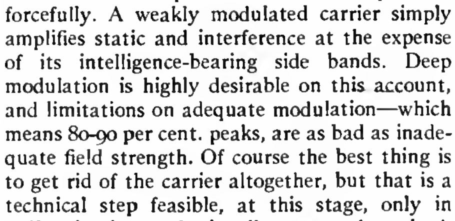


FIG. 3

shown in Fig. 1-A. If, now, inductance and capacity be inserted into the circuit so that it becomes resonant to the carrier frequency, the same keying action will produce, at the receiving end, a trace like that of Fig. 1-B. The circuit now has a certain "stiffness," so that it takes some time for it to reach the full amplitude of oscillation at the carrier frequency, and again,

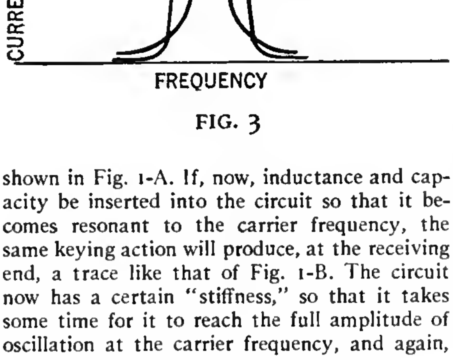


FIG. 4

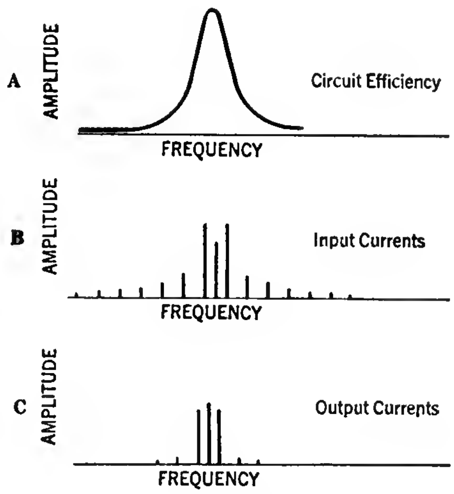


FIG. 2

after the key has been opened, the oscillations continue in a decaying wave train like that of the old spark transmitters. The faster the rate of signalling, the more serious the distortion; if, for example, dots and dashes are made too rapidly, the amplitude will never drop to zero at all, as shown in Fig. 1-C, although complete breaks are made at the key. The reason for this appears in Fig. 2. The top curve (A,) is a typical resonance peak, showing how the circuit efficiency, by virtue of the tuning effect, varies with frequency. This property, as we saw in the first instalment of this abstract, is a valuable means of frequency discrimination. But the effect also involves changing the amplitude of the various components shown in the input currents of Fig. 2-B to the output currents of Fig. 2-C. As we saw in the earlier discussion, 2-B includes the components of a square-topped wave. The suppression of the higher harmonics and the exaggeration of the carrier frequency have destroyed the rectangular wave shape. We could get it back by sacrificing selectivity—by broadening the circuit—but then we sacrifice also the power of discrimination on which we must depend if we are to make the most of the line. Obviously what is needed is a form of frequency discrimination which will pass a certain *band* of frequencies with substantially equal efficiency, and cut off sharply frequencies outside of this band. Reactive networks known as "filters" have been devised by telephone engineers to give this effect. Fig. 3 shows the difference in transmission characteristics between a resonant circuit and a filter designed to pass a band of frequencies in the same neighborhood. Fig. 4 illustrates the principal types of filters and their respective properties. Such circuits are of the utmost importance, not only in the practical communication arts, but also in investigations of the nature of speech and music. (Cf. Jones: "The Nature of Language," abstracted in April, 1927, Radio Broadcast.)

Besides the property of selective frequency transmission, the characteristic impedance of such networks is of importance. Fig. 5 illustrates two types of band filter with substantially similar elements, but designed for different connections. *A* is feasible for parallel connections, the impedance being very high for all frequencies save the band the network is designed to pass. But when the terminating elements are as shown in *B* the impedance to frequencies other than those in the transmitted region is low, so that such filters may only be connected in series. By the use of networks suitably designed and connected a number of carrier frequencies may be delivered to a line without mutual absorption, and then separated for individual demodulation at the receiving end of the line.

By the methods described above the multiplexing of lines is accomplished. As an example, Jewett gives the schematic circuits for the multiplication of telephone channels over an open wire toll line.

Up to about 100 cycles per second the line is available for d.c. telegraph purposes. Above this point comes the d.c. telephone band with its 300-2800 cycle range, approximately. From 3000 cycles up to about 35,000 may be used for carrier-current telephone channels. It is customary in most cases to use the frequencies below 20,000 cycles for transmission from east to west, and those above this figure for transmission from west to east. The attenuation suffered by currents in the upper range is naturally greater and correspondingly higher amplification is required for equal received energy. A band about 2500 cycles wide must be allowed for each carrier channel, and a space of 1000 cycles is required for separation between channels with band filters

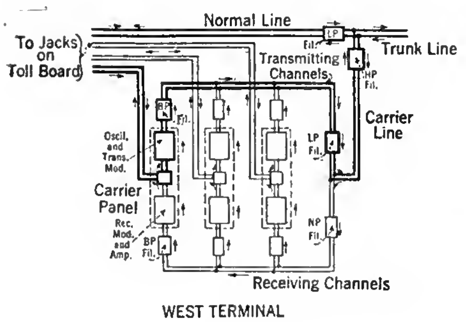


FIG. 6

possessing the usual discrimination characteristics.

Fig. 6 shows one terminal of a carrier telephone system. At this end we shall follow out the steps involved in multiplex transmission. As the line is also used for d.c. telegraphy and telephony, a low-pass filter is inserted in the metallic circuit to prevent the carrier frequencies from reaching subscribers through the toll board. Likewise in the carrier line, a two-way high pass filter prevents the currents below 3000 cycles from being absorbed in the carrier apparatus. Three pairs are shown leading from the toll board to the carrier equipment. In the case of the channel which is shown in heavy lines, the voice currents pass first through a low frequency circuit which permits the passage of current between the normal line and either the transmitting or receiving side of the carrier equipment, but which blocks currents between these two halves in a

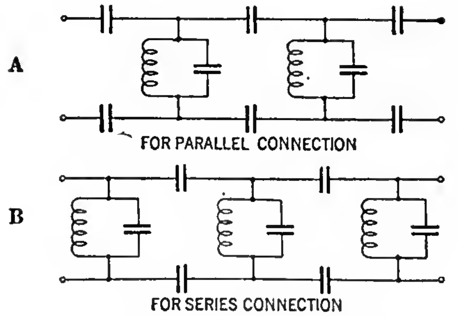


FIG. 5

vertical line. The importance of this feature will appear later on. When the subscriber on this end talks the voice currents generated in his desk set modulate the output of one of the carrier oscillators, and, passing through a band filter, which selects one of the side bands, merge with other side bands and go to the trunk line. First, however, it will be noted that they pass through a low-pass filter, designed to transmit the eastbound group of frequencies below 20,000 cycles. This filter prevents the transmitting carrier circuits from absorbing incoming energy intended for the receiving channels.

At the other terminal of the line, sketched in Fig. 7, the receiving process may be traced. Again the common line is connected to a low-pass and a high-pass filter. At this crossroads the low-pass filter selects currents associated with d. c. telegraphy and telephony and admits them to the composite set. The high pass filter selects the carrier side bands coming in from the west terminal and conducts them to the grouping filters, where the incoming currents are led to the receiving modulators. Again a band filter selects the appropriate side band for each branch. The demodulated currents pass to their respective jacks on the toll operators' board, through the low frequency balancing circuits. If it were not for these circuits obviously the received voice currents would be sent back through the transmitting carrier equipment, instead of being confined to the subscriber at the east terminal.

Jewett sums up the process physically as follows:

> We have . . . followed through, from one toll board to the other, a particular signal and have seen how it is moved about on the frequency scale to a position which identifies it from other similar signals, how it is associated with such signals on a common line, transmitted to the distant terminal, isolated at the receiving end from these other signals and finally restored to its original position upon the frequency scale.

When a circuit is to be multiplexed for telegraph the range between 3000 and 10,000 cycles is normally devoted to this purpose. The directional dividing line is then usually at 6000 cycles, frequencies below this point being used for transmission from west to east and frequencies above 6000 for transmission from east to west. Various combinations of carrier telephone and telegraph are possible. One layout shown in Jewett's paper comprises the following facilities: 2 full duplex normal telegraph channels; 1 normal telephone channel; 10 full duplex carrier telegraph channels; 3 carrier telephone channels. This amounts to a total capacity of 24 one-way telegraph messages and 7 one-way telephone messages for one pair of wires.

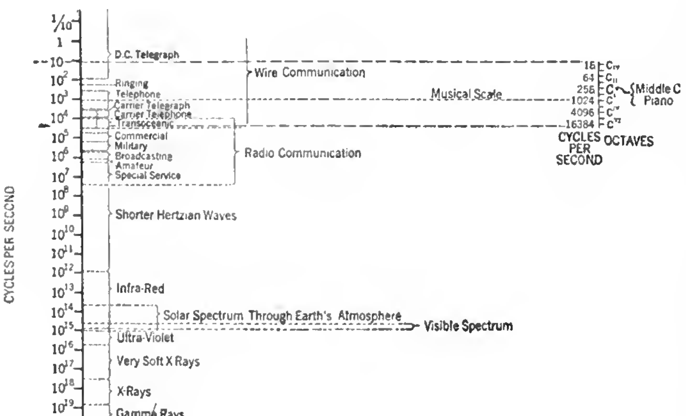


FIG. 8

Carrier channels, employing currents of relatively high frequency, are subject to correspondingly greater attenuation and must sometimes be provided with repeaters at points where low frequency channels do not require amplification. At such a repeater station the low frequency currents are carried around the carrier repeaters by means of two low pass filters and a wire circuit. By means of group filters the telegraph channels are separated from the telephone channels, and finally each individual frequency is led by a band filter to the repeater designed for it.

Jewett ends his paper by a brief discussion of the multiplexing of radio circuits. He points out that at the high frequencies employed in radio transmission the range covered by a simple resonant circuit is usually sufficient to include a band wide enough for good telephonic quality, so that filters, with their rectangular characteristics, are not required.

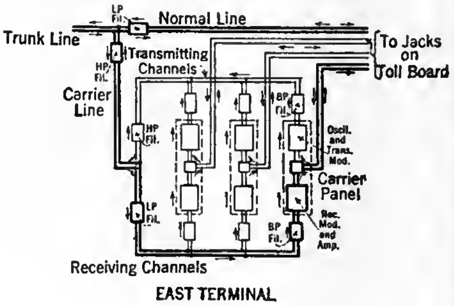


FIG. 7

A spectrum chart of electromagnetic waves, with frequency plotted on a logarithmic scale, taking in everything from the commercial d. c. telegraph to the gamma rays of radium, is also supplied, and is reproduced here as a matter of general interest (Fig. 8).

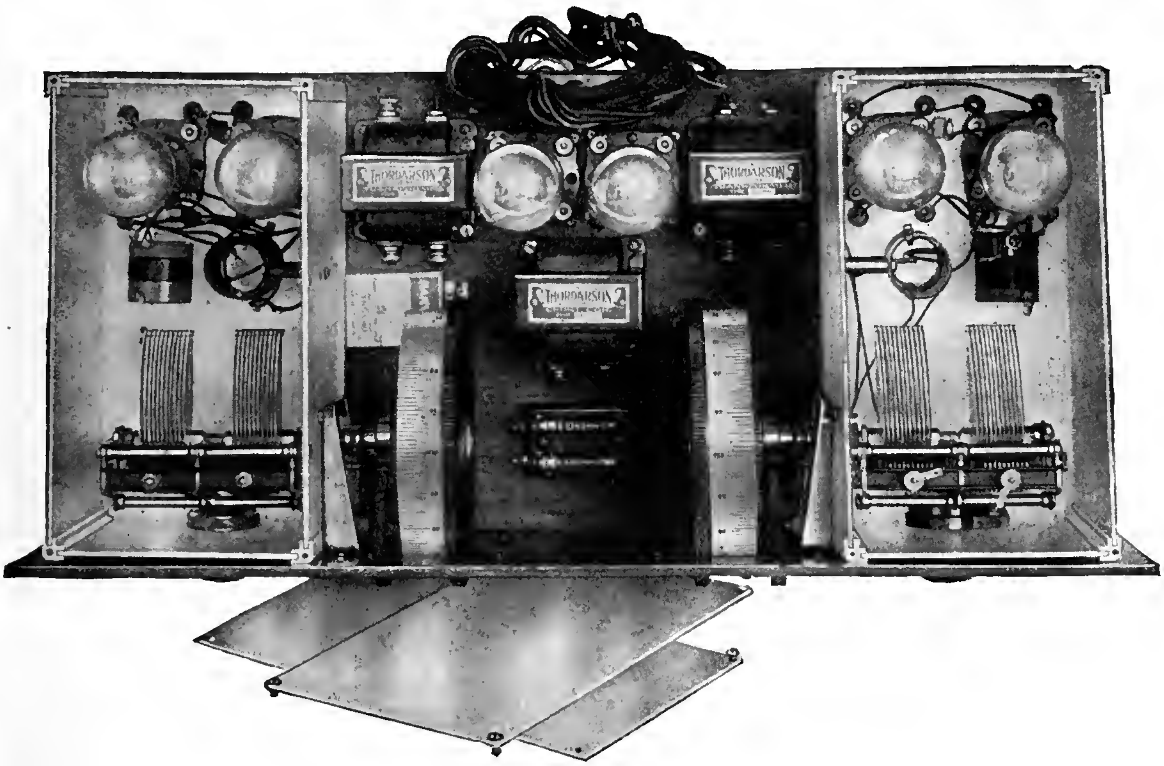
Auditorium Acoustics

THE Celotex Company of 645 North Michigan Avenue, Chicago, have issued a good-sized booklet describing their patented sound absorbing material, Acousti-Celotex, which, among other applications, has found use in various broadcasting studios in this country. About eight pages of the pamphlet are devoted to a fairly technical discussion of "Analyzing the Acoustics of Auditoriums," the subject matter covered being the same as that of our article on "Studio Design" in the June, 1927, issue of Radio Broadcast. The former article, being considerably longer, goes into more detail and takes up special problems, such as the effect of stage openings and balconies in auditoriums, factors influencing distribution of sound, etc. Naturally Acousti-Celotex is the absorbing material used in the examples, but the discussion is commendably general and only a small portion of the space in this section is devoted to advertising the manufacturer's product. The pamphlet should prove of interest to many broadcasters and acoustic engineers.

A word about commercial aspects in such matters. This department does not recommend specific products to its readers, but neither does it labor under any phobia as regards commercial publications. It is glad to receive them, and, when the material appears interesting and useful to technical broadcasters, in the personal judgment of the one who happens to be writing these papers, they will be mentioned at suitable times

ALUMINUM

AT THE RADIO SHOWS



THIS year's Radio Shows demonstrate that Aluminum has been adopted for shielding by more of the leading manufacturers and Radio Engineers than ever before.

The RGS "Octa-Monic" is an outstanding example of the use of Aluminum in prominent sets. The specifications call for Aluminum Box Shields to insure amplification, tone quality, sensitivity and selectivity.

The standard "knock-down" ALUMINUM BOX SHIELDS—5" x 9" x 6"—are adaptable to many hook-ups.

Write for new booklet, "Aluminum for Radio," telling of the advantages of Aluminum in Radio apparatus.

ALUMINUM

ALUMINUM COMPANY OF AMERICA

2464 Oliver Building, Pittsburgh, Pa.

Offices in 18 Principal American Cities

ALUMINUM IN EVERY COMMERCIAL FORM

Employing the New "Octa-Monic" Principle

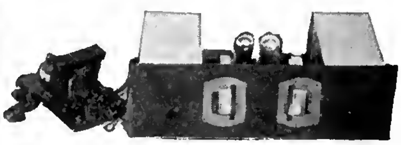
Not Regenerative! Not Tuned Radio But the Radically and

R·G·S

A. C. Tube Models

R. G. S. "Octa-Monic" A-C Tube Kit

including instructions and blue-prints; all necessary apparatus, ready to build, ***$119.60***



R. G. S. "Octa-Monic" A-C Tube Chassis

Completely assembled according to latest laboratory methods, (carefully tested and selected heavy duty wire, lamp socket connections, cable, Power (A-C) Transformer, etc., etc.,) with instructions and blue-prints for installation, ready to plug in your lamp socket and operate, ***$129.60***

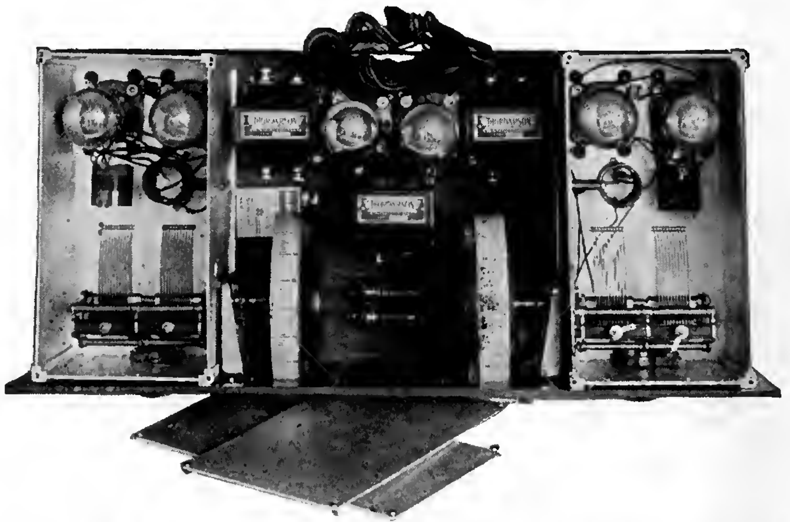
R. G. S. "Octa-Monic" A-C Tube Receiver

housed in an attractive, partitioned, walnut table cabinet, ***$149.60***

NOTE: ***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.***

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, thereby representing a very distinct saving to you.



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.

DEALERS: *Write for Complete Merchandizing Proposals*

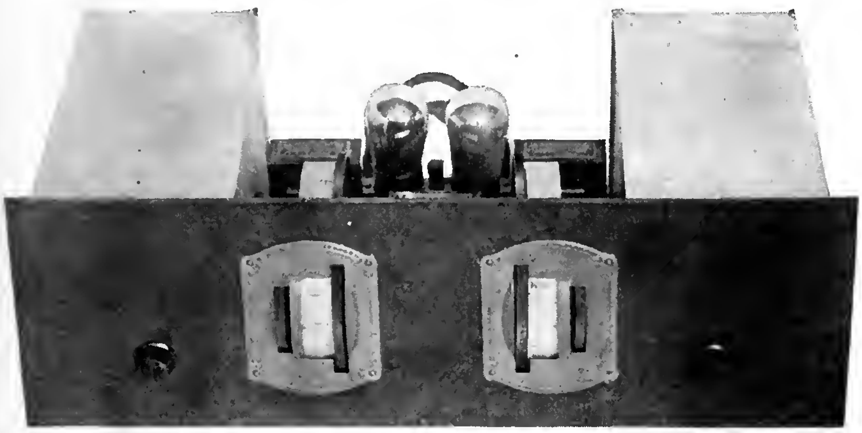
BUILT FOR MODERN BROADCAST CONDITIONS

Employing the New RGS *"Octa-Monic" Principle*

Frequency! Not a Super-Heterodyne!

Fundamentally New

"OCTA-MONIC"*



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 (5 CX301-A's and 1 CX371, 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 (20" x 9") to which is mounted a beautiful walnut finished, standard size panel (7" x 21") that will fit any good cabinet or fine console 7" x 21". The panel and drum escutcheons are trimmed in dull bronze.

You will find your R. G. S. "Octa-Monic" mighty easy to operate.

There are but two drums with vernier adjustments and two control knobs, one of which is an ordinary volume control and filament switch, the nearest approach to tuning efficiency, **possible.** Stations actually "click" or "tumble-in" as you slowly revolve your drums.

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.

Orders cannot be accepted for individual pieces of apparatus or blueprints.

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."***

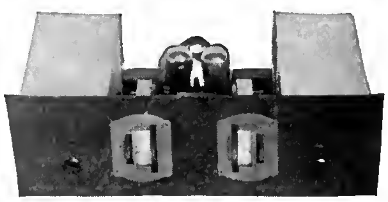
All models of the R. G. S. "Octa-Monic" and the R. G. S. "Four" are fully protected by Grimes Patents issued and pending.

**Trade Mark Registered.*

Battery or "B" Eliminator Models

R. G. S. "Octa-Monic" Kit

of parts including all required apparatus, complete instructions and blue-prints, ready to build, ***$84.60.***



R. G. S. "Octa-Monic" Chassis

completely assembled according to latest laboratory methods, (closely co-ordinated and specially designed apparatus, eight foot Da Hery cable, etc., etc.) with complete operational instructions, 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, ***$63.60***

R. G. S. "Octa-Monic" Tuning Chassis

completely assembled according to latest laboratory methods with complete instructions and ready to wire to your favorite amplifier, ***$66.60***

Price Note

The apparatus required to build the radically new and fundamental R. G. S. Octa-Monic actually lists at over $100.00.

R. G. S. MANFG. CO., Inc.
Staten Island, New York

Gentlemen:

Please arrange with my dealer, whose address I have printed below, for a demonstration of the new and revolutionary R. G. S. "Octa-Monic". 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...

DEALERS: ***Write for Complete Merchandizing Proposals***

R-G-S Manfg. Co., Inc.

Staten Island **New York**

BUILT FOR MODERN BROADCAST CONDITIONS

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. 137 RADIO BROADCAST Laboratory Information Sheet November, 1927

Operating Vacuum Tubes in Parallel

METHODS AND RESULTS

IT IS sometimes desirable to operate several tubes in parallel in order to obtain a greater power output, and it is of interest to know how efficiently this may be done.

If two tubes are to be used in parallel in the output of an audio amplifier the two sockets are wired so that the grid of one tube connects to the grid of the other tube and the two plates connect together. The two filaments are also connected together. The result is that from these two tubes we will have only four leads—one from the grids, another from the plates, and two others from the filaments.

The amplification constant of the combination will be equal to the constant of a single tube, provided both of the tubes have the same constant. If one of the tubes had a low amplification constant and the other a high constant the resultant amplification constant of the two would be equal to the arithmetic mean. If the amplification constant of one tube is six and the other four, the resultant amplification constant will be five.

The resultant plate impedance will be equal to one half the impedance of a single tube, and if unlike tubes are used, the total impedance can be calculated by the simple laws governing resistances in parallel. The combined impedance can be stated as follows:

$$\frac{\text{Imped. of one tube} \times \text{Imped. of other tube}}{\text{Imped. of one tube} + \text{Imped. of other tube}}$$

The greatest power output is obtained when the two tubes have identical plate impedances and amplification constants. Fortunately, however, a very large fraction of the total power of the two tubes can be obtained even if they differ considerably.

To illustrate, two tubes might be connected in parallel, the amplification constants of which are in a ratio of 2 to 1, and the plate impedances of which are equal, and from the combination we could obtain 90 per cent. as much power as could be obtained if the tubes were operated in separate circuits. If, with equal amplification constants, the plate impedances are in a ratio of 2 to 1, the total power will be about 90 per cent. of the maximum possible value. It is evident, therefore, that the total power will not be decreased by any great amount even if tubes quite widely differing in characteristics are used. From two perfectly matched tubes, feeding into a load resistance equal to their combined plate impedance, we can obtain twice as much power as can be obtained from a single tube feeding into a load resistance equal to its plate impedance.

No. 138 RADIO BROADCAST Laboratory Information Sheet November, 1927

The Unit of Capacity

CALCULATION AND FORMULAS

THE capacity of a condenser is stated in terms of the quantity of electricity it will hold per volt. When a condenser stores a specific quantity of electricity known as a coulomb and there is an electrical pressure of one volt across its terminals then the capacity of the condenser is one "farad." A condenser must be very large to have a capacity of a farad and therefore a millionth part of a farad has been adopted as the practical unit and it is called the "microfarad," meaning one-millionth of a farad. Capacities smaller than one microfarad can be expressed in micro-microfarads, corresponding to a millionth of a microfarad.

The capacity of a condenser may be computed from the general equation:

$$C = \frac{2250\ AK}{10^{10} d}$$

where C = capacity of condenser in microfarads
K = dielectric constant
A = total area of dielectric between plates in square inches
d = thickness of dielectric in inches

Example:

What is the capacity in microfarads of a condenser having 2000 plates? The dielectric consists of paraffined paper 0.002 inch thick. The part of each sheet of dielectric actually between the plates has an area of 6.3" x 8".

Vaseline	Ebonite	Glass	Mica	Paraffin Wax	Porcelain	Quartz	Resin	Shellac	Castor Oil	Olive Oil	Petroleum Oil
2.0	3.0	7.0	6.0	2.5	4.0	4.5	2.5	3.5	5.0	3.0	2.0

From the table in this sheet it will be seen that the constant of the dielectric is 2.5.

The total area, A, of the dielectric is:—

$$A = 6.3 \times 8 \times 2000$$
$$= 100{,}000 \text{ square inches, approximately}$$

Therefore

$$C = \frac{2250 \times 100{,}000 \times 2.5}{10^{10} \times 0.002}$$
$$= 28.1 \text{ microfarads}$$

No. 139 RADIO BROADCAST Laboratory Information Sheet November, 1927

Inductive Reactance

HOW IT IS CALCULATED

IF AN inductance coil 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 coil 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 coil 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 coil had an inductance of 1.0 henry, we would find that 0.292 amperes of current would flow through the circuit. Then 110 volts divided by 0.292 gives 377, which is the reactance in ohms at 60 cycles of a coil with an inductance of 1.0 henry. The reactance of a coil depends upon its inductance and upon the frequency of the current. It can be calculated by means of the following formula:

$$\text{Reactance} = 6.28\ FL$$

where F = the frequency of the current in cycles per second, and L = the inductance of the coil in henries.

In many calculations it is necessary to know the reactance of some particular coil at some frequency and for this reason on Laboratory Sheet No. 140 is given a table of reactance for inductance coils between 0.01 and 100 henries at frequencies from 60 to 100,000 cycles. From the formula given herewith it is evident that the reactance of a coil is directly proportional to the inductance of the coil and also directly proportional to the frequency. Doubling the size of the coil gives twice the reactance and twice the reactance is also obtained if the frequency is doubled. If these two factors are remembered it is a simple matter to calculate mentally the reactance of any coil not given in the table on Laboratory Sheet No. 140. For example a 10-henry coil has one third the reactance of a 30-henry coil at, say, 100 cycles. Since the reactance of a 10-henry coil at 100 cycles is 6280 ohms, it follows that the reactance of a 30-henry coil at the same frequency must be 18,840 ohms.

No. 140 RADIO BROADCAST Laboratory Information Sheet November, 1927

Coil Reactance

Coil Inductance in Henries	Reactance in Ohms at Various Frequencies						
	60	100	250	500	1000	10,000	100,000
0.01	3.77	6.28	15.7	31.4	62.8	628	6,280
0.05	18.8	31.4	78.5	157	314	3,140	31,400
0.1	37.7	62.8	157	314	628	6,280	62,800
0.5	188.5	314	785	1,570	3,140	31,400	314,000
1.0	377	628	1,570	3,140	6,280	62,800	628,000
2.0	754	1,256	3,140	6,280	12,560	125,600	1,256,000
5.0	[illegible],885	3,140	7,850	15,700	31,400	314,000	3,140,000
10.0	3,770	6,280	15,700	31,400	62,800	628,000	6,280,000
20.0	7,540	12,360	31,400	62,800	123,600	1,236,000	12,360,000
30.0	11,310	18,840	47,200	94,200	188,400	1,884,000	18,840,000
40.0	15,080	24,720	61,800	123,600	247,200	2,472,000	24,720,000
50.0	18,850	31,400	78,500	157,000	314,000	3,140,000	31,400,000
100.0	37,700	62,800	157,000	314,000	628,000	6,280,000	62,800,000

This table shows how the reactance of various inductance coils varies with different frequencies. Laboratory Sheet No. 139 explains what inductive reactance is and upon what it depends.

No. 141 RADIO BROADCAST Laboratory Information Sheet November, 1927

A. C. Tube Data

"HEATER" AND FILAMENT TYPES

ON THIS Laboratory Sheet are given data on the new a. c. tubes, type UY-227 (C-327) and type UX-226 (CX-326). The former tube is of the heater type whereas the latter is of the a. c. filament type. The heater tube requires a special five-prong socket whereas the type 26 may be used with any standard socket. The filament voltage and current of the type 27 are 2.5 volts and 1.75 amperes respectively. The type 26 requires a filament voltage of 1.5 volts and the filament current is 1.05 amperes. The filament current of these tubes is quite large, especially so in a multi-tube receiver, and for this reason it is essential in wiring the filament leads that heavy wire be used. Determine the total current required by all the tubes and table No. 1 below will tell you what size of wire to use.

TABLE NO. 1

Size (B & S Gauge)	Current
12	20 amperes
14	11 amperes
16	6 amperes
18	3 amperes
20	1.5 amperes

Table No. 2 on this sheet gives the characteristics of these tubes under various conditions of plate and grid voltage.

TABLE NO. 2

Type of Tube	Plate Voltage	Negative Grid Voltage	Plate Current	Plate Impedance	Mutual Conductance	Undistorted Power Output in Watts
UY-227 & C-327	90	5	3	11,300	725	0.020
	135	9	5	10,000	820	0.055
	180	13.5	6	9,400	870	0.140
UX-226 & CX-326	90	6	3.7	9,400	875	0.020
	135	9	6	7,400	1100	0.070
	180	13.5	7.5	7,000	1170	0.160

Balkite has pioneered—
but not at public expense

Licensed under Andrews-Hammond patent applications

Balkite "A" *Contains no battery.* The same as Balkite "AB" 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" *One of the longest lived devices in radio.* The accepted tried and proved light socket "B" power supply. The first Balkite "B," after 5 years, is still rendering satisfactory service. Over 300,000 in use. 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 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, operating only while the 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 at 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 of the first 16 light socket "B" power supplies put on the market, Balkite "B" alone remains in its original form; all others have either been radically revised in principle or completely withdrawn.

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 (with batteries or without), 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.

LICENSED UNDER HAMMOND-ANDREWS PATENT APPLICATIONS

Balkite "AB" *Contains no battery.*

A complete unit, replacing both "A" and "B" batteries and supplying radio 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

Licensees for Germany: Siemens & Halske, A. G. Wernerwerk M Siemensstadt, Berlin

Sole Licensees in the United Kingdom: Messrs. Radio Accessories Ltd., 9-13 Hythe Rd. Willesden, London, N. W. 10

FANSTEEL
Balkite
Radio Power Units

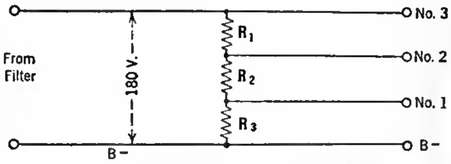
No. 142 RADIO BROADCAST Laboratory Information Sheet November, 1927

Obtaining Various Voltages from a B-Power Unit

VALUES AND CURRENT-CARRYING CAPACITY

IT IS comparatively simple to calculate the resistance values required in the output circuit of a B-power unit in order to obtain any specific voltages. This Laboratory Sheet will explain how to calculate the values of these resistances.

Consider the fundamental output circuit of a B-power unit as illustrated in the sketch. The diagram of the rectifier and filter has been omitted since they play no important part in the calculation of resistance values. Suppose tap No. 1 is to be 45 volts and is to be used to operate a detector tube. We will assume that the loss current through R_3 is 3 milliamperes, or 0.003 amperes. This is an average figure for the loss current and can generally be used in this type of calculation. If the voltage at tap No. 1 is to be 45, then the voltage drop across resistance R_3 must be 45. The resistance of R_3 will be equal to the voltage across it divided by the current through it or, in this case, 45 divided by 0.003, which gives 15,000 ohms as the value of R_3. The voltage at tap No. 2 is to be 90. Since the voltage drop across R_3 is 45, it follows that the voltage drop across R_2 will also be 45 in order to make the total voltage between the negative B and tap No. 2 equal to 90. The current flowing through the resistance R_2 will be equal to the loss current at 3 milliamperes plus the current drawn by the detector tube, which is 1 milliampere. Therefore the value of resistance R_2 will be equal to the voltage across it, 45, divided by the current through it, which is 0.003 plus 0.001, or a total of 0.004 amperes. This gives a value of 11,250 ohms for R_2. Suppose that the total drain from the 90-volt tap is 10 milliamperes. Then the total current flowing through R_1 will be equal to 10 plus 1 plus 3, or 14 milliamperes. If the maximum voltage available from the power unit is 180 and the voltage at terminal No. 2 is to be 90, it follows that the voltage drop across R_1 must be 90. Ninety volts divided by 0.014 amperes gives 6400 ohms as the value of R_1.



Resistance units for B power units are usually rated in watts and it is essential that the resistances used be capable of carrying the necessary load without overheating. The load in watts being handled by a resistance can be determined by multiplying the resistance in ohms by the square of the current in amperes. In this particular example:

Watts through R_3 = 15000×0.003^2 = 0.135 watts

Watts through R_2 = 11250×0.004^2 = 0.18 watts

Watts through R_1 = 6400×0.014^2 = 1.25 watts

No. 143 RADIO BROADCAST Laboratory Information Sheet November, 1927

Solenoid Coil Data

UNITS FOR THE BROADCAST BAND

THIS Laboratory Sheet gives the data necessary to wind the secondaries of solenoid type coils for use with 0.0005-mfd., 0.00035-mfd., or 0.00025-mfd. variable condensers. The wavelength range of the coil will be approximately 200 to 550 meters. The coils may be wound on hard rubber or bakelite tubing, or some type of self-supported winding may be used.

Diameter of Tube in Inches	Size of Wire	Number of Turns of D.C.C. Wire Required with Various Sizes of Tuning Condensers		
		0.0005 mfd.	0.00035 mfd.	0.00025 mfd.
3½	28	28	38	50
	26	31	42	54
	24	34	46	58
	22	38	50	64
	20	42	55	72
3	28	35	48	62
	26	39	52	67
	24	43	56	73
	22	47	61	81
	20	51	67	88
2¾	28	42	54	63
	26	45	58	73
	24	48	63	80
	22	51	70	90
	20	53	78	98

No. 144 RADIO BROADCAST Laboratory Information Sheet November, 1927

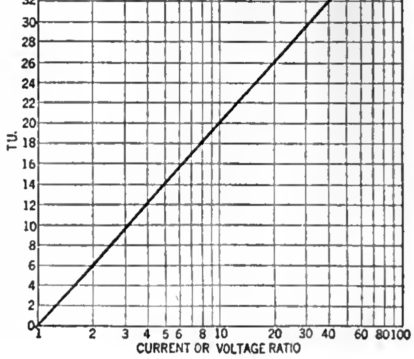
The Transmission Unit

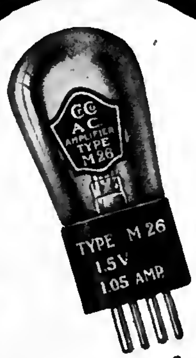
CORRECTION OF LABORATORY SHEET NO. 114

TWO errors occurred in LABORATORY SHEET No. 114 published in the August, 1927, RADIO BROADCAST. In the last line in the first column, the word "natural" should be changed to read "common," and in the first line in the second column, the same change should be made.

The chart on this sheet makes it possible to determine easily the number of telephone transmission units if the current or voltage ratio is known. For example, from the curve it is evident that if two voltages or two currents are in a ratio of 5, then the TU difference between them is 14. If we are dealing with powers rather than currents or voltages, it is merely necessary to divide the number of TU obtained from the curve by 2 in order to determine the TU difference of any two powers. For example, two powers in the ratio of 8 to 1 have a TU difference of 9. To determine this value we look up the number of TU corresponding to a ratio of 8 which gives 18 and then divide by 2.

To illustrate the use of the curve we might take an audio amplifier requiring a tenth of a volt input to produce three volts at the output. If we wanted to know the overall gain in TU we would divide three by 0.1, which gives 30. This ratio on the curve corresponds to a 29.5 TU voltage gain.



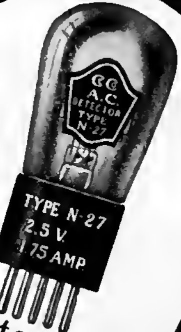


Amplifier
Type M-26

A. C.
AMPLIFIER
Type M-26
(226)

Fil. Volts	1.5
Fil. Amp.	1.05
Plate Volts	90-135
Not to Exceed	180

List Price
$3.00



Detector
Type N-27

Announcing

A. C. TUBES

Alternating Current

The new M-26 and N-27 tubes are tubes using raw A. C. on the Filament or Heater and can be used in any set specifying these types. The M-26 is used in the radio and audio frequency stages and has a standard base. The N-27, of the separate heater type is used as a detector or amplifier and has a five prong base. These tubes will give superior results and maximum useful life in any set designed to use A. C. tubes of this type.

Write for particulars

C. E. MFG. CO., Inc.

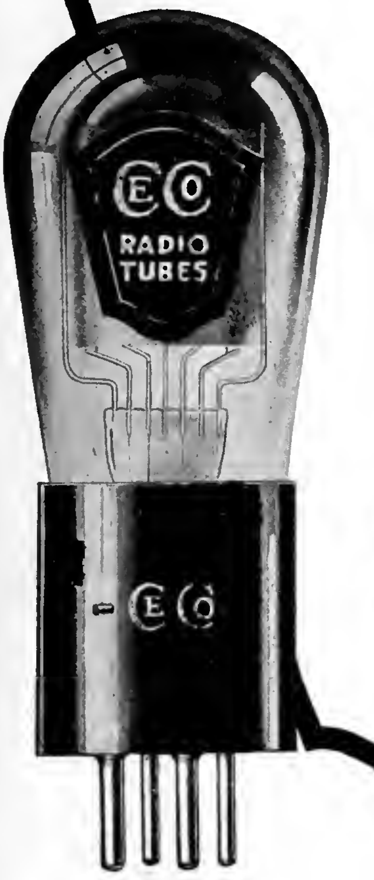
Providence, R. I. **U. S. A.**

Largest Plant in the World Making Radio Tubes Exclusively

A. C.
DETECTOR
Type N-27
(227)

Heater Volts	2.5
Heater Amps.	1.75
PLATE VOLTS	
As Detector	45
As Amplifier	90-135
Not to Exceed	180

List Price
$6.00



CeCo
RADIO
TUBES

CeCo
A Tube for Every Radio Need

General Purpose Tubes
Special Purpose Tubes
Power Tubes
Filament Type Rectifiers
Gas Filled Rectifiers
A. C. Tubes

Make a Good Receiver Better

CeCo announces a complete kit of tubes for the "Improved Aristocrat" by Arthur H. Lynch. Get the kit from your dealer and be sure you are right.

1 Type K, R. F. Amp.		Price $3.00
1 " H, Spl. Detector		" 2.50
2 " G, HiMu Amp.		" 5.00
1 " F, Semi Power		" 4.50
	Total for kit	$12.50

The specified types for the improved Aristocrat can not be substituted due to there not being any other brand having similar characteristics to the Hi-Mu, Detector and Special Radio Frequency types. Demand CeCo.

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 64. 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 64)

The Celestial Stradivarius
The Advanced Hi-Q* Six
BOTH CUSTOM-BUILT!

The Hi-Q Six—the newest advance in radio—four completely isolated tuned stages—Automatic Variable Coupling—symphonic amplification. A non-oscillating, super-sensitive receiver that assures maximum and uniform amplification on all wave lengths and establishes a totally new standard of tonal quality.

JUST as Antonio Stradivari gave the priceless *Custom-built* violin to musicians of his day, so does Hammarlund-Roberts offer music lovers of our day the *Custom-built* Radio.

The advanced "Hi-Q Six"—designed by ten of America's leading manufacturers—made with America's finest parts—incorporating every modern constructional feature—and built under your own eyes from plans so complete, so exacting and so clear cut that the only outcome can be absolute radio perfection.

In addition to its unprecedented performance, the Hi-Q Six offers equally unprecedented economy, for by building it yourself you can save at least $100.00 over the cost of finest factory-assembled sets. Complete parts including Foundation Unit chassis, panels, with all wire and special hardware cost only $95.80.

The Hi-Q Instruction Book tells the complete story with text, charts, diagrams and photos. Anyone can follow it and build this wonderful instrument. Get a copy from your dealer or write us direct. Price is 25 cents.

Hammarlund ROBERTS Hi-Q* SIX

HAMMARLUND-ROBERTS, INC.
1182 Broadway Dept. A New York City

Associate Manufacturers

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-milliampere 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.

103. A. C. Tubes—The design and operating characteristics of a new a. c. tube. Five circuit diagrams show how to convert well-known circuits. Sovereign 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.

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.

USE THIS BOOKLET COUPON

Radio Broadcast Service Department
Radio Broadcast, *Garden City, N. Y.*

Please send me (at no expense) the following booklets indicated by numbers in the published list above:

....

....

Name..

Address..
(*Name*) (*Street*)

....
(*City*) (*State*)

ORDER BY NUMBER ONLY
This coupon must accompany every request. RB 11-27

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 68 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 $30.00.

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.

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 emp oyed. 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 w thout cabinet.

217. AERO SHORT-WAVE KIT—Three plug-in coils designed to operate with a regenerative detector circuit and having a frequen y 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.

WHAT KIT SHALL I BUY? (*Continued*)

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 dectector, 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.

224. BROWNING-DRAKE—Five tubes; one stage tuned radio frequency (with special neutralization system), regenerative detector (tickler control), three stages of audio (special combination of resistance- and impedance-coup ed audio). Two controls.

225. AERO Short-Wave Transmitting Kit consists of interchangeable coils to be used in tuned-plate tuned grid circuit. Kits of coils, two choke coils, and mountings, can be secured for 20-40 meter band, 40-80 meter band, or 90-180 meter band for $12.00

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Thumb Nail Reviews

WLS—A skit having to do with various and droll adventures around the lion's cage in a circus and centering about one J. Walter Sapp. The mechanically simulated lions' roars were perfectly swell. As for the spoken lines, they were not at all bad, but suffered from high-schoolish and unconvincing delivery—a frequent enough radio play complaint.

WOR—The Kapellmeister String Quartet, excellent interpreters of chamber music, playing on this occasion the Schubert Quartet in D minor.

WBBM—The station's own string trio performing its routine tasks with great gusto and a splendid attack.

WJZ—The Arion Male Chorus singing "Sleep Kentucky Babe" in mellow fashion and introducing some tricky guitar effects against a background of humming.

JOHN WALLACE.

USE THIS COUPON FOR COMPLETE SETS

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"RADIO BROADCAST'S" DIRECTORY OF MANUFACTURED RECEIVERS

¶ A coupon will be found on page 68. 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. Milliammeter 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 60¼ 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. 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. 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. 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 5½ x 7¾ 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. 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 7¾ 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. 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. 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$\frac{1}{16}$ x 7⅞ x 8⅛. Price: $130 without accessories.

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. 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. 542. PFANSTIEHL JUNIOR SIX

Six tubes; 3 t.r.f. (01-A), detector (01-A), 2 audio. Pfanstiehl circuit. Volume control: variable resistance in r.f. plate circuit. One dial. Shielded. Battery cable. C-battery connections. Etched bronze panel. Antenna: outdoor. Cabinet size: 9 x 20 x 8 inches. Price: $80, without accessories.

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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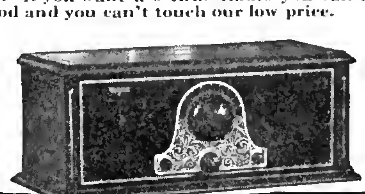

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NO. 485. BOSWORTH B6

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: 17¾ x 5¼ x 7⅝. 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: 20¼ 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 10⅛ inches; NR-66 20 x 10¼ 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 .o 25 mA. "Technidyne" circuit. Completely enclosed in aluminum box. Battery cable. C-battery connections. Cabinet size, 8¾ x 19½ x 9½ 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. 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. 543. ATWATER KENT, MODEL 33

Six tubes; 3 t.r.f. (01-A), detector (01-A), 2 audio (01-A and 71 or 12). One dial. Volume control: r.f. filament rheostat. C-battery connections. Battery cable. Antenna: 100 feet. Steel panel. Cabinet size: 21⅛x6⅜x6⅞ inches. Price: $90, without accessories.

NO. 544. ATWATER KENT, MODEL 50

Seven tubes; 4 t.r.f. (01-A), detector (01-A), 2 audio (01-A and 12 or 71). Volume control: r.f. filament rheostat. C-battery connections. Battery cable. Special bandpass filter circuit with an untuned amplifier. Cabinet size: 20¾ x 13 x 7¾ inches. Price: $150.

NO. 452. ORIOLE 90

F ve 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 8¾ 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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Everything that Radio Has to Give

The Kingston B Supply Unit brings to your radio evenings a new richness and a new delight—full tones, clearness and perfect reception always! It maintains your set at its perfection peak, operates silently, and forever removes the trouble and expense of batteries. The Kingston is beautifully made, is smartly finished in satin black, and is built by experts with extreme care and accuracy. There are provided three voltage terminals, each adjustable over a wide range, making possible any desired voltages from 5 to 200. In keeping with Kingston quality, the Raytheon 125 milliampere type BH tube is used as a rectifier.

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Type 2, for 110-120 Volt AC 50 or 60 Cycle Current, $35.00.
For receiving sets having not more than eight tubes and not having type UX171 power tube or equivalent.

Type 2A, for 110-120 Volt AC 50 or 60 Cycle Current, $42.50.
For all sets using type UX171 power tube or equivalent and for all large sets having nine or more tubes.

Type 2C, for 110-120 Volt AC 25, 30 or 40 cycle current, $47.50.

Prices include type BH Raytheon tube.

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SLIP a Carborundum Grid-Leak into your set and you will notice an improved reception instantly.

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No chance for the creation of minute noisy arcs—no glass tube. They can't disintegrate. They are unbreakable.

All standard values, both Grid-Leaks and Fixed Resistors.

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No. 79 Carborundum Resistors, values 2500 and 5000 Ohms, each 1.00
No. 79 Carborundum Fixed Resistors, values 12,000, 25,000, 50,000, 75,000 and 100,000 Ohms, ea., .75

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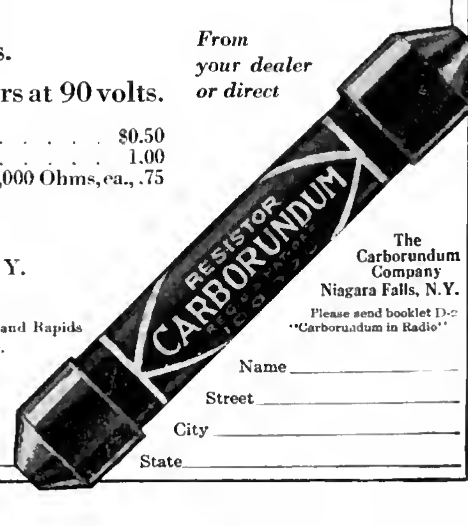

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NO. 530. KOLSTER, 7A AND 7B

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 14½ inches. Price not established.

NO. 542 RADIOLA 16

Six 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: 19⅛ 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 13⅞ 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 7⁄16 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 3⁄16 x 16¾ x 14 3⁄16 inches; No. 602, 28¾ x 51½ x 19¾ 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: 2-mA. Cabinet size: 26½ x 8 x 12 inches. Price $140.

BENJAMIN

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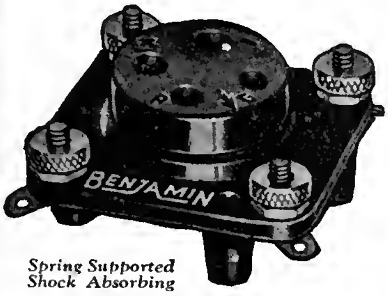
Cle-Ra-Tone Sockets

are specified for the

Hammerlund-Roberts Hi-Q Circuit



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Tube holding element "floats," independently of the base, on four perfectly balanced springs. Positive tube to terminal connections. Shock absorbing feature is not affected by stiff bus wiring.

Non-Microphonic. The greatest aid to the non-noisy operation of the set. Gives longer life to the tubes.

The choice of experts and amateurs for practically every prominent and successful circuit for several years.

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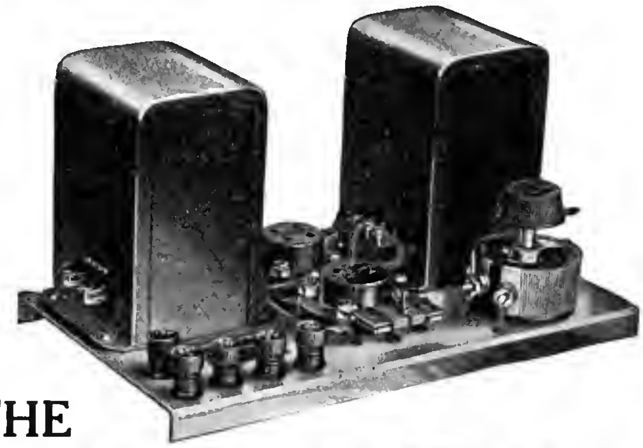
increases undistorted power output of amplifier tubes



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GENERAL RADIO

Type 441 Push-Pull Amplifier

In a search for an amplifier combination which would give the maximum in quality and volume, the push-pull method has proved particularly satisfactory.

While push-pull transformer coupling does not increase the amplification per stage, the maximum undistorted power output is greatly increased. The reason for this is that distortion due to tube overloading cancels out, permitting a greater output from each tube than would be possible if the tubes were used as in other methods of coupling. A further advantage of push-pull amplification when using an A. C. filament supply is that hum voltages also cancel out, rendering the amplifier very quiet.

The type 441 unit with two type 171 power tubes having a plate voltage of 180 will give more volume and better quality than a single transformer coupled stage using the type 210 power tube with 400 volts on the plate.

The General Radio Type 441 unit is completely wired and mounted (as illustrated) on a brass base-board with conveniently located binding posts so that the unit may be built into a receiver or connected with an existing set as a separate unit.

The type 441 may be used with either the UX-226, UX-326, or UX-171, CX-371 tubes.

Type 441 Push-pull amplifier.......................... $20.00

The Type 441 unit is licensed by the Radio Corporation of America for radio amateur, experimental, and broadcast reception only, and under the terms of the R. C. A. license the unit may be sold only with tubes.

Type UX-226 or CX-326 Amplifier Tube.................. $3.00
Type UX-171 or CX-371 Amplifier Tube.................. $4.50

GENERAL RADIO COMPANY

Cambridge — Massachusetts

A KEY TO RECENT RADIO ARTICLES

By E. G. SHALKHAUSER

THIS is the twenty-fourth in stallment 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.

R402. SHORT-WAVE SYSTEMS. SHORT-WAVE TRANSMISSION.
QST. July, 1927. Pp. 8–14.
"Short-Wave Radio Transmission and Its Practical Uses," C. W. Rice. Part 1.
The ionization of the atmosphere through cosmic radiation as well as through propagation of electron streams from the sun determines the nature of electromagnetic waves, as stated. How this ionization affects day and night and also seasonal variations is explained from experimental data obtained to date. Comparison is made between auroral phenomena and the theory of ionization as well as the effect of terrestrial magnetism on the motion of the electron. Skip distance effect is said to be due to the bending of the waves in the upper atmosphere, the degree of bending depending on the wavelength.

R201. 6. HIGH-FREQUENCY BRIDGE. BRIDGE, *High-Frequency.*
QST. July, 1927. Pp. 15–20.
"A Bridge to Measure Capacity, Power Factor, Resistance, and Inductance," J. Katzman.
The purpose of the article is to describe and explain the important factors of the Wien Series Resistance Bridge when used to measure C, L R and power factor accurately to 1/10 of 1 per cent.

R344.3. TRANSMITTING SETS. TRANSMITTERS, *Tuning.*
QST. July, 1927. Pp. 24–28.
"Some Light on Transmitter Tuning," R. A. Hull.
The construction of a shielded oscillator and its use in tuning transmitter circuits for good signal output are outlined. Good plate and filament supply regulation is one of the main requirements. The proper method of tuning various circuits to adjust the wavelength of the oscillator and the antenna, and the correct amount of grid excitation to be used are told. Key thumps can be greatly reduced by having proper coupling and antenna tuning.

R402. SHORT-WAVE SYSTEMS. SHORT-WAVES.
QST. July, 1927. Pp. 29–30.
"An Investigation of the 5-Meter Band," E. M. Guyer and O. C. Austin.
Some problems on the construction and the operation of 5-meter transmitters are related, photographs of several sets being shown with a list of material for their construction appended.

R342. AMPLIFIERS. KEYING AMPLIFIERS.
QST. July, 1927, Pp. 33–35.
"Keying the Amplifier," A. G. Shafer.
A keying system, whereby a specially constructed key is placed in the grid circuit of one of the amplifier tubes, is utilized to prevent key thumping. The system consists of changing the capacity of the coupling capacity to such an extent as to prevent proper transfer of energy from the oscillator without actually breaking any part of the circuit.

R344.3. TRANSMITTING SETS. TRANSMITTER, *Short-Wave.*
QST. July, 1927. Pp. 36–40.
"A Constant Frequency Transmitter," W. H. Hoffman.
A non-crystal oscillator, capable of maintaining a constant frequency output, yet flexible enough that the frequency may be shifted to other amateur wavelengths, is described and illustrated.

R344.5. ALTERNATING-CURRENT SUPPLY. SOCKET POWER, *"A—B—C"*
Radio. July, 1927. Pp. 25–ff.
"ABC Socket Power For Large Tubes," G. M. Best.
A discussion on the assembly and the operation of several combination ABC socket power units and the results obtained when used with a Browning-Drake receiver are given. The Raytheon 350-mA. tube is used with each combination. All wiring details of the units, including those of the Browning-Drake receiver, are shown.

R160. RECEIVING APPARATUS. RECEIVER, *Single-Control.*
Radio. July, 1927. Pp. 29–ff.
"Trouble Shooting the Single-Control Set," M. P. Gilliland.
In adjusting single-control receivers for selectivity the following points are said to be of importance: Proper neutralizing of all radio-frequency stages; balancing of tuned circuits. For volume control a shunt resistance across the secondary of the first audio transformer is recommended.

R330. ELECTRON TUBES. ELECTRON TUBES.
Radio. July, 1927. Pp. 47–ff.
"Vacuum Tube Characteristics."
The characteristics of dry cell tubes, power tubes, high-mu tubes, and special detector tubes, also of the new a.c. filament tubes such as the UX-226, the UX-280, the UX-281, the CX-327, are given. The quadratron, the Emerson multivalve, the Sovereign A-C tube, the Van Horne A-C tube, the new A-C Magnatron tubes and the Armor A-C 110 tube are described.

R160. RECEIVING APPARATUS. RECEIVER MEASUREMENTS.
Proc. I. R. E. May, 1927. Pp. 387–395.
"Notes on Radio Receiver Measurements," T. A. Smith and G. Rodwin.
The comparison of radio receivers electrically involves the three main points: sensitivity, selectivity and fidelity, as stated. The method of test and of making and interpreting the curves presented are outlined.

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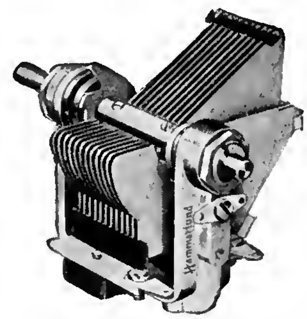

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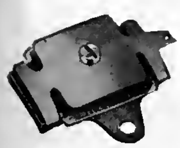

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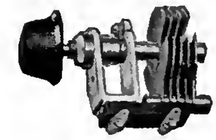

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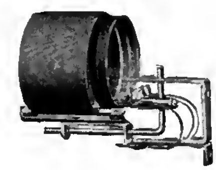

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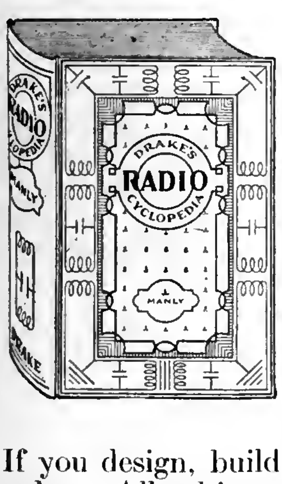

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R376.3. LOUD-SPEAKING REPRODUCERS. LOUD SPEAKERS.
Proc. I. R. E. May, 1927. Pp. 363–376.
"Loud-Speaker Testing Methods," I. Wolff and A. Ringel.

An electric oscillator method is used in obtaining quantitative measurements in testing loud speakers. The output of an oscillator, having a continuously variable frequency is fed to the loud speaker. The results are recorded on a revolving drum mechanism. The curves, showing variation of sound pressure against frequency, reveal interesting characteristics, as explained.

R1113.3. DIRECTIONAL VARIATIONS. TRANSMISSION PHENOMENA.
Proc. I. R. E. May, 1927. Pp. 377–385.
"High Angle Radiation of Short Electric Waves," S. Uda.

The paper describes some accounts of experimental work on the field distribution due to straight vertical unloaded antenna operating at one of its harmonics. Short waves of 2.66 meters were employed, and observations have been made with the grounded and the ungrounded antennas.

The paper also gives the test results on a new wave projector devised by the author with special reference to high angle radiation of short electric waves.

R344.3. TRANSMITTING SETS. TRANSMITTER.
Proc. I. R. E. May, 1927. Pp. 397–400.
"The Tuned-Grid Tuned-Plate Circuit Using Plate-Grid Capacity for Feed-Back. A Derivation of the Conditions for Oscillation," J. B. Dow.

Mathematical equations are developed showing the conditions required for oscillation in the tuned-grid tuned-plate circuit of a transmitter.

R162. SELECTIVITY OF RECEIVERS. RECEIVERS, *Selective.*
Proc. I. R. E. May, 1927. Pp. 401–423.
"Selectivity of Tuned Radio Receiving Sets," K. W. Jarvis.

The question of modern receiver design, incorporating selectivity, fidelity of reproduction, and adequate sound volume, is discussed. The resonance circuit and its requirements are analyzed mathematically and curves presented howing relation between amplification and electivity of radio-frequency stages. Discussing quality of reproduction the problem of regeneration, the phase shift of the side bands and the transient response of the circuit are mentioned.

R113.3. DIRECTIONAL VARIATIONS. TRANSMISSION PHENOMENA.
Proc. I. R. E. May, 1927. Pp. 425–430.
"Radio Phenomena Recorded by the University of Michigan Greenland Expedition—1926," P. C. Oscanyan, Jr.

The experiences encountered by the writer when using short waves for transmission on Maligiak Fiord, North of the Arctic Circle, are related. It was ıoted that when attempting to receive signals from stations working on wavelengths of 50 meters or below, complete screening was f-fected when the receiver was placed at the foot of a hill which is of a height greater than 17 degrees from the horizontal of the station. Photographs of the station are shown.

R500. APPLICATIONS OF RADIO. APPLICATIONS, *Paper weighing.*
RADIO BROADCAST. Aug. 1927. Pp. 199–202.
"Saving Paper!" J. Millen.

The device illustrated and described consists of an oscillating circuit coupled to a tuned circuit, a thermal meter recording the deflection when in resonance. The material to be measured acts in the capacity of a dielectric, thus changing the frequency of the resonant circuit, this change being recorded on the thermal meter.

R134.8. REFLEX ACTION. REFLEX CIRCUIT.
RADIO BROADCAST. Aug. 1927. Pp. 208-210.
"Have You a Roberts Reflex?" J. B. Brennan.

Improvements which can be made in the Roberts circuit consist in increasing the sensitivity and selectivity, improving the quality of reproduction, making it more stable in operation, and increasing its volume. These changes are discussed in detail.

R376.3. LOUD-SPEAKING REPRODUCERS. LOUD SPEAKERS.
RADIO BROADCAST. Aug. 1927. Pp. 211–212.
"The Balsa Wood Loud Speaker."

Data on the assembly and the properties of the new Balsa wood loud speaker are given. The wood is obtainable in kit form, and by careful assembly of the parts a speaker of excellent reproducing qualities is said to result. Suggestions concerning changes and improvements are offered for those who experiment with this type of loud speaker.

R344.3. TRANSMITTING SETS. TRANSMITTER, *Short-Wave.*
RADIO BROADCAST. Aug. 1927. Pp. 213–217.
"A Flexible Short-Wave Transmitter," H. E. Rhodes.

The construction of a portable telegraph-telephone transmitter for short-waves, using tuned-plate tuned-grid circuit, is outlined, many data being given concerning the general characteristics of the circuit employed. The set operates between 7900 kc. and 2650 kc. (38 to 113 meters). A series of tests were carried on, the results of which are shown graphically and discussed in detail. These include: 1, The effect of varying the grid leak resistance; 2, the effect of varying the resistance of either the tuned-grid or tuned-plate circuit; 3, the effect of varying the coupling between the plate and the antenna coils; 4, the effect of varying the plate voltage.

R200. RADIO MEASUREMENTS AND STANDARDIZATION. TONE QUALITY.
RADIO BROADCAST. Aug. 1927. Pp. 224–226.
"Judging Tone Quality," E. H. Felix.

The subject of distortion in radio receivers is discussed from the standpoint of the listener when trying to discriminate between good and poor tone quality. What is desired is faithful reproduction throughout, from microphone to loud speaker. Because of the importance of harmonics in distinguishing different instruments it is essential that frequencies up to 6000 cycles be reproduced. Suggestions as to methods which can be used in judging the reproducing qualities of receivers are offered.

R220. CAPACITY. CAPACITY MEASUREMENTS.
RADIO BROADCAST. Aug. 1927. Pp. 227–228.
"Condenser, Coil, Antenna Measurements," K. Henney.

The measurements of variable and fixed condensers, distributed capacity of inductance coils and of antenna capacity and inductance can readily be made with the aid of a calibrated modulated oscillator. Data for the use of this instrument and typical measurements are presented.

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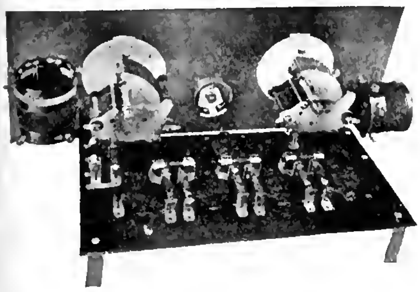

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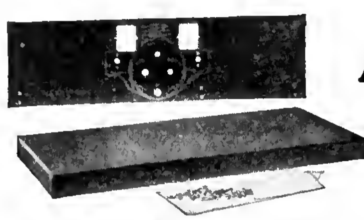

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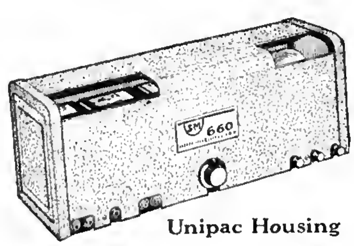

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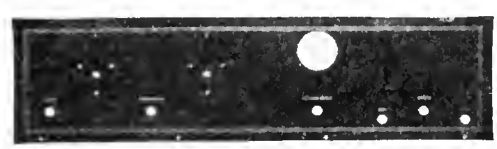

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R343. Electron-Tube Receiving Sets. Receiver *Neutrodyne, AC.*
Radio Broadcast. Aug. 1927. Pp. 232–234.
"Constructing a Five-Tube Neutrodyne," H. E. Rhodes.
A shielded, two radio-frequency, detector and two audio-frequency tube neutrodyne, using the new a. c. tubes, is shown and details for its construction given. Great sensitivity, selectivity and ease of operation are claimed for this circuit arrangement.

R330. Electron Tubes. Electron Tubes, *High mu.*
Radio Broadcast. Aug. 1927. Pp. 238–240.
"Use of Tubes Having High Amplification," A. V. Loughren.
The amplification characteristics of high-mu tubes are treated. The discussion analyzes the frequency characteristics of each stage in a resistance-coupled amplifier and the choice of the amplification factor. Oscillographs and curves show the results to be expected.

R270. Signal Intensity. Signal Intensity, *Broadcast.*
Radio News. July, 1927. Pp. 12–13.
"The Service Area of a Broadcast Station," S. R. Winters.
Results of measurements made with a loop test set by S. W. Edwards, radio supervisor of the 8th radio district, on signal strength from several broadcast stations, are given. These show to what extent steel buildings, static, electrical disturbances and other noises affect radio reception at a distance. The working standard of 10,000 micro-volts per meter intensity was used to determine a reliable reception area about the station.

R3.2.7. Audio-Frequency Amplifiers. Transformers *Coupling.*
Radio News. July, 1927. Pp. 25–ff.
"Why Loud Speaker Coupling Devices are Necessary," I. F. Jackowski.
An explanation is given of the necessity of coupling the loud speaker to the audio amplifier through some coupling transformer and auxiliary apparatus, in order to bypass the direct-current component of the power tube output energy.

R800. (535.3) Photo-Electric Phenomena. Crystals, *Photo-electric.*
Radio News. July, 1927. Pp. 32–ff.
"Light-Sensitive Crystals," G. C. B. Rowe.
The construction of simple light-sensitive cells, using ordinary metals such as copper, zinc, etc. or molybdenite and the substance selenium, is described. The numerous applications of such cells are mentioned and diagrams show how such cells may be used by the experimenter.

R330. Electron Tubes. Electron Tubes, *High mu.*
Radio News. July, 1927. Pp. 50–51.
"A New Electron Tube," S. Harris.
A tube having a fourth element has been developed for use in circuits where objectionable feed-backs are encountered. With the aid of the fourth element, known as the "shielded grid," the *effect* of plate to grid capacity has been eliminated. It is stated that the amplification obtainable with this tube is as high as 200 per tube at 50 kc.

R387. 1. Shields. Shielding.
Radio News. July, 1927. Pp. 52–ff.
"The Effects of Shielding," H. A. Zahl.
The effect that shielding has on the electrical properties of circuits is discussed in detail, with curves shown, and the method of making the measurements is described.

R201. Frequency, Wavelength Frequency. Measurements Measurements.
Exp. Wireless (London). July, 1927. Pp. 394–401.
"The Exact and Precise Measurement of Wavelength in Radio Transmitting Stations," R. Braillard. (*Concluded*).
The description of the wavemeter is continued from the previous article and the method of standardization is outlined. Its accuracy is said to be exceptional, transmitters being adjustable to a variation limit of $\frac{1}{10,000}$ of their wave.

R134.75. Super-heterodyne. Super-heterodyne.
Exp. Wireless (London). July, 1927. Pp. 402–411.
"Design and Construction of a Super-heterodyne Receiver," P. K. Turner. (*Concluded*).
In the last of a series of articles on the super-heterodyne the author discusses the intermediate stages of amplification and the low-frequency stages, and proceeds to give a detailed analysis of the actual construction of the set.

R800 (621.354). Batteries, Secondary. Batteries, *Edison.*
Amateur Transmitter. April, 1927. Pp. 10–ff.
"Edison Storage B Batteries," H. Rodloff.
The construction of small Edison cells from standard parts is described. Considerable information as to their characteristics and their properties is related.

R382. Inductors. Choke Coils.
Amateur Transmitter. May, 1927. P. 11.
"Radio-Frequency Choke Design," Wm. Zeidlik.
In order to obtain maximum efficiency in the operation of any shunt-fed transmitter, properly designed radio-frequency choke coils are essential, as stated. The method of determining correct coils for such purposes is outlined.

R800(621.313.7). Rectifiers. Rectifiers, *Electrolytic.*
Amateur Transmitter. May, 1927. Pp. 12–15.
"Electrolytic Rectifiers, Lead-Aluminum Type," J. E. Hall.
The theory and the principle underlying electrolytic rectifiers is given. Information concerning the electrolytes used, the forming process, the heating of the cells and the capacity of the units constructed, is outlined in detail.

R344.3. Transmitter Sets. Transmitter, *Short-Wave.*
Amateur Transmitter. June, 1927. Pp. 7–ff.
"Master Oscillator Kinks," K. M. Ehret.
The design and construction of a master-oscillator, power-amplifier transmitter, using two UX-210 tubes are outlined in detail. The circuit differs somewhat from the usual, but is considered to give very good results and a sharp signal when adjusted properly. Complete circuit diagram and list of parts are presented.

RADIO BROADCAST

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Applications of the Double-Grid Vacuum Tube

How to Build the Cooley Radio Picture Receiver

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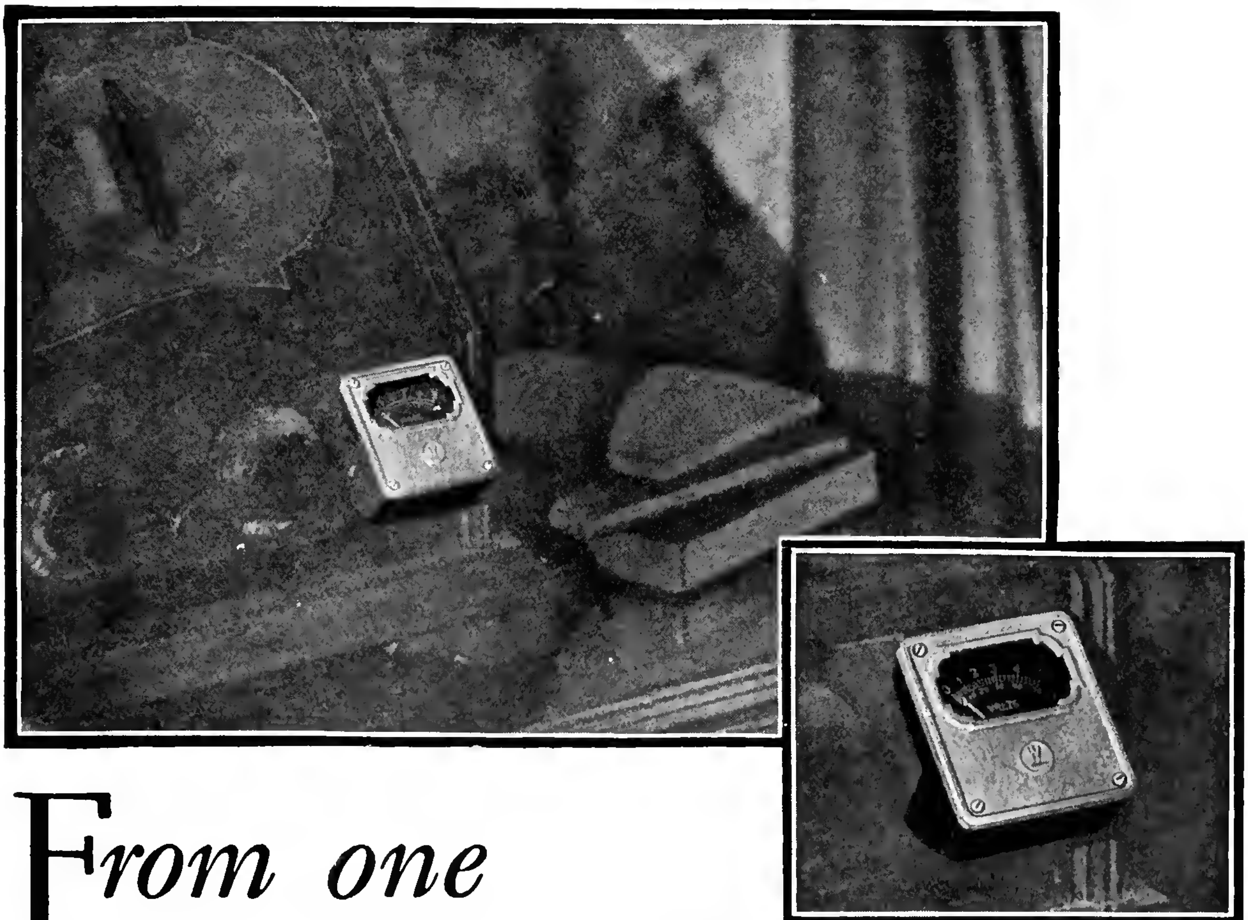
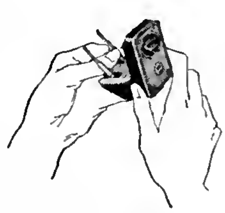
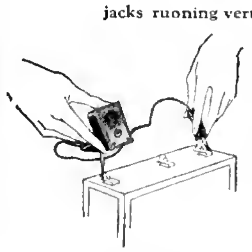


From one radio fan to another



Pins screw in this way for jacks running horizontally.

Pins screw in this way for jacks running vertically.



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RADIO BROADCAST

DECEMBER, 1927

WILLIS KINGSLEY WING, Editor

KEITH HENNEY, Director of the Laboratory

EDGAR H. FELIX, Contributing Editor

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AMONG OTHER THINGS. . .

PROBABLY the most interesting article in this issue from the point of view of the experimenter is the constructional data and operating and assembly instructions on the Cooley "Rayfoto" radio picture receiver. By the time this magazine is in the hands of its readers, all the essential apparatus will be available on the market and nothing will delay the experimenter in his experience in this new field. RADIO BROADCAST is glad to forward the names of readers who are interested in receiving printed matter and late bulletins to manufacturers who are supplying the various parts for the "Rayfoto" apparatus. After the appearance of Mr. Cooley's November article, a great number of our readers wrote us for this information which has been supplied. A letter should at once be addressed to the undersigned, asking for additional data in case you have not already written.

WASHINGTON is the center of interest these days, what with the International Radio Conference and the changes in the Federal Radio Commission. The death of Commissioner Dillon is a great loss to radio in the United States and it will be next to impossible to fill his place. The resignation of Commissioner Bellows removes one of the ablest members of the Commission, but President Coolidge has filled his place through the appointment of Sam Pickard, former secretary to the radio body. Mr. Pickard is a likeable and able individual and we believe his appointment is a wise one. Carl H. Butman, of Washington, was appointed as Secretary to succeed Mr. Pickard. Mr. Butman has long served RADIO BROADCAST as its Washington news representative and we are indeed pleased that the Commission has so wisely chosen a man who knows radio problems so well.

A WORD about the authors in this issue: William J. Brittain is an English writer on radio and scientific topics who has just returned from a European trip to see what is being done in television. Theodore H. Nakken is a research engineer for the Federal Telegraph Company. He is a pioneer in photo-electric cell work and is unusually familiar with radio progress abroad. Austin Cooley, whose "Rayfoto" picture apparatus has attracted national attention, is a native of the state of Washington, received his technical training at M. I. T., and except for his trip in 1926 with the MacMillan Arctic expedition, has been in New York for the past four years. John F. Rider is a well-known New York technical writer who is at work on an interesting series of "fact" articles about manufactured receivers.

THE next issue will contain another story about the Cooley "Rayfoto" radio picture system and its operation, as well as interesting data about push-pull power amplification. Another of Mr. Rider's articles about manufactured receivers will be featured as well as a wealth of constructional matter.

—WILLIS KINGSLEY WING.

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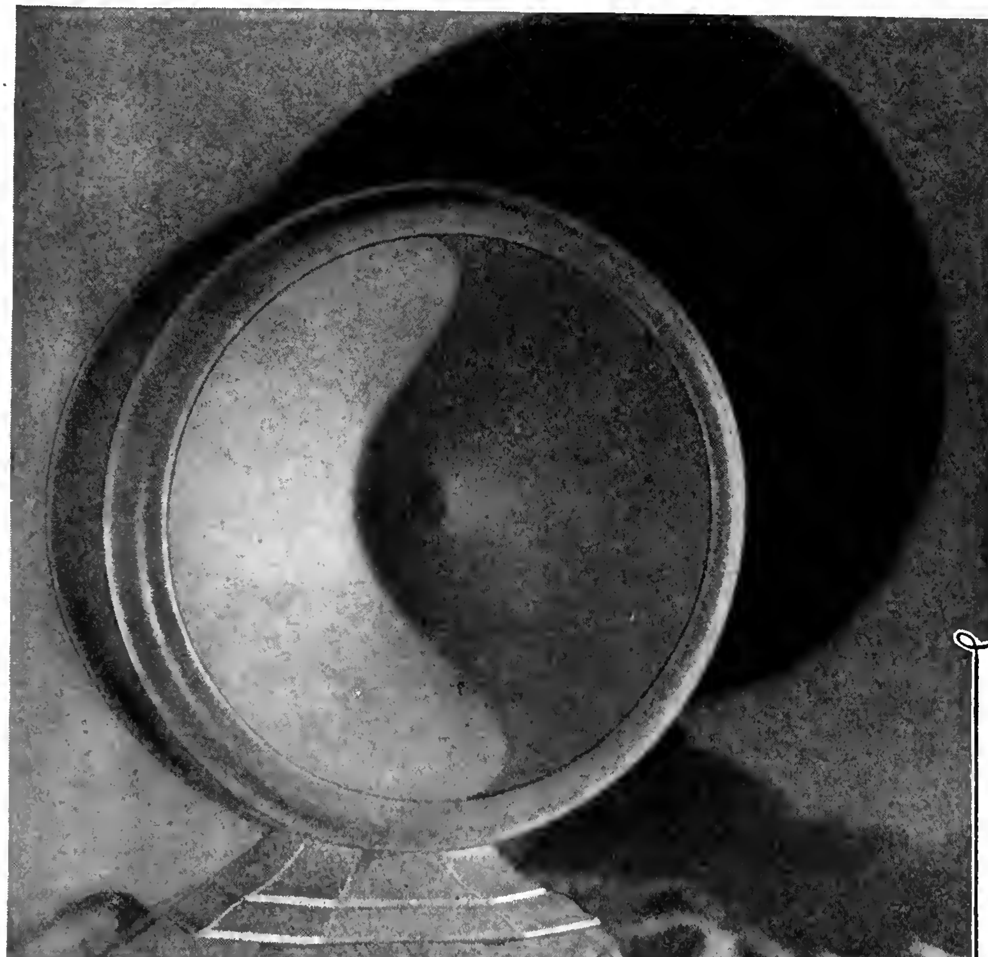

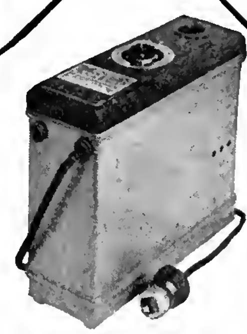

Acme E4-B Supply, $35

Acme B Power Supply units were the first on the market to use a Raytheon tube as rectifier. The E-4, above, is the latest B Power Supply achievement of the Acme engineers. Price includes Raytheon BH Tube.

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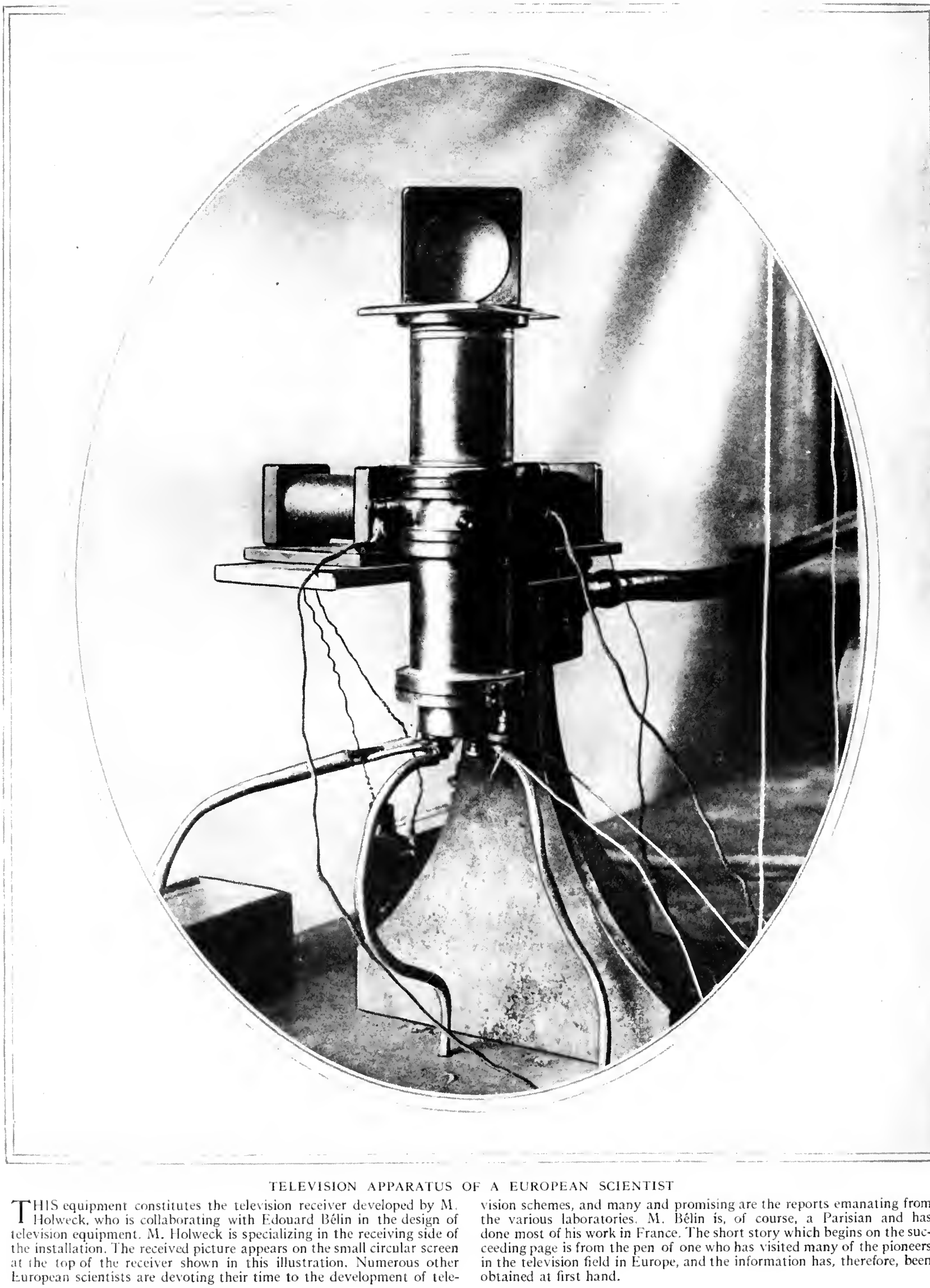
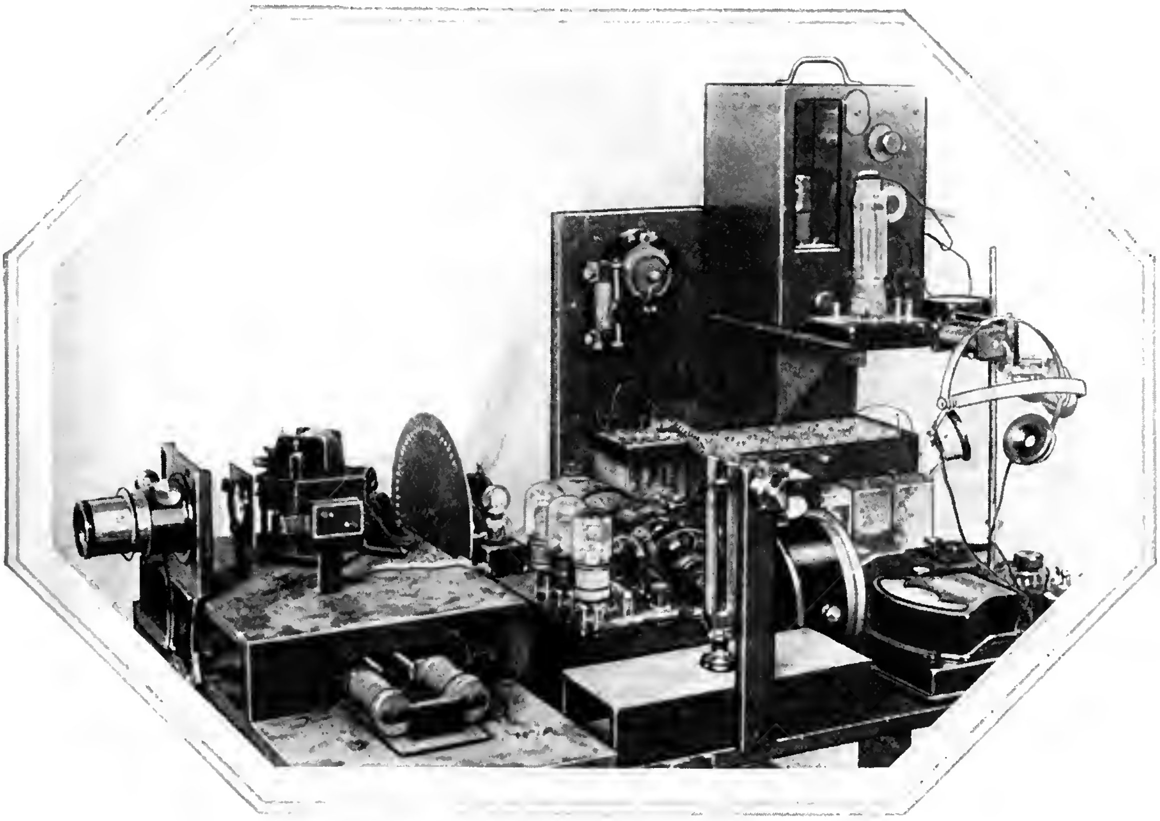


TELEVISION APPARATUS OF A EUROPEAN SCIENTIST

THIS equipment constitutes the television receiver developed by M. Holweck, who is collaborating with Edouard Bélin in the design of television equipment. M. Holweck is specializing in the receiving side of the installation. The received picture appears on the small circular screen at the top of the receiver shown in this illustration. Numerous other European scientists are devoting their time to the development of television schemes, and many and promising are the reports emanating from the various laboratories. M. Bélin is, of course, a Parisian and has done most of his work in France. The short story which begins on the succeeding page is from the pen of one who has visited many of the pioneers in the television field in Europe, and the information has, therefore, been obtained at first hand.



VON MIHÁLY'S TRANSMITTING APPARATUS

TELEVISION IN EUROPE

By WILLIAM J. BRITTAIN

WHAT is Europe doing towards the furtherance of television? America already knows quite a lot about the work of Baird, and the public company formed to develop his machines has made his name known in most countries. But aside from this, little is known of the progress of the many experimenters in this fascinating art on the other side of the Atlantic.

Recently the author went from England to find out what the Continental men are doing, what their apparatus is like, and whether they are preparing a surprise for the world, and in Berlin was found the man preparing the surprise. He is Dénes von Mihály, a young Hungarian, and chief consulting engineer to A. E. G. (the General Electric Company of Germany). An engineer brought from America for the purpose is making a simplified version of Von Mihály's apparatus to be shown in Berlin and London as a preliminary to forming television companies there.

The vital feature of Von Mihály's method is an oscillograph which consists of a tiny mirror mounted on twin wires. The mirror vibrates between two electro-magnets at speeds which sometimes reach thousands of times a second. Light reflected from the object—a face, a scene, or whatever it may be—is focussed by a specially constructed set of Zeiss lenses upon the mirror. The mirror, vibrating rapidly, sees each point of the object in turn, in the manner necessary for television, and flashes it to a photo-electric cell.

Von Mihály has made his own cell, and it sends out currents corresponding exactly to the intensity of light or depth of shadow of each tiny point as it is reflected upon it.

In his receiving apparatus Von Mihály again uses vibrating mirrors. An electric lamp, shining brightly or becoming dim as the current from the transmitter is strong or weak, is concentrated by lenses upon mirrors which repeat the action of the mirror at the sender and zig-zag a beam of light over a ground glass screen. The varying light beam, covering the screen eight times a second, makes up the picture.

To ensure that the sending and receiving mechanisms are working exactly in time—so that the mirror at the receiving end is shining light upon the centre of the screen at the same fraction of a second as the mirror at the transmitting end is "seeing" a bright part in the center of the object—Von Mihály uses a tuning fork arrangement on the same principle as those that have been used by experimenters in phototelegraphy. A tuning fork in the receiver, kept vibrating by an electro-magnet, acts as a switch, regulating current to other magnets which allow a wheel to progress one cog for every impulse, and so regulate the vibrations of the mirror. The apparatus at each end now fills a table, but Von Mihály says he can simplify it to work as a home set in conjunction with a one-tube radio receiver.

Behind this assurance is a secret. The secret is in a small black cylinder, five inches by two and a half inches. The inventor calls it his "little black wonder." He will not tell the world what is inside, but told the author that with it it is possible to do away with the great amplifiers necessary in other systems.

"Television sets for the home," he said, "will be simple and yet give a boxing match or a horse race. They will be sold in a few months for the equivalent of a hundred dollars."

Von Mihály has been working for thirteen years on television. He first became interested when he was twenty, after hearing a lecture on photo-telegraphy by Professor Arthurn Korn. He carried on his work for the Austria-Hungarian government during the war, and on July 7, 1919, gave his first crude demonstration of television. Ministers in the laboratory of the Telephon Fabrik in Budapest then saw on a screen the images of the letters M. D. and REX transmitted from the young engineer's home laboratory in another part of the city.

It was the writer's privilege to be present at a recent demonstration of Mihály's apparatus. The results obtained were considerably better than those of the early demonstrations referred to above, and the images were clearer than those seen by the author on Baird's screen. On the picture of a "televised" boy it was possible to see the collar, the wavy outline of the hair, the shape of the ear, the forehead, the eye, the nose, and the mouth, the latter merging into shadow on the left side of the face.

OTHER EXPERIMENTERS

PROFESSOR Max Dieckmann, whom I met in his station near Munich, Germany, has up to the present no result like this to show. He has achieved results, but has scrapped the transmitter and other apparatus that gave them.

"I used mirrors," he told me, "but I came to the conclusion that no mechanism could ever be made light enough and accurate enough for television. I am therefore trying to make use of electrons. By two electro-magnets, alternated by currents of different frequencies, I make the stream of electrons—or the cathode ray—zig-zag over the object, and I am now experimenting with devices to register the result of this 'exploring.'

"With electrons I think I have the real instrument for television. Electrons are almost weightless and can travel at any speed we need. All mechanism has a weight and inertia that in my opinion will always drag down efforts at perfect television. By perfect television I mean, of course, the reception of images as fine as published photographs. It is possible now to have crude television. You can have a picture on as large a screen as you like, but the larger the screen is the larger must be the patches making up the picture. Distance of transmission, too, offers little difficulty. We must concentrate on producing a finer image, and I believe electrons will enable us to do it."

Professor Dieckmann is retaining his former receiver which already uses electrons. The receiver is like a bottle. The received currents vary the flow of electrons from a tube fixed to the neck of the "bottle." By magnets similar to those in his new transmitter the varying flow of electrons is made to zig-zag over a screen at the bottom of the "bottle" which glows as the electrons touch it. When a strong current, showing that a light part of the object is being encountered at the transmitter, sets off a heavy flow of electrons, the screen glows strongly at that part, and the glowing patches make up the picture.

PROFESSOR MAX DIECKMANN

With Mr. Rudolf Hell, his chief assistant, Professor Dieckmann is working with enthusiasm at his latest apparatus.

Mirrors form an essential part of the apparatus of M. Edouard Bélin, the scientist famed for his systems for phototelegraphy, who has large stations at La Malmaison, near Paris. M. Bélin inspired cartoons with a television machine thirty years ago. His latest apparatus looks businesslike.

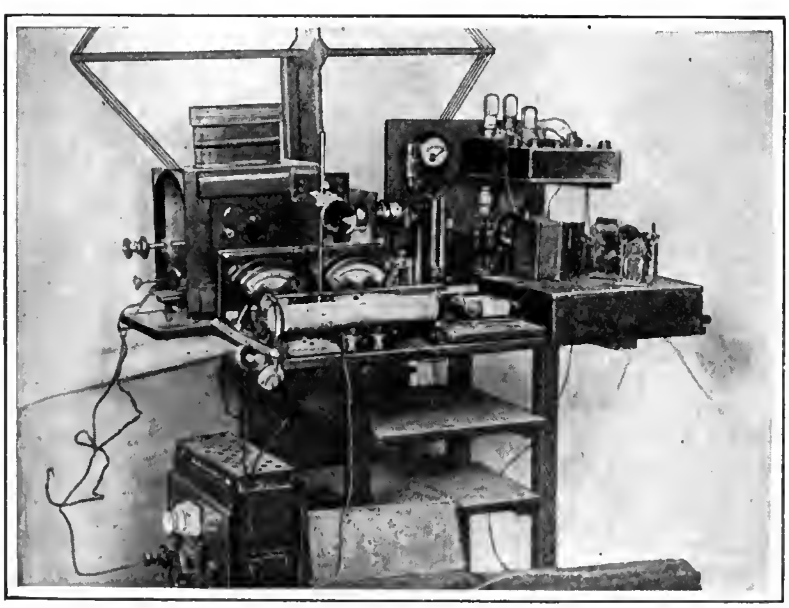
Two rectangular mirrors, about half an inch long, set at right angles, are made to oscillate by cranks and connecting rods driven by an electric motor. A beam of light shines on the mirrors and is reflected zig-zag in the usual way. For his object M. Bélin uses his hand. Light from the hand as the beam passes over it is caught by an eighteen-inch concave mirror at the bottom of a drum which concentrates the light on a photo-electric cell held by an arm half-way down the drum. With this apparatus, M. Bélin told me, he can record fifty thousand flashes of light and shade a second.

M. Holweck, collaborator with M. Bélin, is responsible for the receiver. He has designed a special form of cathode ray oscillograph in which as complete a vacuum as possible is kept by an air pump, also of his own design. M. Holweck is working to perfect the fluorescent screen so that it will vary its glow exactly according to the strength of the stream of electrons. He has also made the apparatus more sensitive so that a difference of potential of five volts between the grid and the filament will absolutely cease the flow of electrons. This means that slight differences of light and shade in the object, and therefore, tiny differences in the current received, are recorded on the screen.

Promising results are being obtained. At present M. Bélin is transmitting only the silhouettes of his hand. On the screen the outline of the hand can be seen clearly. The hand can be seen to move, and the fingers to bend. A silhouette of the profile of a face, and a simple photographic negative, have been transmitted with equal success.

"Our work is progressing gradually" said M. Bélin. "We have found it better to pass over the object a bright spot of light rather than illuminate fiercely the whole object. It we used flood lighting to obtain the same brilliancy as our spot light gives us over a person's face the intensity would be insupportable.

"Earlier in the year we were sending over our object in a thousand points; now we have reached two thousand five hundred. We cover the object eight times a second which means that in our ordinary experiments twenty thousand signals are flashed a second. We are greatly encouraged by our present results. In a few months we should have something to offer the world."



VON MIHÁLY'S TELEVISION RECEIVING APPARATUS

This is the stage European inventors have reached. Each one of them is watching carefully every step forward by other workers and trying to go a step further. Von Mihály is confident that all his system needs now is to be put on the market. Dieckmann and his young assistants are working quietly but eagerly. And all the time I was at the *éstablissement* Edouard Bélin I was filled with the boyish enthusiasm which permeates the atmosphere there.

Of hopes and plans it would be possible to write pages but in this article an attempt has been made to keep plainly to facts to let America know just what Europe is doing in television.

THE MARCH OF RADIO

NEWS AND INTERPRETATION OF CURRENT RADIO EVENTS

How the Radio Commission Can Set Radio to Rights

AS THE peak of the radio season approaches, we look upon the situation with considerable satisfaction. Last year, broadcasting was in chaos and the Radio Act had not been passed; this year, progress has been made in the direction of restoring order. Public interest in radio is at a maximum; the Radio Show at New York broke all records for attendance at an industrial exposition. Manufacturers and dealers report brisk sales. Broadcasting now has the stimulus of two competing chains. Everywhere there is activity and progress.

The only sore spot in the radio situation is in the regulation of broadcasting. The Commission went about its task with diligence as soon as it was formed. It cleared the Canadian channels and put the stations back on even ten-kc. channels. Then it spaced the New York and Chicago broadcasters at fifty-kc. intervals, forcing time sharing in some cases to make it possible. After these commendable steps had been taken, the Commission confined its activities to juggling a channel here and switching a station there.

We understood that the assignments of June 15 were merely an experiment, a stopgap measure effective only until a comprehensive plan of allocation could be worked out, which would mean an end to the heterodyne whistle. The persistently optimistic announcements of the Commission that the broadcasting situation is now remedied give the impression that the Commission considers its major task completed.

At the opening of the Radio World's Fair, Admiral Bullard pleaded for more time to give the Commission an opportunity to do its work; at the Radio Industries Banquet, he made numerous proposals to the radio industry, many of them no less than amazing, but nowhere have we had a simple, direct statement of the future plans of the Commission. Does the Commission consider its task virtually completed or will it devote itself to a radical improvement of broadcasting conditions?

The Admiral's speech at the banquet contained some striking indications. Briefly, he stated that broadcasters should find a way to fix the responsibility for statements made in radio advertising; that direct advertising stations should be taxed; that radio ought to be a public utility regulated by public service commissions; that provision should be made to link up broadcasting for national sos calls, perhaps for such occasions as the loss of the President's racoon; that motors for electric elevators should be re-designed; and most ingenuous and amazing, that receiving sets should be equipped with crystals to permit of greater selectivity.

A few words at the very end of this astounding speech were devoted to the Commission's plans. With regard to the high power stations serving the long distance listener, "the Commission is looking forward to a time when the listener, on any night of good reception, can hear broadcasting stations from the Atlantic to the Pacific, from Canada to Mexico, without interference, on channels cleared for them, not by arbitrary rulings of the government, not by fixed and necessarily discriminating classifications, but by the normal, logical process of demonstrated fitness and capacity to render a great public service. Such a development is entirely practicable on the basis of allocations now in force. It requires no sweeping changes, but only a clear picture of the ideal to be attained, and a steady careful improvement of existing conditions. . . ."

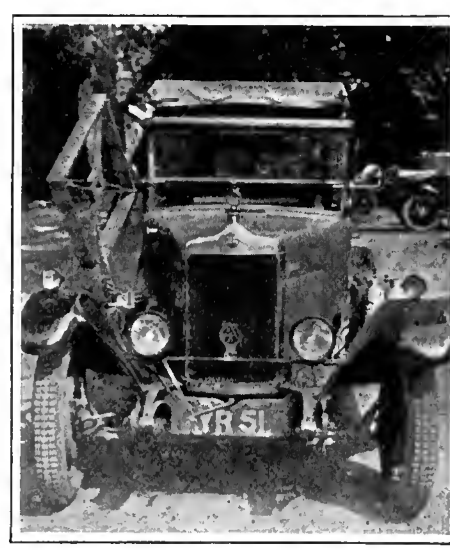
Thus the ingenious Commission will by "orderly and natural, rather than by autocratic and arbitrary methods" bring us these ideal listening conditions. No one, unless it be the broadcast listener, will be imposed upon; only stations which elect by natural processes to eliminate themselves will be taken off the broadcasting lists.

The listener unless he lives within the shadow of a broadcasting station, that is, in that short distance which engineers like to call the service range, must put up with disagreeable heterodyne whistles. Only if we use "arbitrary" methods, which means actually applying the regulatory powers with which the Commission is endowed, can we hope for fewer stations. The natural tendency is toward increasing the number of stations and the power they use. The Commission leans upon a broken reed, if it expects "normal, logical processes" to eliminate stations. Rubber spine methods cannot help the broadcasting situation. There is only one solution, which we repeat, like Cato and his "Carthage must be destroyed," and that is the elimination of at least four hundred broadcasting stations.

What Can the Commission Do?

SECTION IV of the Radio Act authorizes the Commission to classify broadcasting stations, to prescribe the nature of service rendered by each, to assign bands and powers, and to determine the location of stations. There is no limitation on how far it may go in its work of classification.

Why does not the Commission use these powers? Why does it not classify broadcasting stations as (1) national, (2) regional, (3) local; divide the country into geographical areas and prescribe exactly how many



A RADIO TOUR OF THE CONTINENT

Capt. L. F. Plugge, an English radio enthusiast, spent the months of July and August on a tour which the accompanying map shows. There were two radio-equipped cars, one of which is illustrated. Each had a loop-operated super-heterodyne and a short-wave transmitter operating on 6660 kc. (45 meters). Intercommunication was attempted and reception conditions along the route noted stations of each class shall be licensed in each of those areas?

Public convenience and necessity clearly establish the point that interference among stations should not be tolerated and certainly the Commission should be competent, if it earns its keep, to determine how many stations of various powers will be accommodated in the present broadcasting band. In fact, all of these points have been analyzed for it by qualified experts in precise and unequivocal terms.

NATIONAL STATIONS, to which exclusive channels should be assigned, might be defined as follows: (1) *Power*, 10,000 watts or over; (2) *Service*, fifty hours a week or more; (3) *Location*, at least ten miles from all centers of 100,000 or more population and at a point more than fifty miles from the nearest national station and not within 200 miles radius of more than five national stations.

REGIONAL STATIONS, sharing channels with other regional stations more than 1000 or 2000 miles distant: (1) *Power*, 2000 to 5000 watts; (2) *Service*, at least twenty-five hours a week, and (3) *Location*, not more than 100,000 population within a five mile radius, nor more than five regional stations within 100 miles.

LOCAL STATIONS: (1) *Power*, between 250 and 500 watts; (2) *Service*, at least twenty-five hours; and (3) *Location*, such that there are not more than five local service stations within a hundred mile radius.

Such a program would, of course, require the elimination of stations in a few of the congested areas, a blessing to the radio audience. The stations so eliminated need not go out of business, but merely consolidate with others serving the same area. Stations of less than 250-watt power should be ruled off the air at once, not because they themselves contribute seriously to congestion but because their channels might better be assigned to national or regional stations.

Concrete suggestions, which are not only logical, but also require the exercise of some of the "arbitrary" powers conferred upon the Commission by law, may be in order. We respectfully suggest the promulgation and actual observance of regulations for the accomplishment of four objectives, the constitutionality of which cannot be questioned:

1. ALL STATIONS should be required to adhere to their frequencies and those failing to do so, after occupying their assigned channels for more than thirty days, should be fined $500 for each violation noted, *without any further consideration of their cases*. The Commission has been buncoed by whining station managements into the belief that staying on a channel requires extraordinary equipment and engineering genius. A station failing to adhere to its channel is not technically competent and not worthy of a franchise on the air. Furthermore, after its fourth offense, a station's license should be cancelled, without further consideration of the case. The ether space thus regained should not be assigned to a new ether nuisance, but utilized in relieving congestion where it exists. The Commission's leniency with regard to channel wobbling, to which it attributes practically all heterodyning, is a remarkable example of unwarranted bashfulness and consideration the stations don't deserve. The five hundred dollar fine for each violation of the Commission's regulations gives the Radio Act plenty of teeth but, to our knowledge, the Commission has never tried them out.

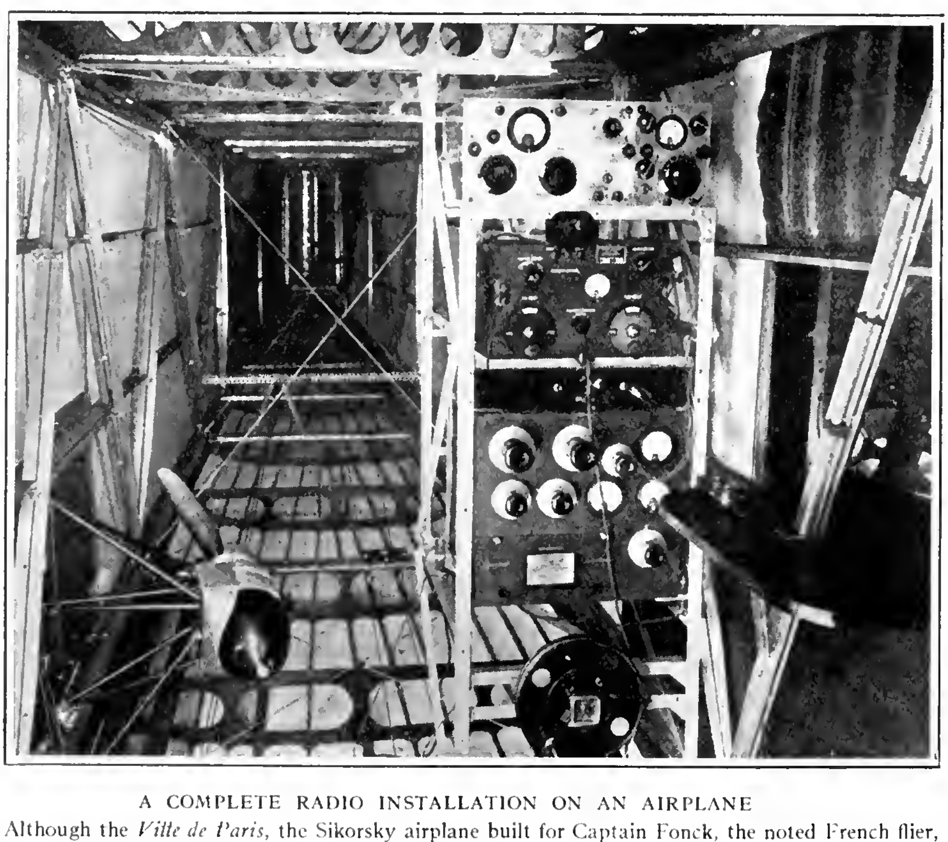
2. THE COMBINATION and consolidation of broadcasting in congested areas should be encouraged by guaranteeing to the consolidators the combined broadcasting privileges of the stations so consolidated. For example, four, full time, 500-watt stations, combined into one, should be permitted a power increase to 2000 watts, or two, half-time stations, forming one, should receive full time. Furthermore, all local and regional stations, not sharing the same channel, which combine, should be guaranteed privileged consideration on the basis of program merit, should they seek to secure full time on a single channel by challenging another station.

3. POWER INCREASES to local and regional stations shall not be granted where congestion exists, unless other stations, having a power equivalent to the increase, be absorbed. Thus, for example, for a thousand-watt station in New York to jump to 1500 watts, it should be necessary for it to absorb a 500-watt station.

National stations, on the other hand, serving large areas, should be encouraged to increase power, because they require clear channels and failure to employ the maximum power means that they are not making full use of the channel assigned to them.

4. THE COMMISSION, empowered to assign hours of broadcasting to stations, should conserve ether space by limiting licenses only to hours actually used by the stations concerned. It has left problems of time division to the stations themselves, instead of utilizing its power to help in relieving congestions. There are many broadcasting stations which are assigned fifty per cent. of the time on a channel which use only ten per cent. of it, while the other station on the channel is required to remain silent, although it has program material to fill the unused time. In congested areas, the assignment of the time should be based upon the average hours which a station broadcast over the same period in the preceding year. Increase over this time should be granted only upon the basis of program merit and service, or the unused time held to encourage consolidations and to accommodate other stations.

The present assignment of forty channels to New York and Chicago, nearly half the ether space in the eastern part of the United States, is an imposition upon the listener. Yet new stations are being licensed in New York and Chicago, although six stations in each of those cities have coralled ninety per cent. of the audience. This concentration of broadcasting facilities in two centers



A COMPLETE RADIO INSTALLATION ON AN AIRPLANE

Although the *Ville de Paris*, the Sikorsky airplane built for Captain Fonck, the noted French flier, never started toward Paris, plans for the flight were exceptionally complete. Top right shows the small transmitter and a larger set below it. In the center is a regenerative receiver and at the extreme bottom, the antenna reel. The motor generator unit is at the extreme left and supplies plate current for the transmitter. The generator and propeller can be swung out through the fuselage when in use of population forces the rural listener to contend with heterodyning all over the dials and precludes power increases in rural areas where better and bigger stations are actually needed.

The Federal Radio Commission has worked long and hard with its problem. It has done the best possible job without seriously disturbing or curtailing the privileges of the broadcasting station owners. But, so long as it fails to regard its duty as serving the interests of the listening public, and fails to use the ample powers conferred upon it by the Radio Act to reduce the number of stations on the air, ether congestion will remain the unhealthy disease of the broadcasting situation.

$100,000 to Improve Broadcasting

THE National Association of Broadcasters appropriated the sum of $100,000 to make a scientific study of broadcasting. It plans to employ field engineers and program specialists to visit individual stations throughout the country. The procedure of the Association in the effective utilization of this fund has not yet been established. If it is sensibly administered, very valuable contributions can be made in the technical, economic and program problems of the broadcaster. From the technical standpoint, studio methods, as they affect transmission quality, and the correct operation of the broadcasting stations to help in eliminating ether congestion are fruitful subjects for research. The Association might well help in determining just what the capacity of the broadcasting band is with regard to power, service range and geographical location of stations.

In the field of program technique, critical study of the outstanding features and systematic examination of voice and musical instruments which make good broadcasting could be very helpful. An investigation of the possibilities of building high grade programs by the use of recording methods, as suggested by Edgar H. Felix in a speech before the Association, might also be studied with a view to investigating its practicability. Mr. Felix suggested the recording of "scenes," blending the voices of speakers and pick-up music through mixing panels and the "editing" of programs much as films are cut and assembled, until the ideal feature is assembled. When thus worked over and perfected, it may be presented as often and through as many stations as its popularity warrants, without further cost for talent. This suggestion may result not only in better planned and coördinated programs, but it may help to reduce the mounting wire costs which commercial broadcasters now meet.

In the field of commercial broadcasting, a close study of the methods used to associate the commercial program with the product of its sponsor and to secure the most effective results in a manner pleasing to the listener might help to increase the effectiveness of commercial broadcasting, an end

© Henry Miller

THE LATE COL. JOHN. F. DILLON

Colonel Dillon, member of the Federal Radio Commission from the Pacific Coast, died early in October. His loss will be keenly felt by the Commission and the radio world at large. A practical radio man of wide experience, Colonel Dillon had served in various technical capacities in the Signal Corps, and as radio inspector in charge of the Eighth District when headquarters were in Cleveland in 1913 and 1914. He was later transferred to San Francisco as Radio Supervisor for the Sixth District and it was from this duty that his appointment as a Radio Commissioner called him. His wide practical experience with government, amateur, and commercial radio made Colonel Dillon one of the most valuable members of the Radio Commission

which is necessary to aid economic stabilization of broadcasting stations.

The National Association of Broadcasters is to be commended for its foresight in making this substantial expenditure, which is likely to be returned many fold through better broadcasting and larger audiences.

What to Tell the Consumer—And Where

AFFLICTED with the expanded craniums resulting from mushroom growth, the larger manufacturers of the radio industry are often flattered into advertising excesses which ultimately cause financial embarassment. As typical of this trend, we received a dealer notice, not long ago, describing a new type of A, B, and C power device which was to make its debut to the world principally through three publications having a combined circulation of over three million copies. Although a prophet is not often recognized in his own country, so frequently has the folly of plunging into expensive national mediums been demonstrated to the radio industry, that most manufacturers first make an effort to sell the merits of their products among the more influential radio listeners.

The general public has been too frequently fooled by innovations to become immediate buyers through the medium of an advertising flash in national weeklies. They are inclined to consult the most expert enthusiast whom they can reach before they are willing to risk their money on a device which may fail. The more successful manufacturers establish their products among the more influential groups of radio buyers before they plunge recklessly into national campaigns in behalf of products which do not have behind them the weight of acknowledged approval of the better informed radio enthusiast. The influence of the radio enthusiast, like halitosis, is often the insidious element which prevents the success of the national advertising campaign which is not supported by the goodwill of well informed broadcast listeners and constructors.

WHAT BROADCASTERS WANT

A LIST of hearings scheduled by the Federal Radio Commission early in October indicates the evils of requiring hearings upon all applications, regardless of their merit. For example, WBAW, Nashville, Tenn., a 100-watt station, operated by a drug concern, seeks to increase its power to 10,000 watts, making it necessary for nineteen stations to defend themselves against this unwarranted incursion of their service range by the drug store carrier. There is no channel available for any new 10,000-watt stations anywhere.

Another hearing is demanded by WJBL of Decatur, Illinois, operated by a dry goods store, calling for a power increase which would damage the service of ten stations, including such widely recognized stations as WBAL and WJAX.

WORD, the Peoples Pulpit Association in Chicago, seeks to occupy the channel of WTAS and WBBM, both well established and serving large groups. There is little question but that the defending stations will be able to show the Commission the presumptuousness of those demanding these hearings, but it is unfortunate that lawyers, witnesses and disorganization of station staffs are required to do so.

"RADIO INDUSTRY" STANDARDS

H. B. RICHMOND, Director of the Engineering Division of the R. M. A., perhaps inspired by our suggestions as to the desirability of one set of radio standards rather than two, in an article in the R. M. A. *News*, suggests that the R. M. A. and the N. E. M. A. should combine their work of writing radio standards. Although, as Mr. Richmond points out, the R. M. A. has ten times as many members as the Radio Division of the N. E. M. A., the long engineering experience of the older organization and the great importance of the manufacturers comprising it, makes its coöperation in writing standards of vital importance. Mr. Richmond's fair exposition of the situation is a long step toward affecting a consolidation of the standards committees of both organizations, vitally necessary if either of them are to be in the least effective.

WHY THE SOUTH HAS FEW STATIONS

SENATOR Simmons of North Carolina recently launched an attack upon the Federal Radio Commission, declaring that it showed favoritism to stations in the North. Illinois, Nebraska and Missouri, with a population of fourteen million, have more licenses to broadcast than the eleven states of the south with their population of twenty-seven million.

The Senator is correct in his facts, but he disregards the point that the south has not been sufficiently progressive to erect its share of stations with the consequence that the Northerners have already filled their wavelength bands. So long as the Commission disregards future needs by filling the ether bands with New York and

Chicago stations, there is not room enough for better broadcasting service in the more remote areas.

HOW THE RADIO BEACON WORKS

THE radio beacon operated at Hadley Field, New Jersey, the terminus of the New York-San Francisco air mail route, has proved remarkably satisfactory. Two directional antennas are used, set at right angles. By means of a mechanical keying device, the letter "A" (dot dash) is sent from one antenna and the letter "N" (dash dot) is sent from the second. The transmissions are so timed that the dots and dashes exactly interlock so that, at the points where the signals from both transmitters are received equally, a continuous dash is heard. That point of equal signal strength is exactly midway between the directional signals of the two antennas. The radio listener aboard the plane can determine from the signals he hears whether he is exactly on the course or to the right or to the left of his course, because, in the former case, he will hear the steady dashes, while off his course, he will hear either A or N, depending on whether he is to the left or the right of it. The closer to the landing field he approaches, the more narrow the midpoint at which the signals are heard to form dashes. A few hundred feet from the beacon station, a deviation of ten or twenty feet from the course is clearly indicated by the signal in the headphones.

THE NEW WEAF TRANSMITTER

IN SPITE of its 50 kw., the initial broadcasts of WEAF at Bellmore proved a disappointment to many New York listeners who have depended upon WEAF for their principal program service. There are large areas within twenty-five miles of New York which, due to the change of location, now receive a weaker signal from the 50-kw. transmitter than they did from the old 5-kw. at West Street. There have been other instances when the removal of stations, even a short distance from the congested areas to permit increase of power, have actually reduced the number of persons served.

The transmitting apparatus at Bellmore is the last word in perfected control. The operator in charge sits before his desk and manipulates a number of buttons controlling each operation in the station, which has the proportions of a fair sized power house. If one of the water-cooled rectifier, oscillator or modulator tubes burns out, a light indicates the faulty tube. Pressure of a control button takes it out of service and connects a substitute without interruption of broadcasting.

The receiving set used to maintain the SOS watch has a range of several thousand miles and will be used to advantage by WEAF's operator. WEAF's SOS watches already have the remarkable record of being the first to hear SOS calls in the New York area and notify naval and coast guards in one case out of each three and of hearin the SOS simultaneously with naval and coast guard stations in the same proportion. Most broadcasting stations continue blithely on the air through SOS calls until the silence of the ether around them impresses them with the fact that there must be something wrong.

NEWS OF THE PATENT FIELD

ELEVEN claims of F. A. Kolster's patent 1,637,615, were declared invalid in a decision by the Second Assistant Commissioner of Patents on the grounds that the applicant's combination claim to a radio compass having a coil form of antenna was not novel and was well known at the time the applicant entered the field. ❦ ❦ ❦ THE PATENT Office *Gazette* mentions the following suits over radio patents: Westinghouse vs. Allen Rogers, Armstrong 1,113,149; Radio Frequency Laboratory, Inc. vs. Federal Radio Corporation, Warren patent 1,603,432. ❦ ❦ ❦ THE DUBILIER Condenser Company has filed against the Radio Corporation of America on various socket power patents. ❦ ❦ ❦ JOHN V. L. HOGAN filed against the American Bosch Magneto Company, Stewart Warner Corporation, Freed-Eisemann, Freshman, and Splitdorf for recognition of his patent 1,014,002, and also against a large department store for its sale of Crosley, Stromberg Carlson, Federal and Fada sets which he alleges infringe his basic patent. ❦ ❦ ❦ A. H. GREBE and Company, Stewart-Warner, and the Consolidated Radio Corporation (Wells Gardner, Chicago and Precision Products Company, Ann Arbor, Michigan) are now R. C. A. licensees.

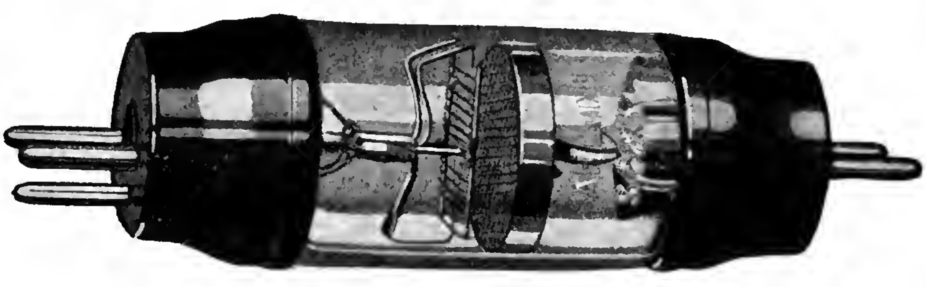
The Month In Radio

THE Eastman Kodak Company suggests that RADIO BROADCAST encourage the use of the term "phototelegraphy" rather than "telephotography" in referring to the radio transmission of pictures. "Telephotography" is used among photography experts to denote the taking of pictures over long distances by the use of special lenses, although Webster approves the use of the term to describe the transmission of pictures by radio or wire. Indeed, so extensive has been this latter use in scientific circles that it would require much more than the approval of RADIO BROADCAST to bring about a change in the accepted terminology. Perhaps a compromise may be suggested which may help to eliminate the confusion. Why not refer to telephotography in the sense of transmitting pictures by wire or radio, as "radio photography" or "wire photography," as the case may be? ❦ ❦ ❦ RADIO will perform a new feat in eliminating the isolation of explorers when the Army Signal Corps and the Pathe Company participate in their exploration of the Grand Canyon of the Colorado. The expedition will traverse the entire length of the canyon, taking moving pictures and collecting data of scientific and educational value. Accompanying the explorers will be a radio telephone transmitter which will be used to link them with broadcasting station KGO, from which reports will be broadcast through a chain of stations. The explorers will venture into dangerous and heretofore inaccessible parts of the canyon. ❦ ❦ ❦ WE NOTE in the list of changes ordered by the Federal Radio Commission, authorization to move KFKX from Hastings, Nebraska, to Chicago, Illinois. KYW has shared its channel with KFKX. The result of the move is to give Chicago listeners the full use of the channel without increasing station congestion. Nebraska and the great open spaces, however, suffer a curtailment of broadcasting service. ❦ ❦ ❦ KOIL is now transmitting its regular programs on 4910-kc. (61.06 meters), as well as its regular channel in the broadcasting band. KOIL is a member of the Columbia chain. ❦ ❦ ❦ THE MACKAY Companies purchased the Federal Telegraph Company's communication system, according to a recent announcement. The Federal Company's equipment consists of high powered arc stations installed along the Pacific Coast for point-to-point service in California, Washington and Oregon, and ship-to-shore service on the Pacific. ❦ ❦ ❦ WE ARE opposed to the radiation of the same program by stations covering the same service area. The listener is entitled to as much variety as the congested ether permits and the employment of two channels to do what may be done effectively with one is a waste of ether space. This practice is frequently indulged in by chain stations. ❦ ❦ ❦ A NOVEL use of broadcasting was employed by the United Gas Improvement Company of Philadelphia to warn its customers that gas service had been temporarily discontinued because of damage by an accidental blast. Undoubtedly, this prevented many accidents upon the resumption of service. ❦ ❦ ❦ THE *American Agriculturist* should be able to write a volume on the service of radio to the farmer as a result of the contest which it recently announced. It offers not too large prizes to farmers writing the best letters on the service which radio renders them. There have been many instances of thousands of dollars of saving through weather and market information. ❦ ❦ ❦ ❦ ❦ ❦ BROADCAST LISTENERS in Germany now number 1,713,899, according to *Wireless Age*, an increase of 78,171 in a three months' period. ❦ ❦ ❦ THIRTY MILLION dollars worth of radio apparatus was involved in international trade in 1926, of which about thirty per cent. consisted of American shipments, twenty-five of German, and twenty per cent. of British. Exports from the United States decreased twelve per cent. in 1926 as compared with 1925, but the figures for the first half of this year show a revival of business. During the first half of 1927, American exports, were $3,705,861, an increase of $450,000 over the same period for the previous year. ❦ ❦ ❦ OUR BRITISH contemporary, *Popular Wireless*, made some measurements as to the radiation range of a two-tube receiver, consisting of one stage of r. f. and detector. The set was presumably a non-radiating one, but actually its radiations were readily heard at a distance of twelve miles, although but fifty volts of plate battery were used. The radiations were found to blanket an area of nearly two hundred square miles in which some five million people reside.

A TUG CAPTAIN WHO CAN TELEPHONE FROM HIS BOAT

More than forty British-Columbian tug-boats, used in towing lumber on the waterways, are equipped with 50-watt radiophone sets, tuned to 1507 kc. (199 meters). The view above shows a Captain's cabin and the complete receiving and transmitting installation

APPLICATIONS OF THE FOUR ELECTRODE TUBE



AN ENGLISH SHIELDED-GRID TUBE
In England and on the Continent, four-electrode tubes have been available for some time. The original research is credited to Schottky in Germany and the "shielded-grid" tube which has recently appeared in this country is credited to Dr. A. W. Hull

By THEODORE H. NAKKEN

A REVIEW of the progress of receiver design, which is possible by turning over the advertising pages of some early radio magazines, would offer some surprising evidence. We would see that mechanical improvements, refinements, and modern methods have been the cause of radical changes in receiver pattern, and have so simplified operation of tuning as to make the modern receiver seem as far in advance of its forbears as is the present-day automobile ahead of the automobile of fifteen years ago. Yet we would note that there has been no basic change in the type of circuit used. The regenerative receiver of ten years ago still stands unchallenged as a sensitive device for translating signals from a distant broadcasting station.

In searching for the reason of this lack of change in circuit arrangement, it will occur to us that we have reached a limit, and that it is almost impossible to obtain greater amplification than the present-day receiver gives us. And this limit is easily located as lying in the inherent characteristics of the vacuum tube as manufactured to-day. Even with its better filaments and better all round design, the vacuum tube of to-day has exactly the same fundamental characteristics as it had when first conceived and built as an experiment. It follows, then, that if any improvements in receivers are to be expected, such improvements will not be realized before radically improved vacuum tubes are made available.

But if we boldly lay the lack of actual progress at the door of the commercial vacuum tube, we must state why the tube should be responsible and how its inherent faults can be eliminated. The indictment against the present-day vacuum tube covers in the main two points—lack of amplification and the tendency to cause oscillations due to inter-element capacity. Another charge that may be brought forward is inefficiency, but this is almost identical with its lack of amplification. How to improve these conditions seems at the present time more important than all other efforts combined to make better receiver circuits, and so we will try to indicate shortly why the vacuum tube is inefficient, and how we can largely do away with the inter-element capacity, so as to get better all around performance from any circuit.

The ordinary vacuum tube contains three elements—filament, grid, and plate. The filament acts as a source of electrons when heated; the plate, by virtue of its positive potential, causes these electrons to be attracted to itself and thus establishes a plate current; the grid, interposed between filament and plate, governs the amount of electrons that can reach the plate, acting, therefore, as a controlling element of the plate current. The grid, generally being held at a negative potential, tends to prevent electrons from wandering away from the source (the filament). The plate attracts electrons only by virtue of its high positive potential, and overcomes the repelling effect of the grid.

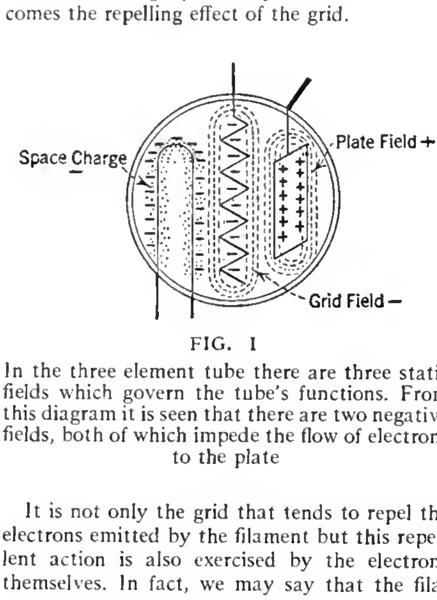


FIG. 1
In the three element tube there are three static fields which govern the tube's functions. From this diagram it is seen that there are two negative fields, both of which impede the flow of electrons to the plate

It is not only the grid that tends to repel the electrons emitted by the filament but this repellent action is also exercised by the electrons themselves. In fact, we may say that the filament is surrounded by a cloud of electrons, which therefore constitute a negative charge, trying to drive the electrons back instead of allowing them free passage to the plate. See Fig. 1. Hence the plate must not only overcome the effect of the negative grid, but it also must nullify the effect of this cloud of electrons, which generally is called the space charge, in addition to its duty to attract electrons and thus establish the plate current.

FOR the last four years, foreign radio periodicals have contained a wealth of articles on the advantages of the double-grid tube. These tubes are chiefly used by our foreign neighbors because of their economy, but it has been inevitable that these tubes should make their appearance in this country. More than a year ago, two manufacturers brought sample double-grid tubes to the Laboratory but the time was not yet ripe for their general introduction. In April, 1926, Dr. A. W. Hull of the General Electric Laboratories described his "shielded-grid" tube in the Physical Review *and on October 1st the New York newspapers carried the announcement of the Radio Corporation that a "shielded" grid tube—the* UX-222*—was in the process of commercial development and would be ready for the general public "some time in the future." Believing that our readers would be interested in a review of important information on double-grid tubes, the following article was prepared at our request by Mr. Nakken who is familiar with the use and operation of multi-grid tubes on the Continent.*—THE EDITOR.

There are two combined factors then which tend to retard the flow of electrons from filament to plate—space charge and the grid, and both are counteracted by the plate potential. It follows that part of the plate potential is utilized only to overcome the repellent action of space charge and grid, and of course, as far as amplification goes, this part of the plate potential is virtually useless. We may then say that the statement to the effect that the tube is inefficient is proved, the more so when it has been established that, in most designs, only from 10 to 15 per cent. of the plate potential is actually available for the establishing of plate current, and the remaining potential serves the purpose indicated.

We know that the space charge is virtually a constant and its effect is added to that of the grid effect. The space charge, having its sphere of influence much nearer to the source of electrons than the grid, is much more powerful in its action, and thus a variation in grid potential, while representing a comparatively large change of the grid action on the flow of electrons, is decreased in its effect by the fact that it represents only a comparatively small change in the total sum of the retarding action of grid and space charge combined. Here again we may say that the tube is proved to be highly inefficient, but now in the sense that the presence of the space charge prevents the grid from being fully effective.

It follows from the foregoing remarks that the main reason for the inefficiency of the vacuum tube may be sought in the presence of the space charge. In fact, if the latter were absent, we would need only a small plate potential to obtain the identical results as at present, with the additional advantage that the grid would be fully effective because the grid field would be the only factor governing the magnitude of the electron flow to the plate, instead of only part of the sum of two factors, of which the second one, the space charge, is by far the greater. The truth of the matter is that, if only the space charge were absent, the grid effect would be from three to four times greater than at present, *i.e.*, without any further changes in the tube the amplification factor would jump from, say, 8 to 30, yet the internal impedance of the tube would remain the same

THE FOURTH ELEMENT

When we consider the static fields present in the vacuum tube we will see that we can count three—space charge, grid field, and plate field. The former two are negative while the latter is positive. The space charge, as we have seen, is a constant, or virtually so, and must be nullified by part of the positive plate field. If, then, a second positive field were introduced, nearer the filament, and thus nearer the space charge, a fairly low potential field would easily nullify the latter's effect. Obviously this can easily be done by a fourth element, which would, of necessity, be placed either between filament and grid, or between grid and plate. This element, however, should not obstruct the flow of electrons from filament to plate, hence it should be an open structure, and for this reason logically take the form of a very open grid. In this way the four-element (double-grid) tube was born.

Let us consider for a moment that such a grid is placed between filament and grid, as in Fig. 2. Due to the construction of the tube it is much nearer the filament than the plate, and as the influence of such a field is inversely proportional to the cube of the distance, it becomes apparent that, if this grid is placed at, say, one third of the distance between filament and plate, its field is 27 times more effective than the plate field. Thus, if in the ordinary tube 90 volts is used on the plate, approximately 3 volts would suffice on this fourth element to completely do away with the space charge effect. This, first of all, increases the percentage effectiveness of any potential change on the controlling element, the grid proper, so that we reach automatically a much higher amplification factor, and secondly, makes it possible to decrease the plate voltage considerably, say to ten or fifteen volts, and still retain a tube of the same general characteristics as the three-element original.

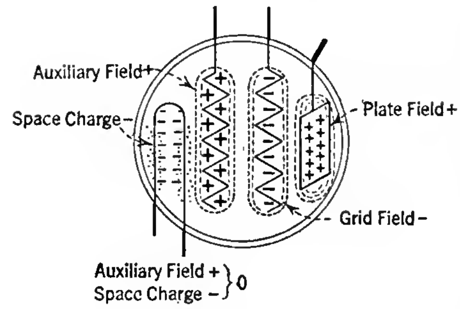


FIG. 2

When an auxiliary positive field is introduced into the tube, the negative field due to the filament is overcome, leaving the total negative field (which is detrimental to the progress of electrons to the plate) in a much reduced condition

It should be noted here, that we have assumed that this fourth element is built into an ordinary tube. The result then is that we have not increased the capacity between the plate and grid, and thus have not increased the tendency of the tube to oscillate due to capacitive feedback. This is a very important consideration, because it is easy enough to build an ordinary three-element tube with as high an amplification factor, as is done with modern high-mu tubes. But the latter is accomplished by narrowing the grid, *i.e.*, by increasing the plate-to-grid capacity, and hence such tubes are almost completely unfit for radio-frequency amplification. In such a tube the tendency for capacitive feedback is increased tremendously, and this capacity affords an easy path for the signal potentials to escape via the plate and become ineffective. As will be seen in Fig. 3, there is nothing strange in the hookup of a four-element tube, the extra electrode being hooked directly to some part of the B battery.

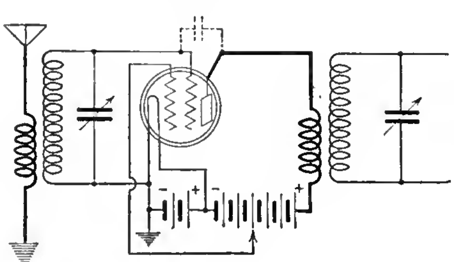


FIG. 3

This diagram is that of a single radio-frequency amplifier using a double-grid tube, the inner, grid being at a positive potential with respect to the filament. The grid-plate capacity remains unchanged

We will now consider the second possibility in construction, *i.e.*, that of placing the fourth element between grid and plate. Of course it must take the form of an open grid, as its purpose again is only to create a positive field, to be used to nullify the space charge effect.

Let us suppose that the tube is now so constructed that this element is placed halfway between filament and plate, in which case it follows that its effect on the space charge is eight times greater than the same potential on the plate. If, then, normally the plate has a potential of 90 volts, a positive potential of 12 volts will be equally effective when applied to the fourth element, so that once more the plate voltage can be decreased to, say, 22½ volts. Due to its open construction the positive grid offers no obstruction to the flow of electrons, and itself draws only a very small current. Once more we make the grid fully effective in its influence upon the flow of electrons, so that the amplification factor of the tube has been materially increased.

But simultaneously we have attained another effect, which merits close investigation. The positive grid, being held at a constant positive potential by the expedient of connecting it to a point on the B battery, may be stated to be constantly at a certain potential above ground potential. But after all, it *is* grounded. As it is interposed between plate and grid, it has the effect of splitting the capacity between these two elements into two capacities, in series as can be readily seen in Fig. 4, because it acts the same as if a grounded plate were inserted between two condenser plates. And as its structure is very open, its capacity to each of the elements of the tube is very small indeed, smaller in fact than the capacity between plate and grid originally was. As the two capacities are in series, the resultant capacity between plate and grid is smaller than either one of the two, and hence we have, in this particular construction of the double-grid tube, almost completely eliminated the plate-grid capacity, with all its baneful effects on receiver efficiency.

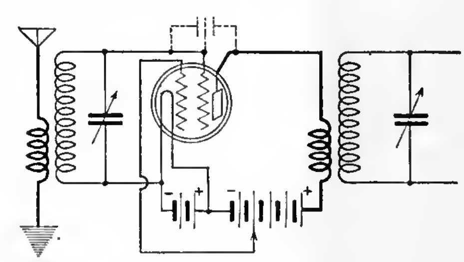


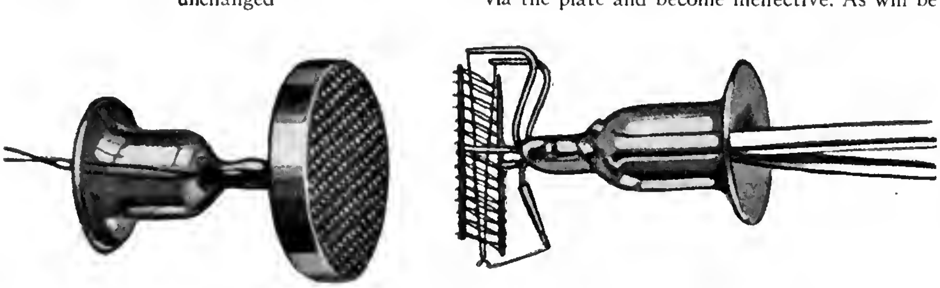
FIG. 4

If the outer grid of a double-grid tube is made positive, the resultant grid-plate capacity of the tube is greatly reduced. At the same time it is possible to build tubes with much greater amplification factor. The plate-grid capacity is reduced owing to the fact that two "condensers" are now in series

Thus, this type of vacuum tube has even greater advantages than when the positive grid is placed between filament and grid. We have created a tube which is highly efficient as to

Milestones in Vacuum Tube Progress

Edison discovered "Edison Effect"	1883
Fleming experimented with Edison Effect	1896
Fleming patented the two-element rectifier tube	1905
DeForest added third element to Fleming valve	1907
Tubes used in transcontinental telephony	1914
Radio telephony from Arlington to Honolulu	1915
Introduction of "hard" tubes to general use	1920
Appearance of thoriated filaments	1923
General use of power tubes	1926
Development of high-current low-voltage filaments	1927
Development of shielded-grid tube	1927



THE "INNER WORKS" OF AN ENGLISH SHIELDED GRID TUBE

One really ought to call them "shielded-plate" tubes, for the grid differs but little from that in ordinary tubes, while the plate is housed behind the shield. This illustration and that which heads this article are reproduced from *Wireless World* (London)

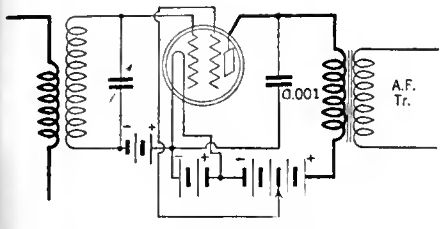


FIG. 5

In this detector circuit the outer grid is positive, the inner grid biased negative to prevent overloading

plate potential, its amplification factor has been increased considerably, and the plate-grid capacity has been largely eliminated, so that the tube may be called self stabilizing.

No wonder then that the European amateur uses these double-grid tubes quite extensively, for the upkeep of a small receiver with tubes of this kind is very economical.

Let us for a moment imagine what can be done

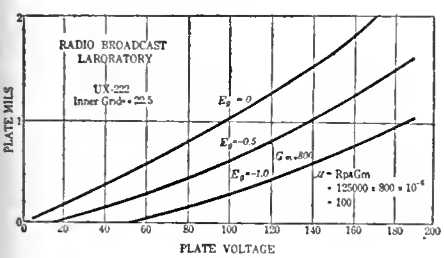


FIG. 9

Measurements made in the Laboratory of Radio Broadcast show that when the inner grid is positive, the mutual conductance of the tube may rise to as high as 800 while the plate impedance is 125,000 ohms, indicating a voltage amplification factor of 100. Plate voltage-plate current curves are shown here

with tubes of this kind. In an ordinary receiver employing two r.f. stages we may be glad if we get a voltage amplification of about eight per radio stage, so that the total amplification before detection is only sixty four. With tubes of this new design, and an amplification factor of, say, 25, we get an amplification before detection of 625 under the same circumstances, and with less trouble, because the capacitive feedback is as much more easily controlled.

An ordinary detector gives an additional amplification of about four, so that with the commercial receiver and ordinary tube the detector delivers a signal with a voltage amplification of about 250. The new tube as a detector would give an amplification of about 12, so that its signal would represent an amplification of 7500 times after the two r.f. stages—and this is voltage amplification only.

Due to this enormous amplification, the conventional condenser and grid leak should of course be discarded for a negative potential on the detector grid, as shown in Fig. 5, because otherwise the detector would surely be overloaded.

For audio amplification the type of double-grid tube used is almost immaterial, but as only the one type (with extra element between plate and grid) gives great advantage of decreased inter-element capacity, and thus will be employed in the r.f. stages, we may just as well use it for the audio stages too. With a good three to one transformer one stage will give us an amplification of about 90, so that the total reaches, after the first stage, 675,000, as against

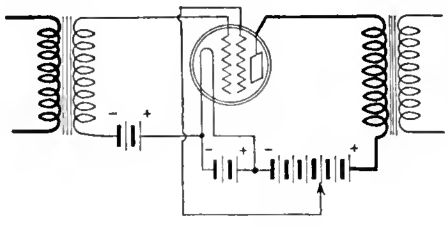


FIG. 6

A transformer-coupled audio amplifier stage using a tube whose outer grid is positive to reduce the space charge and make the plate voltage more effective

ordinary tubes, with the same transformer, 24 for one audio stage and a total amplification of 6000. One perceives that almost unlimited perspectives in receiver design are opened up, that

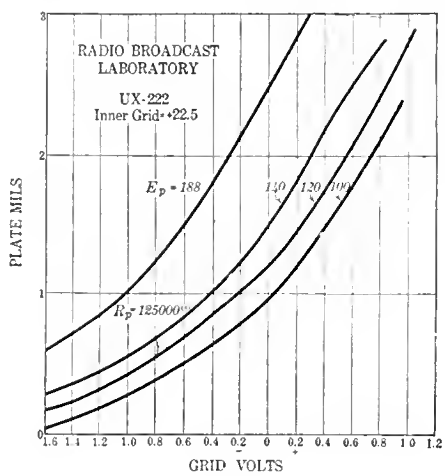


FIG. 10

Grid voltage-plate current curves on the new UX-222 tube with the inner grid positive. Note that the grid voltage lines are only two tenths volts apart indicating a large amplification factor

enormous volume may be expected, and distance undreamed of may be covered.

A study of the diagrams will reveal that the tubes are hooked up almost in the same way as ordinary tubes, with the exception of the posi-

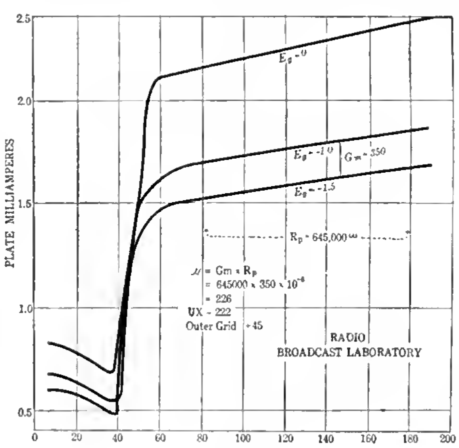


FIG. 11

The most interesting curve of all—the plate voltage-plate current data with positive outer grid. Note the negative resistance at low plate voltages, the rapid rise when the plate voltage equals that of the outer grid, and the very flat straight portion where the tube is ordinarily worked

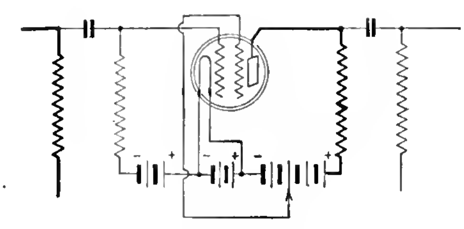


FIG. 7

A resistance-coupled low frequency amplifier with the outer grid of the tube positive

tive grid connection. Figs. 6 and 7 show different audio stage hookups.

The names "double-grid" tube is in the author's opinion, a misnomer. Generally we call the controlling element the grid, and as the fourth element in no way serves as a controlling element, it should not be called a grid, but simply the auxiliary element, or fourth element. Others have called the peculiar action of the fourth element between grid and plate a shield-

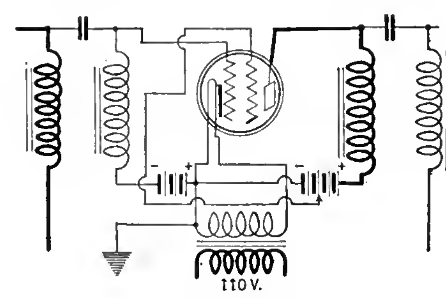


FIG. 8

The circuit of a special a.c.-operated double grid tube in process of development.

ing one, and call a tube thus constructed a shielded grid tube. It will be perceived that there is a good reason for this name, because the grid is actually more or less shielded against the plate effect, causing it to be remarkably stable.

EDITOR'S NOTE

THE curves presented here were made in the Laboratory and show the interesting characteristics of the UX-222—the R. C. A. "shielded grid" tube. Followers of our tube articles should note the extremely flat plate-current plate-voltage curve indicating an impedance—with the outer grid positive—of about 650,000 ohms, the negative resistance or falling characteristic at low plate voltages, and the high amplification factor of 222 secured by multiplying the mutual conductance by the plate impedance. If it is possible to place a load in the plate circuit of this tube, say at broadcast frequencies, of 650,000 ohms, a voltage amplification of 111 will result, compared with the usual amplification of about 10 for a single tube and its accessory apparatus.

With the inner grid positive, the mutual conductance rises, the plate impedance falls, and the amplification factor drops to about 100. Under these conditions the tube can be used in a resistance—or impedance—coupled low-frequency amplifier.

Experimenters will delight in this tube. Its possibilities are many and diverse. It will not revolutionize the radio industry, newspapers to the contrary, nor will it produce an entirely new era in receiver design. It is just one more step toward the ultimate goal of—what? Radio Broadcast will publish additional data as it is available on the use of tubes of this type.

The PHONOGRAPH *Joins*

By Way of Introduction

NOT many months ago, Carl Dreher suggested in his department in RADIO BROADCAST, that a radio broadcast program was almost the most ephemeral thing in the world. Thousands of dollars are spent to engage talent, wires covering half a continent are hired, advertising is scheduled in newspapers, several studio rehearsals are held, and finally the elaborate program is put on the air. For an hour it lasts—but it can never be repeated. If you did not hear it, all the king's horses and all the king's men couldn't put it into your loud speaker again.

If it is not possible to reproduce a complete radio program in one's own home, one can at least recreate the equivalent. A very great number of well-known radio artists are regularly recording for each of the important phonograph companies. Their records—electrically cut—are available everywhere.

These pages list a few of the records made by artists who are perhaps better known to the radio listener than to the average purchasers of phonograph records. Here are fine recordings made by the favorities of the Atwater Kent hour, and the famous artists of the Victor, Brunswick and Columbia hours. As for the jazz bands, the comedy duos, and other entertainers with a more local fame, they, too, are forever at your beck and call on the black discs.

One of the most important advances made in recent years—for which we must thank the scientists—is the great progress made in the reproduction of music and speech by electrical means. All radio folk know how audio amplification has been improved, what with new amplifiers of excellent characteristics, better loud speakers, and so forth. An equally important improvement has taken place in the phonograph field. Now the phonograph, with its electrically cut records and its acoustically excellent exponential horns or cone loud speakers, will rival the musical fidelity of the best radio receiver.

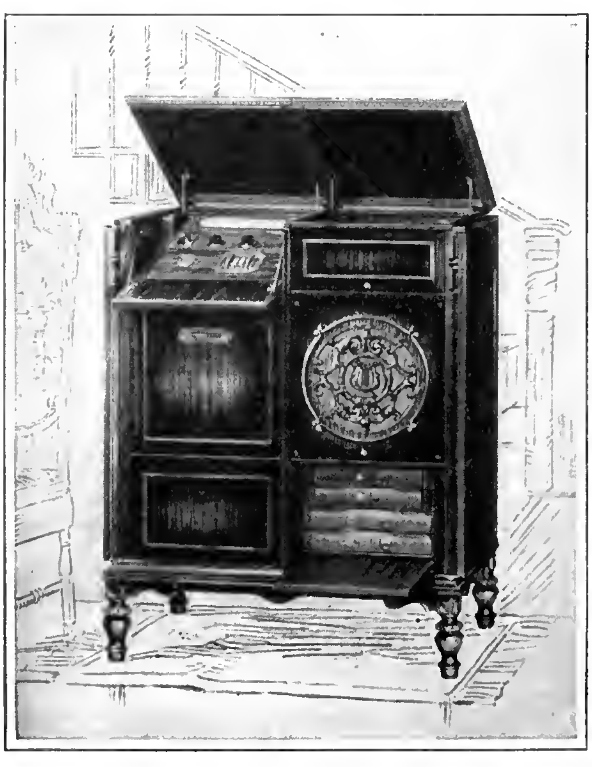
NEW RECORDS BY RADIO FAVORITES

Released Since September

What Do We Do On a Dew-Dew-Dewy Day Is It Possible?	Shilkret-Victor Orchestra Kentucky Serenaders	20819	*Victor*
The Tap Tap If I Had a Lover	Kahn's Orchestra Shilkret and Victor Orchestra	20827	"
President Coolidge Welcomes Colonel Lindbergh at Washington, D. C., June 11, 1927—Parts 1 and 2	Hon. Calvin Coolidge	35835	"
President Coolidge Welcomes Colonel Lindbergh at Washington, D. C., June 11, 1927—Part 3	Hon. Calvin Coolidge	35836	"
Colonel Lindbergh Replies to Pres. Coolidge	Colonel Charles A. Lindbergh		
Colonel Charles A. Lindbergh's Address Before the Press Club of Washington, D. C., June 11, 1927 Colonel Lindbergh's Souvenir Record—*Concluded*	Colonel Charles A. Lindbergh	35834	"
Ciribiribin (Waltz Song) Il Bacio (The Kiss) (Arioti)	Bori	1262	"
Indian Love Call (from Rose-Marie) Rose-Marie (from Rose-Marie)	Virginia Rea Murphy	4015	"
Old Black Joe (Foster) Uncle Ned (Foster)	Tibbett	1265	"
Actual Moments in the Reception to Colonel Charles A. Lindbergh at Washington D. C.—Parts 1 and 2		20747	"
At Dawning The Waltzing Doll	Victor Concert Orchestra	20668	"
Kentucky Babe Mighty Lak' a Rose	Vaughn De Leath	20664	"
Angels Watching Over Me Climbin' Up the Mountain	Utica Jubilee Singers	20665	"
Sam's Big Night The Morning After	"Sam 'n' Henry"	20788	"
Just Like a Butterfly Just Another Day Wasted Away	Franklyn Baur Marvin-Smalle	20758	"
Under the Moon Sing Me a Baby Song	Stanley-Marvin Vaughn De Leath	20787	"
You Don't Like It—Not Much Oh Ja Ja	The Happiness Boys	20756	"

The public has suffered rapid education. They have learned that faithful reproduction of the original is possible in radio sets and in phonographs alike. And if the growth of broadcasting were not enough to sharpen the interest in music of all kinds, the new phonographs and the new records have come along to broaden the domestic entertainment horizon.

The radio receiver has taken its place as a musical instrument—a medium of entertainment—along with the phonograph and the piano. The radio set in the public consciousness is no longer merely a scientific marvel and mystery. And since they are so closely related because of what they can bring to the home, the phonograph and the radio set have been drawn closely together in association of ideas and in actual physical form. Those who wish to buy a combination radio-phonograph can choose many fine models from five or six well-known manufacturers. Those who already have a radio receiver which they wouldn't trade for the royal throne of Roumania can make their audio amplifier and loud speaker do double duty in reproducing phonograph records or a radio program—according to the whim of the owner. All one needs beside a good loud speaker system is any kind of turntable which will twist the record at an even speed of 78 revolutions per minute, and a good electro-magnetic pick-up. And there are many of the latter on the market.



A COMBINATION RADIO-PHONOGRAPH FROM BRUNSWICK

The Brunswick Panatrope-Radiola, model 138C. This instrument contains a Radiola 28 super-heterodyne receiver with enclosed loop, which can be controlled by the dial in the front of the left-hand panel. On the right is the Panatrope and below it the cone loud speaker working out of a UX-210 amplifier which is also the amplifier for the radio set. The instrument, complete with all tubes for 60-cycle a. c. operation lists at $1150

FAVORITES IN CHICAGO

"Sam 'n' Henry"—Correll and Gosden who nightly disport before the twin microphones of WGN and amuse countless WGN listeners. Their verbal antics are embalmed on Victor records, listed above

the RADIO *Set*

New Records by Radio Favorites

Something to Tell Stop, Go!	Shilkret-Victor Orchestra	20682	*Victor*
I Ain't Got Nobody Roodles	Coon-Sanders Orchestra	20785	"
My Wife's in Europe To-Day A Little Girl—A Little Boy—A Little Moon	Fry's Million Dollar Pier Orch.	20726	"
Baby Feet Go Pitter Patter Sometimes I'm Happy	Vaughn de Leath	3608	*Brunswick*
When Day Is Done No Wonder I'm Happy	Radio Franks, White and Bessinger	3588	"
Ain't That a Grand and Glorious Feeling? Magnolia	Harry Richman	3583	"
Just a Memory (Vocal Chorus by Elliot Shaw) Joy Bells (Vocal Chorus by Vaughn De Leath)	Harold Leonard and His Waldorf-Astoria Orchestra	1105D	"
Ooh! Maybe It's You (Vocal Chorus by Franklyn Baur) Shaking the Blues Away (Vocal Chorus by Franklyn Baur)	Harry Reser's Syncopators.	1109D	*Columbia*
Just a Memory My Heart is Calling	Franklyn Baur	3590	*Brunswick*
No Wonder I'm Happy Just Once Again	Ernie Golden and His Hotel McAlpin Orchestra	3604	"
Baby Feet Go Pitter Patter There's One Little Girl Who Loves Me	Abe Lyman's California Orchestra	3605	"
Fantasy on St. Louis Blues Parts 1 and 2	Don Vorhees and His Earl Carroll's Vanities Orchestra	1078D	*Columbia*
Ain't That a Grand and Glorious Feeling? I Ain't That Kind of a Baby	Paul Ash and His Orchestra	1066D	"
Leonora Paree!	Leo Reisman and His Orchestra	1083D	"
Here Am I—Broken Hearted Havana (Vocal Choruses by Franklyn Baur)	Cass Hagan and His Park Central Hotel Orchestra	1089D	"
Swanee Shore Meet Me In the Moonlight	Harry Reser's Syncopators	1087D	"
Do You Love Me?—Vocal chorus by F. Baur Honey—Vocal chorus by Vaughn De Leath	The Columbians	1068D	"
Ain't That a Grand and Glorious Feeling? Vo-Do-Do-De-O Blues	Van and Schenck	1071D	"
That Saxophone Waltz I Could Waltz on Forever with You Sweetheart	Art Gillham-The Whispering Pianist	1081D	"
Gid-Ap, Garibaldi Oh! Ya! Ya!	Billy Jones and Ernest Hare (Happiness Boys)	1074D	"
For Thee (Pour Toi) (Gordon) From Out the Long Ago (Stratton and Dick)	Barbara Maurel	140M	"
Just Once Again (Chorus by F. Baur) Love and Kisses	Paul Ash and His Orch.	1090D	"
Are You Happy? Give Me a Night in June	Ipana Troubadours	1098D	"
Song of Hawaii Hawaiian Hula Medley	South Sea Islanders	1111D	"
Two Black Crows, Part 3 Two Black Crows, Part 4	Moran and Mack	1094D	"
Magnolia Pastafazoola	Van and Schenck	1092D	"
The Varsity Drag (Vocal Chorus by Baur, James, and Shaw)	Cass Hagan and His Park Central Orchestra	1114D	*Columbia*
Dancing Tambourine	The Radiolites		
Good News (Vocal Chorus by Baur, Shaw and Luther) Lucky in Love	Fred Rich and His Hotel Astor Orchestra	1108D	"

THIS RADIO PROGRAM IS RECORDED

Colonel Lindbergh before the Washington microphones which carried his welcome-home ceremonies to the entire nation. Victor has made four excellent records from this event.

FOR the first time, phonograph records of a radio broadcast program are offered to the public. Victor has the distinction of pioneering and they offer three double-face records of the national welcome to Colonel Charles A. Lindbergh at Washington. On these three records you have the voice of President Coolidge, the interspersed announcements of Graham McNamee, a short address by Colonel Lindbergh, and his longer speech at the National Press Club. It's all there and if you close your eyes, it isn't hard to imagine that the events are just taking place—the cheers of the crowd, the applause which interrupts the speakers, the blare of the bands, and the quiet unruffled voice of Lindbergh.

The Victor Company arranged a direct wire from Washington, culminating in their studios through which their recording apparatus got the same program as each of the broadcasting stations. The ceremonies were recorded on forty-six record surfaces and finally edited down to the six surfaces now available. It is a good job from any point of view and Victor is to be congratulated. It is time that some of the historic events which are being offered to the radio listener with impressive regularity were preserved in permanent form. The next offering will be a championship fight, we suppose.

GUESS WHO

None other than Billy Jones and Ernest Hare—known to Eastern listeners of WEAF on Friday nights as the Happiness Boys. Their songs are recorded by Victor and Columbia

A PHONOGRAPH—RADIO COMBINATION FROM VICTOR

"Automatic Electrola-Radiola No. 955" is what Victor calls this beautiful instrument. Records are changed automatically and groups of 12 can be played without attention.

An 8-tube super-heterodyne with enclosed loop operating entirely from the light socket through the power supply for the vacuum tube amplifier and the cone speaker used alike for phonograph and radio reproduction. The radio receiver panel can be used in three positions. List price, $1550

MAKE YOUR OWN RADIO PICTURE RECEIVER

THIS article is the third in the series explaining the use and operation of the Cooley "Rayfoto" picture receiving system. The Cooley apparatus was demonstrated in actual operation at the New York Radio show and attracted an astounding amount of interest. Governor Alfred E. Smith of New York, who made the opening address of the Show, transmitted a part of a picture of himself, reproduced by the Cooley system over WJZ *and other stations of the Blue network. Many of the readers of this article undoubtedly heard that interesting broadcast. The subject of radio photograph reception is so large that it can be discussed only in part on each article. Our readers are advised to preserve carefully each of the articles in* RADIO BROADCAST *on this system, beginning with the first story in the October, 1927, issue. Pictures will be sent by broadcasting stations, using their regular assigned wavelength, and no tuning changes in your present receiver are necessary. Readers are urged to write us their experiences with the construction of the recorder. The development of the Cooley "Rayfoto" system opens for the first time to the American experimenter an important "next step" in radio development.*

—THE EDITOR.

By AUSTIN G. COOLEY

THE articles on the Cooley "Rayfoto" system in the October and November issues of RADIO BROADCAST explained how the system works, told something of the results to be expected, and gave some details regarding the operation of a picture receiver. This third article in the series gives some general and particular information about the system, and diagrams necessary for the construction of a Cooley receiver are also presented.

Many of the units for use in the radio picture receiver have been especially designed for the purpose and therefore possess the necessary characteristics for good results. They have been designed to take care of the present requirements of the receiver and are so flexible that they will still be suitable for use as the system may be gradually developed. Considerable care has been taken in this matter so that it will not be necessary to scrap any of the parts as the natural development of increased speed of reproduction and better quality are consummated. The approved parts, which have all been carefully tested, are made under the Cooley "Rayfoto" trade mark.

Arrangements are now under way to supply various broadcasting stations with phonograph records which will enable them to put Cooley pictures on the air. The radio editor of your local newspaper is the best source of information.

The complete set-up for picture reception by means of the Cooley system consists of three distinct units—the radio receiver proper, the amplifier-oscillator unit, and the printer assembly. The first—the radio receiver—should be capable of quality reproduction of radio programs for if it falls down in this respect it will assuredly do so when called upon to detect and amplify the incoming modulated wave which has super-imposed upon it the audible note representing the picture being transmitted.

Passing from the last audio stage of the receiver proper, the "picture signal" is further amplified in the amplifier-oscillator unit and it then modulates the output of the oscillator in accordance with the modulation produced by the picture. The varying output of the oscillator is made to cause corresponding variations in the output of the corona coil, and thus the intensity of the needle point discharge is made to produce an effect on the proper tallying with the original picture. The corona coil is included in the second unit although the actual needle at which the discharge occurs is naturally a part of the third—the printer-unit. This third unit consists of the needle, the drum upon which the photographic printing paper is wrapped, and the mechanism which causes the drum to revolve. It is purchasable as a whole, for there are few who possess the mechanical ability and facilities for the construction of such an intricate piece of mechanism.

The construction of the amplifier-oscillator unit from the approved parts is a simple matter. Fig. 1 shows a suggested layout while Fig. 2 is the schematic diagram. The following parts are necessary for this unit:

T_1—"Rayfoto" Amplifying Transformer
R_1—Variable Shunt Resistance for Primary of T_1
R_2—200-Ohm Variable Resistance Capable of Carrying 100 Mils.
R_3—12-Ohm Filament Rheostat, ½-Ampere Capacity
R_4—"Rayfoto" Relay
T_2—"Rayfoto" Modulation Transformer
C_3—0.1-Mfd. Condenser
R_5—0.01-Meg. Grid Leak and Mounting
C_1, C_2—0.0005-Mfd. Fixed Condensers
C_4—0.0005-Mfd. Variable Condensers.
L_1—"Rayfoto" Corona Coil
L_2—Radio-Frequency Choke Coil
S_1—Filament Switch
S_2—Push Button or Special Switch
J_1, J_2, J_3—Double Contact Short-Circuiting Jacks
R_6—Filament Ballast Resistance
One Telephone Plug
Milliameter, 0-25-mil. Scale
Two Sockets
Fourteen Binding Posts
Base-Board
Panel
Brackets
"Rayfoto" Printer Unit

Although wide deviations from the layout shown in Fig. 1 are permissible, it is also quite possible that considerable "grief" will be experienced in many cases where original schemes are attempted. We therefore suggest that the home constructor follow our plan of layout and construction very religiously, at least on his first set. The photographs indicate very clearly the arrangement of the apparatus and the experienced home constructor should have little difficulty in putting the apparatus together.

All but the radio-frequency circuits may be wired up in any convenient manner. We find

PICTURES RECEIVED BY THE COOLEY SYSTEM

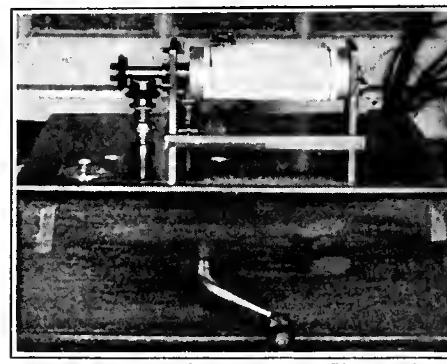
These two photographs have not been retouched and were received at the demonstration at the New York Radio Show. Governor Smith, in his radio address opening the Show let radio listeners hear how his picture, above, sounded. The heading above shows Mr. Cooley and a part of his apparatus as set up in operation at the Show. Governor Smith's picture is on the receiving drum that ordinary No. 18 rubber covered fixture wire is very easy to handle and makes a reasonably neat job. Each circuit should be properly tested out, as will be explained later, before the wires are laced up in bundles. The radio-frequency circuit should be wired up with considerable care, the use of bus bar wiring or rigid wires having a fair amount of spacing between them, being recommended. No particular care need be taken to prevent losses in the radio-frequency oscillator circuit. The secondary of the corona coil, and its lead to the corona needle, however, require very special attention. This subject will be covered in another paragraph.

When the "Rayfoto" printer has been completed and set up with all connections to batteries, proceed as follows for testing and adjusting:

Place two 201-A type tubes in the sockets and see that the filaments are properly lighted and a good range of brilliancy is controlled by the rheostat, R_3, of the amplifier tube. With the input terminals open, plug a pair of phones in meter jack, J_2, for the amplifier. Turn the filaments on and off a couple of times to see if the proper click is obtained in the phones. If it sounds satisfactory, plug in the milliammeter. If you find the milliammeter reading down scale, reverse the connections to it. Adjust the C battery until the plate current is a little less than one milliampere. The plate voltage on the amplifier should be about 180 volts and the C bias to bring the plate current down to 1 mA., will have to be around $22\frac{1}{2}$ volts.

Now connect a piece of wire between the plate terminal of the a. f. amplifier tube socket and the B plus terminal of the modulation transformer T_2, and connect the input of the amplifier to the output of the radio receiver. Tune-in any broadcast signal and watch the milliammeter to see if it varies in accordance with the incoming signal. The phones may be plugged into jack J_2 and the gain control resistance, R_1, varied to determine if the proper control is obtained.

Now connect the lead from the corona coil to



RADIO BROADCAST Photograph

THE PRINTER UNIT COMPLETE

With its spring motor. If the user desires to use the motor in a phonograph which he already has, the illustration on the next page shows a special unit made for that purpose

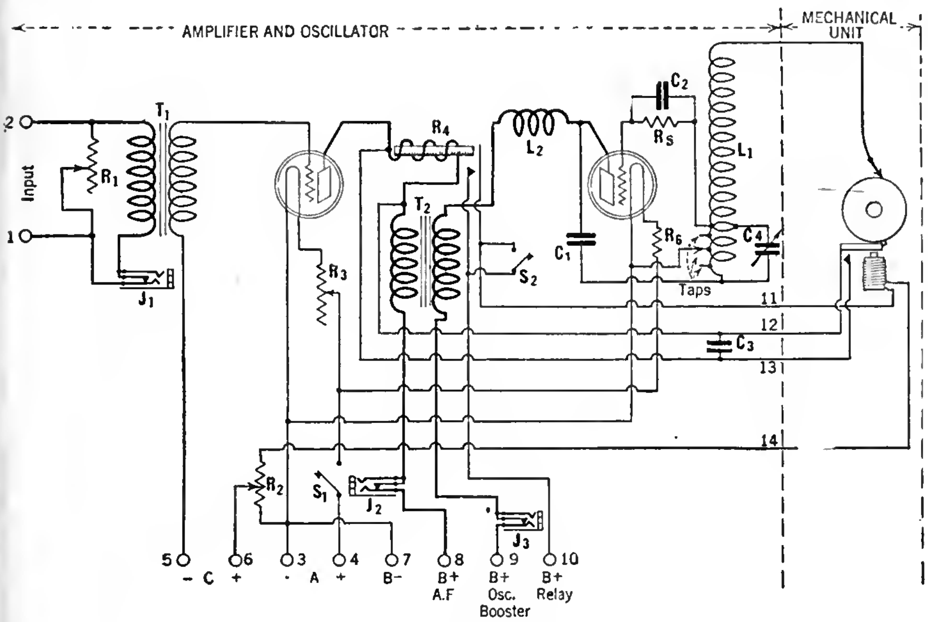


FIGURE 1

The circuit diagram of the amplifier and oscillator is given in this figure

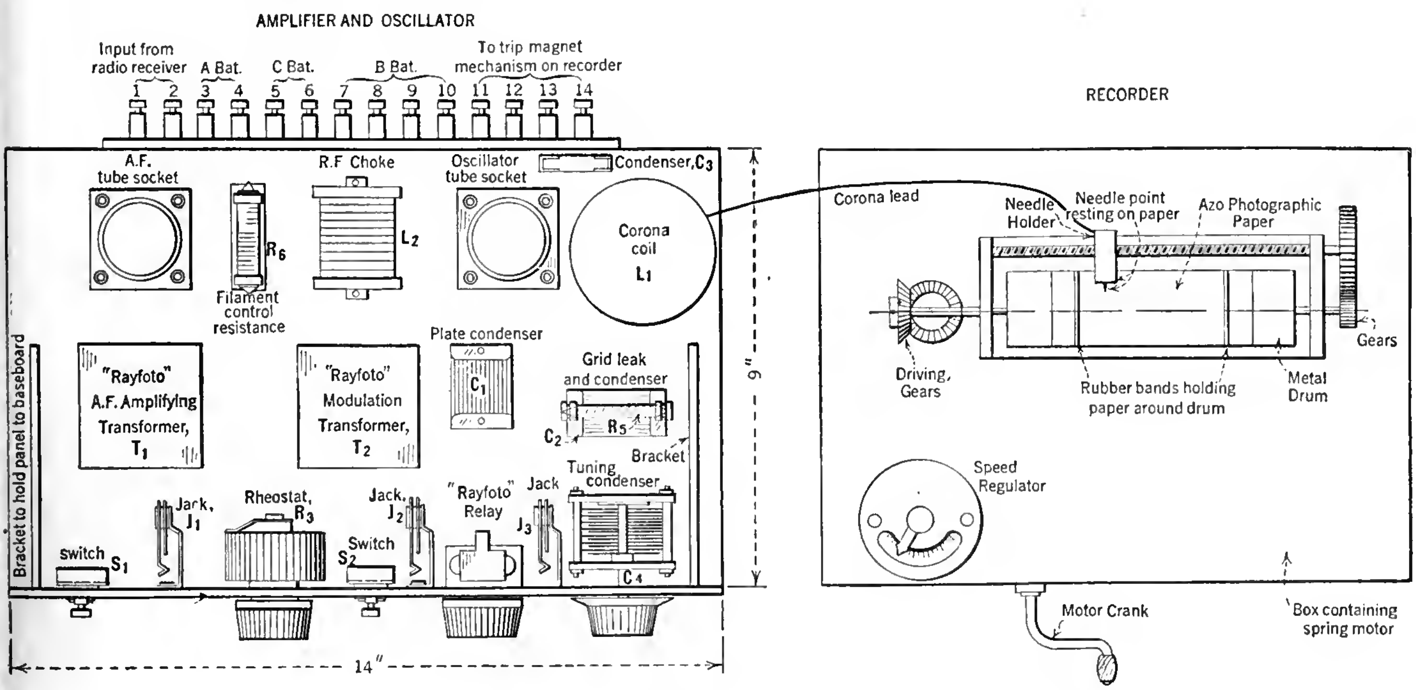


FIGURE 2

The suggested layout of apparatus shown in this drawing may be followed when you construct your amplifier-oscillator unit. The various identifying letters on the parts refer to similar letters on the circuit diagram given in Fig. 1. The lead from the corona coil, L_1 to the needle holder on the recorder should not be over three feet in length and should be supported where necessary by silk thread. The parts for the oscillator-amplifier unit can be purchased and then assembled at home, and no special precautions are necessary in constructing the unit. The wiring may be done in straightforward fashion. The corona lead is a No. 38 wire and should be carefully handled, otherwise it will break. If the lead is broken by accident, unwind about three turns from the coil to make a new lead. The record unit cannot be home constructed and must therefore be purchased as a complete unit. The recorder depicted in this sketch is a complete unit containing a spring motor. R_1 and R_2, not a part of the early model illustrated, may be located at any convenient point in the layout. A fixed condenser was used for C_4 in the first model. It is preferable that it be variable as indicated above.

the corona needle. Give this lead no more support than absolutely necessary. If this important lead needs support, it should only be by suspending it from small threads. The lead should be made as short as possible and in no case should be over three feet long. Place a small piece of Azo No. 4 photograph paper on the drum and let the needle rest on it. The paper may be held around the drum by means of two rubber bands.

Disconnect the input of the amplifier from the radio receiver and connect the booster terminal to about 90 volts of battery. Cautiously plug the meter in the oscillator circuit jack, J_3. If the meter registers over fifteen milliamperes, the circuit is not oscillating properly. Adjust the variable condenser until the current is brought down to less than ten milliamperes.

Now watch the point of the corona needle to see if a very small corona discharge takes place. If not, re-tune condenser C_4. If this does not bring results, try the various taps on the oscillator coil. If you are still unable to obtain any visible corona, increase the booster voltage to about 150 and try the different taps again. It may be found that all the condenser capacity is required to obtain a discharge. The length of the lead wire should then be shortened or a small fixed condenser, of about 0.0005-mfd., may be placed across the variable condenser. Only a good mica condenser should be used. If the discharge is strong enough to burn a hole in the paper, the booster voltage should be reduced. The taps should be tried to determine the best position of maximum discharge.

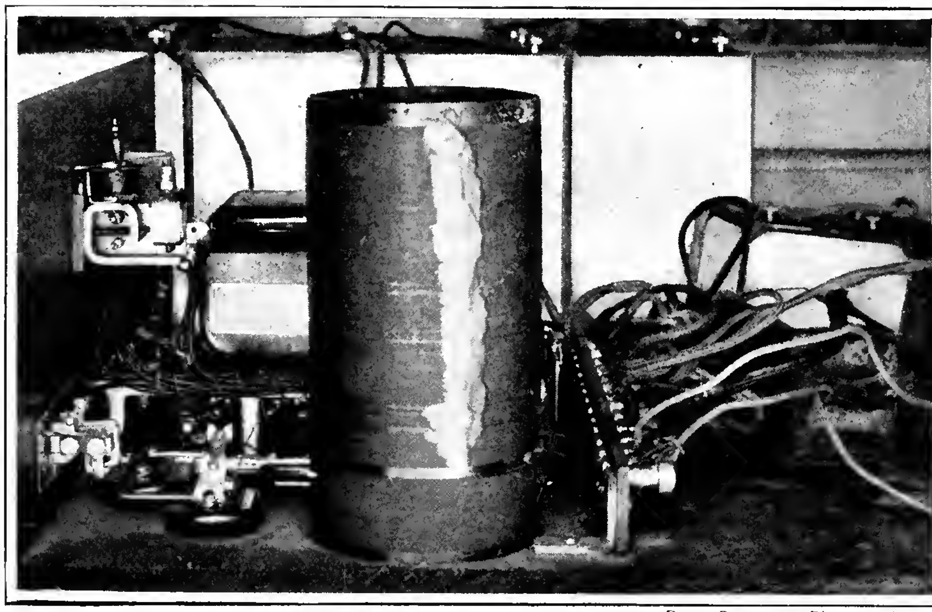
With the printing circuit operating properly, connect the input to the radio receiver and tune-in any broadcast signal. Take off the short circuiting wire on the trip magnet switch terminals and allow the drum to revolve with the needle riding on the paper. If the trip magnet does not trip from the radio signals, release the drum by operating the switch, S_2 across the relay circuit. Watch the needle point to see if the corona varies with the incoming signal.

GENERAL HINTS

AFTER the "Rayfoto" printer and recorder are set up for operation, trouble may be experienced in many cases due to feed-back from the corona circuit about which considerable information was given in the November issue. This trouble will depend greatly upon the characteristics of the radio receiver. To help avoid it, the experimenter should provide a separate set of small $22\frac{1}{2}$-volt B batteries for the printer. As an additional precaution, the printer and recorder should be placed at a considerable distance from the radio receiver, say eight or ten feet, if convenient. After the apparatus is set up and working properly, attempts may be made to reduce this distance. Also experiments can be made with the battery circuits to determine the feasibility of operating the radio receiver and printer with the same B batteries. The experimenter will be aided greatly by the use of low-resistance B batteries. The filaments of the tubes in the "Rayfoto" printer may be operated from the same storage battery used for the radio receiver. All the above precautions should be taken to prevent feed-back before attempting to tune up the "Rayfoto" printer. If feedback still occurs after tuning up the printer, additional steps may be taken to suppress it.

If there is any feed-back from the printer circuit, the discharge will be strong and continuous. A high reading on the meter when no signals are coming in indicates feed-back.

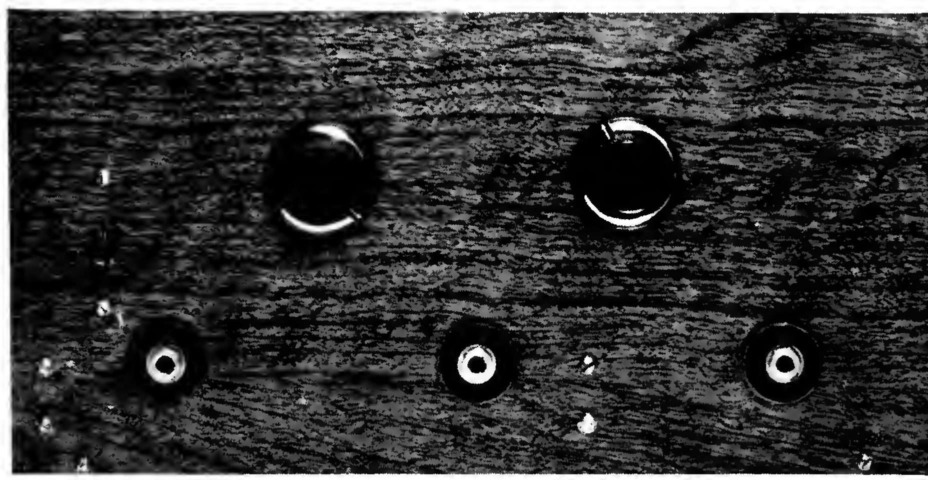
The last resort to prevent feed-back is to shield the printer circuit. The shielding should not be attempted before the unit is set up and ready

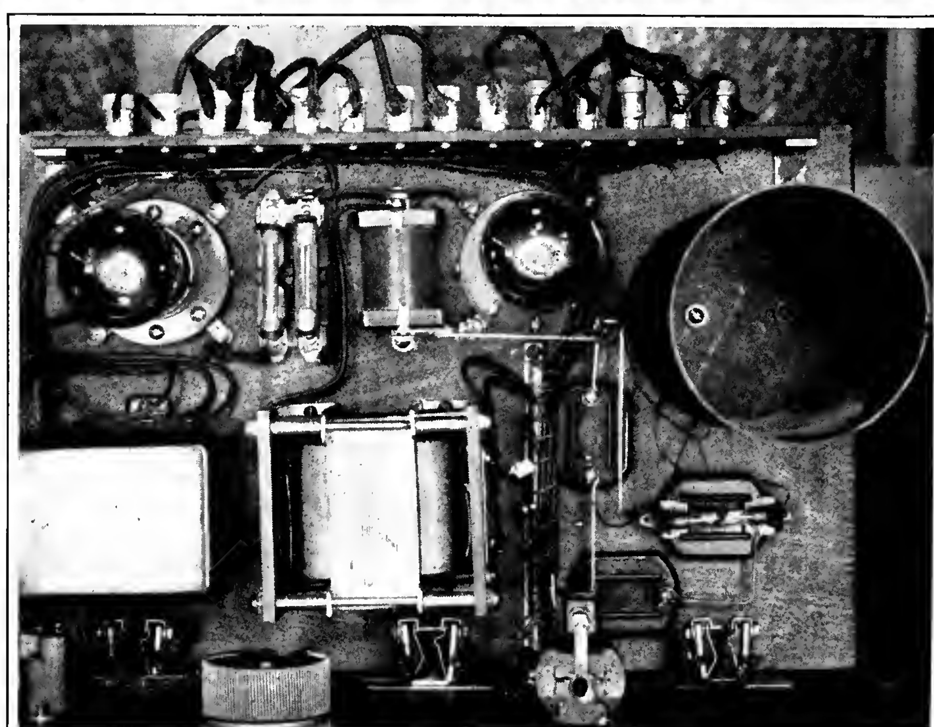


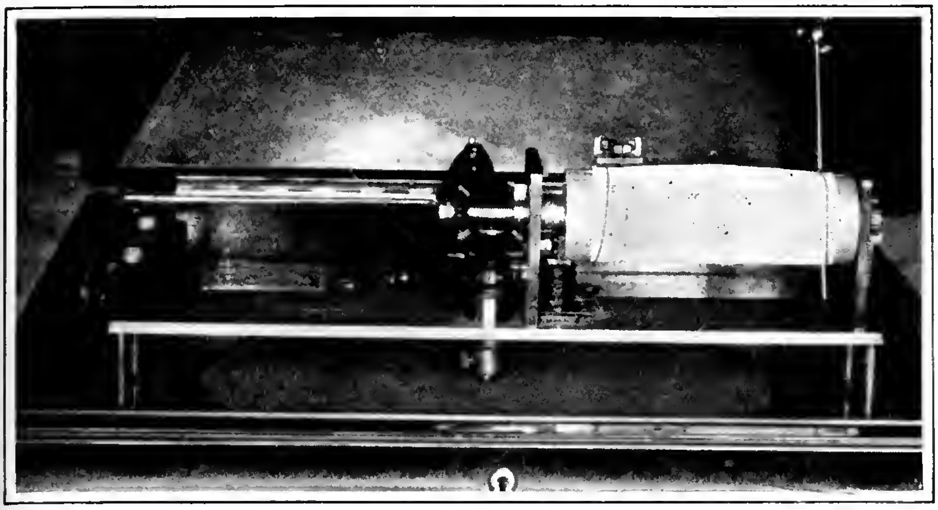
Radio Broadcast Photographs

THREE VIEWS OF THE AMPLIFIER-OSCILLATOR UNIT

The upper view taken from the side, shows the home-made relay mounted on the front panel and the corona coil is in the foreground of the picture. The center view shows the front panel layout and a top view is given below







RADIO BROADCAST Photograph

USING A PHONOGRAPH AND ITS MOTOR

The printer unit depicted above is designed for use with any standard phonograph and utilizes the spring motor in the phonograph for the operation of the drum

for operating because in many cases the shielding will do more harm than good if it cannot be first tested out in an experimental way.

Due to the different characteristics of radio receivers, we cannot give information here that will cover every case. In general, the proper results may be obtained by running very small gauge grounded wires parallel to the corona feed wire and separated from it by a number of inches. This may necessitate re-tuning the oscillator circuit. Experiments with shield wires and shield plates will eliminate feed-back in most cases.

In many cases it will help matters to adjust the neutralizing on the radio receiver or slightly de-tune one stage of radio-frequency amplification.

With the printer circuit working properly, we may now adjust the relay and trip magnet. Adjust the relay contacts so that they close before the armature strikes the magnet pole. With the contacts *closed*, you should be able to slide a piece of thin paper (the thickness of this page) between the pole and armature. The gap between the contacts when *open* should be equal to two thickness of the paper used on the cover of this magazine. If sparking is bad, it may be necessary to increase this slightly. A condenser across the contacts will do more harm than good as it will cause the contacts to stick unless the spring tension is excessive.

With the trip magnet contacts open, adjust the C battery so that the plate current of the amplifier is about five mils. Adjust the spring tension of the relay so as to barely hold the contacts open with the five mils. in the circuit. After this adjustment is made, return the C battery adjustment to its original point.

The voltage for the trip magnet should be as small as practical, consistent with strong operation of the magnet. The power for this magnet may be taken from the batteries operating the radio receiver if small batteries are used for the printer circuits.

With all the foregoing adjustments and tests made, the experimenter is ready to test his set out on picture signals. It is well to have the developer and fixer solutions made up in advance although it will not hurt to let the undeveloped picture stand for a considerable time if the paper is protected from light. Instructions will be found on the developer tubes and fixing powder cartons for making up the solutions so we will not cover that information here. Regular trays for the solutions should be used for the sake of convenience although any enamel or glass tray or dish will serve the purpose. In mixing up the solutions, it will do no harm if they are made a little more concentrated than the manufacturers specify, using about 6 oz. instead of 8 oz. of water.

With the trip magnet properly adjusted, the speed of the drum should be adjusted and checked by counting the number of revolutions of the drum. If a converter drum speed of 100 r.p.m. is used, the recorder drum speed should be about 105 r.p.m. The clutch should be free enough on the first tests so that the turntable will revolve with the drum in its locked position. By loosening up on a set screw on the collar directly below the spring, the clutch friction may be regulated.

To receive a Rayfoto picture, tune-in signals from the station transmitting the signals so that they are received with maximum intensity. If the meter in the amplifier circuit runs up over fifteen mils. on the strong signals, reduce the intensity by the volume control on the radio set or the gain control on the printer amplifier. In most cases it will be good practice to reduce the radio-frequency input to the detector circuit.

The minimum signal should be between one and four milliamperes. Adjustment of the minimum signal is more important than that of the maximum for if the minimum is too high, it will operate the relay when it should not, and if too low, it will cause irregular relay operation.

While the synchronizing pulse is being transmitted from the station sending pictures, the drum should revolve and trip regularly with only a brief period of rest or lap. By regulating the speed of the driving motor the lap can be regulated. If the lap should be very long, you will find that the speed is too slow and that the drum is tripping only on every second synchronizing impulse. Increase the speed.

After the drum is adjusted to trip regularly, a "range" should be taken; that is, the signal should be increased to the point where the relay trips from the minimum rather than the synchronizing signal, and then the signal should be decreased to the point where the relay does not trip at all. The operating adjustment should be about half way between the two points. The operating range of the relay should be as large as possible. If it is very small, it may be increased by increasing the amplifier tube's C-battery potential so that the plate current is practically zero when no signals are being received.

When the synchronizing adjustments are made and the paper placed on the drum, you are ready to start as soon as the picture signals begin. The paper should be drawn up to fit the drum tightly. If the center of the paper at the lap bulges out very far, a rubber band may be placed around the center of the drum and slid along when the needle approaches it. Care should be taken not to get the hand close enough to the corona feed wire to detune the circuit.

After the picture is received the paper is placed in the developing solution until developed to the proper density. It is then dipped in the washing bath and placed in the fixing solution. After remaining in the fixing solution for ten or fifteen seconds, it may be removed temporarily for observation purposes but should be replaced in this solution for ten or fifteen minutes and washed in running water for five or ten minutes, if it is desired to preserve the picture indefinitely.

In some cases the experimenter will experience excessive blurring, lack of detail, streaks in the pictures, improper contrast, etc. In the next issue of RADIO BROADCAST we will give more complete information that will enable the experimenter to clear out any such troubles should they arise.

The Freedom of the Air

EXCERPT from a news item in the New York *Times* of May 3, 1927, under the caption, "Pacifist Talk Hushed by Radio Station WGL:"

"We are proud that Mrs. Corson is a woman," Mrs. Ford said, "proud that she comes from Denmark, that country which upholds an ideal of peace, that country which said to the enemy, "If you must cut through our country, even if you must cut through our women and children"—

At this juncture Mr. Isaacson cut out the microphone through which she was speaking and substituted one in the studio through which music was broadcast as a stopgap.

Mr. Isaacson later explained to the radio audience what had happened. In discussing the incident later he said:

"We believe in free speech and I have always been willing to extend the use of our station to anyone to express his views, but there are certain things which are dictated by good taste. This was not the time nor the occasion for such a speech."

Excerpt from a news item in the New York *Sun* of July 18, 1927, under the caption, "Worm Controversy To Be Aired from WGL:"

Fred B. Shaw, one time international fly fishing champion, will have an opportunity to discuss President Coolidge and his angleworm fishing to his heart's content to-night when WGL will allow him to broadcast, uncensored, his speech which was barred last week by another station.

"Our broadcast policy has always upheld free speech on the air," declared Dr. Charles D. Isaacson, program director of WGL, in extending the invitation to Mr. Shaw yesterday, "and for that reason we are only too happy to extend the privileges of our broadcast station to you."

A vexing question is thus cleared up for all time. What is free speech à la Isaacson? It is freedom to discuss angleworm fishing. But not to discuss war.

Beauty *the* Keynote *of*

AN INSTALLATION that is completely self-contained—the Bosch Model 57. Although there is a very efficient loop built in, provision has been made for the use of an outside antenna where desirable. The receiver employs seven tubes, and is tuned by a single main dial. A cone loud speaker is harbored within the cabinet. Price, $340. For power operation, $100. extra

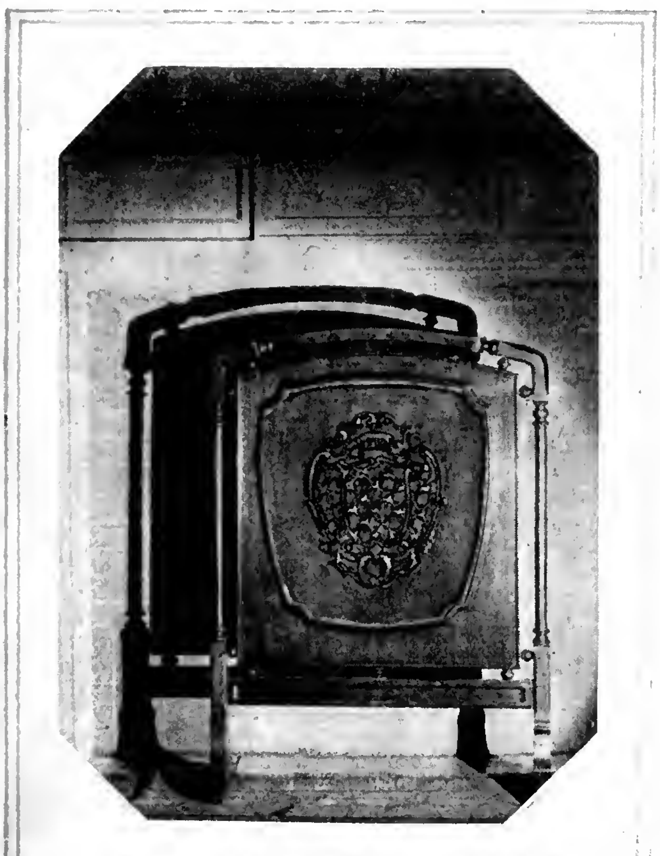
ANOTHER receiver which may be operated with either loop or outside antenna. This one is the Fada 8. There are, as the model number implies, eight tubes, but there is a switching arrangement whereby either seven or the eight may be used. There are four t.r.f. stages. All the radio and audio stages and tubes are individually shielded. When not in use the loop is folded behind the cabinet. Price, $400.

THE set builder can now obtain a cabinet for his receiver which is every bit as beautiful as those which house the most expensive of factory-built receivers. The Model 80 cabinet of the Musical Products Distributing Company, New York, here illustrated, is in combination walnut and satinwood. The set compartment measures approximately 28 inches long, 10 inches high, and 15 inches deep. Price, $250.

the New Radio Receivers

Making the Most of Surroundings

It is easy enough to discuss the offerings of the current radio season abstractly but one should visualize this year's radio sets in the proper domestic surroundings to appreciate what great strides have been made toward making radio a truly domestic bit of furniture. The illustrations on these two pages show radio equipment in home settings and who will deny their grace?



AN INTERESTING design in loud speakers, the new Amplion "Fireside." This loud speaker has a large cone mounted on a big sound-board, exceptional fidelity of reproduction being possible. The screen stand and long cord render the "Fireside" readily portable, making it easy to place the loud speaker anywhere in the room or outside on the porch. The panelling is of embossed walnut, attractively curved, combining a grille front and back. The height is 36½ inches, and the cone is 16½ inches. Price, $97.50, with 20-foot cord

A TYPICAL example of the trend of the more expensive radio receiver, in which utility and beauty are in combination. We are taken back by this Winthrop secretary to America's younger days, when money was scarce and furniture was made to serve dual purposes. Nowadays a return to this state of affairs is demanded since home space is so scarce. The radio receiver built into the Winthrop is the popular Splitdorf single-control six-tube set. The price, complete with power operation and loud speaker, is $600.

What B Device Shall I Buy?

By HOWARD E. RHODES

TO WRITE of B power units in general terms, with the object of assisting in their wise selection, is not difficult because there are simple rules that can serve to guide the prospective purchaser. In the first place it should be realized that the satisfaction which any power unit gives in service frequently bears a close relation to its cost, for power units can be built to meet almost any price. Cheap units, constructed of inferior materials, are often capable of giving as good results as more expensive devices, during a single demonstration, but whether the cheaper device will stand up for as long a time in service is certainly open to question.

The first rule in the purchase of a B power unit should be insistance upon a well-known make, purchased through a reputable dealer, for only from such a source can you be assured of obtaining satisfactory service. One of the simplest and most satisfactory methods of appraising a B power unit to make certain that it will satisfactorily operate your receiver, is to give it a trial lasting several days in your own home, under actual working conditions. Only a reputable dealer selling a good product can afford to do this for you. A cut price dealer, with little or no interest in his customer once the sale has been made, cannot afford to sell a unit to you on the basis of a trial lasting several days. The unit purchased from a reputable dealer might cost somewhat more, but the higher price is justified because of the better service and greater assurance of satisfaction which you can obtain.

There are many things about a B power unit which must be taken more or less on faith. You can't tell, by looking at the device, what kind of chokes are used or if the condensers in the filter circuit have a sufficiently high voltage rating so as to prevent any possibility of breakdown. Then again, the design of the transformer supplying the rectifier and filter circuit is something that cannot be examined when you buy the unit. It is only by relying upon the reputation of the dealer and of the manufacturer whose product he sells, that you can have any assurance of a properly designed unit. If care is taken in the selection and use of a B power device, it will give satisfactory operation and lasting service for years.

In the list appended, we have given the important characteristics of about twenty-five well-known B power units. Since there are being made at the present time about one hundred and thirty of these units, it will be seen that the list is by no means exhaustive.

The proper selection of a B power unit is a matter of knowing the total plate-current drain of the receiver and of then finding a device that will supply the correct voltages to your receiver at this current drain. You must make certain that the maximum voltage available from the device when supplying a milliampere load equal to that of your receiver is sufficient to supply the power tube you are using. The maximum output voltage of the device should be 180 volts, or slightly more if a 171 type tube, with 40.5 volts grid bias, is used in the output; if a 112 type tube is used, with 9 volts grid bias, the maximum voltage should be about 135 volts. The information given in the appended list includes the maximum output voltage which the units will supply at various current drains.

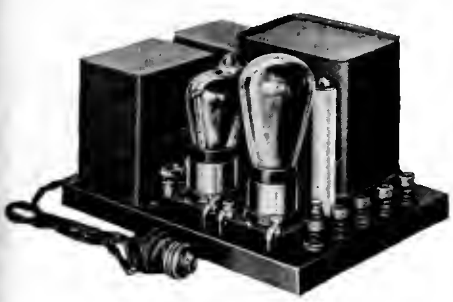
Of course, it is also essential that the power unit be capable of supplying the other tubes in the receiver with the voltages they require. These voltages are obtained from voltage taps on the power unit and in most cases the voltage that is obtained from any one of these taps varies with the current being drawn from it and the other voltage taps, and for this reason it is not possible to give any definite figures for the voltage output from these taps. Many power units use adjustable or semi-adjustable resistances so that the desired voltages can be obtained by proper adjustment of the resistance. These resistances should not be adjusted by guess but should be adjusted with the aid of a high-resistance voltmeter. This is a service any reliable dealer can give you.

There are some power units (those using glow tubes) which give practically constant output voltages independent of the load. If such a unit is purchased it may be connected to any receiver with assurance that the actual voltages being supplied to the receiver will be near enough to those marked on the terminals of the power unit for satisfactory operation.

As will be seen in the accompanying list, some of the devices have been approved by the National Board of Fire Underwriters and many of the other devices have been submitted for test but have as yet not been approved. The submission of B power units to the National Board of Fire Underwriters for their approval is a distinct step in the right direction. It gives the prospective purchaser the assurance that the unit conforms to definite standards designed to make certain that the operation of the device will be entirely safe.

The power input to a power unit is a measure of the cost of operating the unit. The input power to the average B power unit is about 25 watts, which is the amount of power required by a small electric light bulb. If we obtain power from the electric light company at the rate of ten cents per kilowatt hour, it will cost just about one quarter of a cent per hour to operate the average plate-supply device. To this cost of operating, we should, of course, add depreciation on the unit and the cost of tube renewals which must be made on an average of once a year.

All B power units for use with an alternating-current supply must use rectifiers of some sort. A majority of units use a tube for this purpose, but there are also quite a large group that use electrolytic rectifiers; thousands of B power units using either type of rectifiers have given satisfactory service. When purchasing a power unit avoid those using unknown makes of rectifiers. Whether you purchase a power unit



B POWER UNITS FOR YOUR RECEIVER

The power unit at the left is the Erla Steadivolt BC Converter and it utilizes a Raytheon BH rectifier tube and a glow tube to maintain the output constant at all loads. It will supply up to 80 milliamperes at 180 volts. It lists at $40 including tubes. The Exide unit in the center and the Burns power device at the right both contain adjustable resistance units to regulate the voltage at the various terminals and further information regarding these two devices will be found in the listings on these pages

using an electrolytic or tube rectifier is a matter of personal preference.

WHEN YOU USE A B-POWER UNIT

A LOUD hum audible in the output of a receiver operated in conjunction with a B power unit may be due to coupling between the receiver and the power unit itself. If the hum is due to such a cause it can generally be eliminated by placing the power unit in some other position relative to the receiver. Also if hum is to be prevented it is essential that the negative B be grounded directly, and in some cases it is necessary to connect a 1-mfd. 200-volt condenser between the grounded negative B terminal and one side of the input power lead. If these simple remedies do not eliminate the hum it is likely that there is some defect in the unit itself and the dealer should be consulted for, if the power unit is operating properly it should produce practically no audible hum in the output. Every plate-supply unit must contain a transformer designed to step up the input voltage to an amount depending upon what output voltage is required and upon what type of rectifying element is used. The rectifier, whether it be a tube or an electrolytic device, modifies the alternating current obtained from the power supply and changes it to a pulsating direct current. The filter circuit smooths out the pulsation in the rectified current and delivers a steady fluctuating direct current to the output terminals of the device. Some power units use half-wave rectifiers and others use a full-wave rectifier. In the first case, only half of the alternating voltage is used and when full-wave rectification is used both halves of the alternating voltage wave are utilized. The filter system may contain either one or two sections. Whether a half- or full-wave rectifier is used or whether a one- or two-section filter is used is something that need not particularly concern the prospective purchaser. The design of the filter in either case should be such as to eliminate any hum, and so long as the device which you buy does not hum excessively, you may be sure that the filter circuit has been correctly designed for the type of rectifier used. The coils and condensers used in the filter circuit do not become weak with age, and a filter system capable of giving an output voltage free from hum will continue to do so unless some unit in the system completely fails.

Facts About Some B Units

ACME APPARATUS CO., MODELS E-1, E-2, E-3, AND E-4

Maximum output voltage of a.c. models: 205 at 20 mA., 185 at 30 mA., and 160 at 50 mA. Uses Raytheon BH rectifier. Two adjustable voltages. Two-section filter. Approved by National Board of Fire Underwriters. Size: $8\frac{3}{4}$ x $3\frac{1}{4}$ x $7\frac{3}{4}$ inches. Models E-1, E-3, and E-4 for operation on 110 volts 60 cycles a.c. Model E-2 for operation on 120 or 220 volts d.c. Model E-1, with cable, for one- to twelve-tube sets, $50; Model E-2, with cable, for one- to twelve-tube sets, $25; Model E-3, with cable, for one- to eight-tubes sets, $85; Model E-4, with binding posts, for one- to eight-tube sets, $35.

ACME ELEC. AND MFG. CO., MODEL BE-40

Maximum output voltage; 200 at 20 mA., 185 at 30 mA., and 145 at 50 mA. Uses QRS rectifier. Two adjustable voltages. Full-wave rectifier. Two-section filter. Approved by National Board of Fire Underwriters. For operation on 110 volts 50-60 cycles a.c. Recommended for five- to eight-tube sets with power tubes. Size: $7\frac{3}{8}$ x $11\frac{1}{2}$ x $3\frac{11}{16}$ inches. Price, with tube, $34.50.

ALL-AMERICAN, MODELS A-1, A-3, A-4, AND A-8

Maximum output voltage of Model A-8; 200 at 20mA., 180 at 30 mA., 140 at 50mA. (with "high-low" switch in "high" position); 140 at 20 mA., 120 at 30 mA., and 70 at 50 mA. (with "high-low" switch in "low" position). Other models supply about 10 volts less. Approval pending by National Board of Fire Underwriters. Raytheon rectifier is used. Two-section filter. Adjustable output voltages. Model A-1 for operation on 110 volts 50–60 cycles a.c.; Model A-3, 25–40 cycles; Model A-4, 220 volts 50–60 cycles a.c.; Model A-8, 110 volts 50–60 cycles a.c. Size: Models A-1, A-3, A-4, 9 x 7 x $5\frac{1}{4}$ inches; Model A-8, 3 x 7 x 10 inches. Prices, including rectifier; Model A-1, $37.50; Model A-3, $42.50; Model A-4, $42.50; Model A-8, $27.50.

BURNS, MODELS 750-A, 750-B, AND 800-B

Maximum output voltage of Models 750-A and 750-B; 190 volts at 30 mA., and 180 volts at 50 mA. Model 800-B, 205 volts at 20 mA., and 190 volts at 30 mA. Uses Raytheon rectifier. Amplifier and detector voltages adjustable. Two-section filter. Approximately 20 watts a.c. input with 30 mA. load. Designed to operate 171 type power tubes. Size: Models 750-A and 750-B; $7\frac{3}{8}$ x $10\frac{1}{2}$ x $6\frac{3}{4}$ inches; Model 800-B, $4\frac{7}{8}$ x $10\frac{1}{2}$ x $5\frac{5}{8}$. Prices: Models 750-A and 750-B, $47.50 with tube; Model 800-B, $35 with tube.

AMRAD, MODEL NO. 280

Maximum output voltage; 200 at 20 mA., 180 at 30 mA., and 165 at 50 mA. Uses type 280 or 213 thermionic rectifier. One-section filter. Fixed output voltages. Full-wave rectifier. Twenty watts a.c. input at 30 mA. load. For operation on 100–120 volts 60 cycles a.c. Size: $10\frac{1}{2}$ x $6\frac{1}{4}$ x $7\frac{1}{2}$ inches. Price, without tube, $45.

ARCO B POWER

Maximum output voltage: 180 volts at 50 mA. Uses filamentless rectifier. Two-section filter. Full-wave rectification. Fifteen watts input with 30 mA. load. Size: $9\frac{3}{4}$ x $3\frac{3}{4}$ x $8\frac{7}{8}$ inches. For operation on 110 volts 60 cycles a.c. Price, without tube, $32.50.

BREMER-TULLY B POWER

Maximum output voltage: 216 at 20 mA., 195 at 30 mA., and 150 at 50 mA. Uses Raytheon BH rectifier. Output voltages adjustable by fixed steps. Two-section filter. Full-wave rectifier. Seven watts input with 30 mA. load. Approved by National Board of Fire Underwriters. Will supply receivers having up to ten tubes. For operation on 110–115 volts 60 cycles a.c. Size: $4\frac{1}{2}$ x $9\frac{3}{4}$ x $6\frac{3}{4}$ inches. Price: $37.50, without tube.

BASCO B POWER

Maximum output voltage: 250 at 20 mA., 230 at 30 mA., 190 at 50 mA., and 175 at 60 mA. Uses Raytheon BH rectifier. Two-section filter. Full-wave rectification. Fixed detector voltage. Other voltages variable. A special primary rheostat functions to regulate output to supply different types of power tubes. Twenty watts input with 30 mA. load. Size: 12 x $4\frac{1}{2}$ x $7\frac{1}{4}$ inches. Price, with tube, $35.

King, Types M and V

Maximum output voltage: 238 at 20 mA., 215 at 30 mA., and 180 at 50 mA. Uses type 213 rectifier. One-section filter. Full-wave rectification. Type M has variable detector and amplifier voltages. Type V has variable detector voltage and fixed 90, 135, and power tube taps. Twenty watts input with 30 mA. load. Can supply up to nine tubes. Size: Type V, $9\frac{1}{2}$ x $4\frac{1}{2}$ x 7 inches; Type M, 11 x 6 x 6 inches. Prices: Type M, $45.00; Type V, $37.50.

Exide, Model 9-B

Maximum output voltage: 208 at 20 mA., 194 at 30 mA., and 180 at 40 mA. Uses electrolytic rectifier, arranged in bridge circuit for full-wave rectification. Two intermediate and detector voltages adjustable. Two-section filter. For operation on 105–125 volts 50–60 cycles a.c. Ten watts input with 30 mA. load. Approved by National Board of Fire Underwriters. Designed to supply sets with six or more tubes. A 112 or 171 type power tube may be used. Size, $6\frac{1}{2}$ x $11\frac{1}{8}$ x $9\frac{3}{4}$ inches. Price: $42 50.

General Radio, Type 445

Maximum output voltage: 200 at 20 mA., 185 at 30 mA., and 160 at 50 mA. Uses type 280 rectifier tube. Two-section filter. Output voltages adjusted by means of sliding taps on wire-wound resistance. C voltage available for power tube. Twenty-eight watts input with 30 mA. load. Designed to meet specifications of National Board of Fire Underwriters. Automatic switch breaks the 110-volt a.c. input circuit when cover is removed. Size: $15\frac{1}{4}$ x 7 x 7 inches. Price: $55.00, without tubes.

Freed-Eisemann, Model 16

Maximum output voltage: 135 at 30 mA. Uses type 280 rectifier tube. Also uses type 874 glow tube to maintain output voltages constant independent of the load. Two-section filter. Three C voltages available;-$4\frac{1}{2}$, -9, and -27. Twenty-five watts input with 30 mA. load. For operation on 105–120 volts 60 cycles a.c. Size: 7 x 7 x $9\frac{3}{4}$ inches. Price: $35.00, without tubes.

Majestic, Super-B Power Unit

Maximum output voltage: 186 at 20 mA., 156 at 30 mA., and 112 at 50 mA. Adjustable output voltages. Special "high-low" switch gives two voltage ranges. Full-wave rectification. Two-section filter. For operation on 110 volts 60 cycles a.c. Size: $10\frac{1}{2}$ x $5\frac{1}{2}$ x 9 inches. Price, complete with tube, $29.50.

Freshman, Model A

Maximum output voltage: 220 volts at 40 mA. Uses tube rectifier in full-wave circuit. Adjustable output voltages. Two-section filter. Unit supplies following C voltages: -$4\frac{1}{2}$ -9, -40. Thirty watts input with 30 mA. load. Designed to supply sets using up to seven tubes. Price complete: $45.

Muter B Power Units

Two types made, one for Raytheon BH tube, the other for 213 or 280 type rectifier. Maximum output voltage (Raytheon type); 200 at 20 mA., 180 at 30 mA., and 150 at 50 mA. Other type gives output voltages about 10 volts lower. Full-wave rectification. Two-section filter. Fixed output voltages. Twenty-one watts input with 30 mA. load. For operation on 110–120 volts 60 cycles a.c. Prices: Raytheon model, $26.50; other model, $24.50.

Presto-O-Lite "Speedway" B

Maximum output voltage: 188 at 20 mA., 175 at 30 mA., and 148 at 50 mA. Fixed output voltages. Compensation for variations in line voltage obtained by adjusting three-point switch. One-section filter. Full-wave rectification. Twenty-five watts input with 30 mA. load. Uses Raytheon BH rectifier. Size: 6 x 8 x 8 inches. Price: $37.00, including tube.

Sentinel, Model B-C

Maximum output voltage: 180 at 80 mA. Uses two rectifier tubes. Two variable voltages. Unit supplies two C voltages, -$4\frac{1}{2}$ (fixed) and -$4\frac{1}{2}$ to -45. Voltage control to compensate variations in line voltage. Beverly model is equipped with special instrument used to read the voltages being supplied by the various taps on the power unit. Prices, including two tubes, regular model, $44.50; Beverly model, $65.00.

Silver-Marshall, Type 656

Maximum output voltage: 170 at 20 mA., 160 at 30 mA., and 140 at 50 mA. Unit uses UX–213 (CX–313) rectifier and UX–284 (CX–384) glow tube. Glow tube maintains output voltages practically constant independent of load. Two-section filter. Twenty-five watts input with 30 mA. load. Size: $6\frac{1}{2}$ x $7\frac{1}{2}$ x 5 inches. Price: $38.50.

Stewart, U–80

Maximum output voltage: 190 at 20 mA., 175 at 30 mA., and 140 at 50 mA. Two-section filter. Full-wave rectification. Thirty watts input with 30 mA. load. Adjustable detector voltage. Rheostat in the primary to compensate differences in line voltage. Uses Raytheon type B or BH rectifier. Size: $11\frac{1}{2}$ x $4\frac{1}{2}$ x $8\frac{1}{2}$ inches. Price: $34.50.

Dis-ton, Types D-60 and D-25

Maximum output voltage: 215 at 20 mA., 200 at 30 mA., and 185 at 50 mA. Adjustable output voltages. Two-section filter. Full-wave rectification. Fifteen watts input with 30 mA. load. Unit uses two thermionic rectifiers. Supplies C bias up to 22 volts. Self-contained milliammeter indicates performance. Price $29.50, without tubes. *Type D-60*

Maximum output voltage: 120 at 20 mA., and 95 at 30 mA. Adjustable output voltage. One-section filter. Half-wave rectification. Nine watts input with 30 mA. load. Uses one thermionic rectifier. Size: 10 x 4 x 6 inches. Price: $23.50, with tube. *Type D-25*

Sterling, Type R-97

Maximum output voltage: 300 at 20 mA., 286 at 30 mA., and 262 at 50 mA. Adjustable output voltages. Full-wave rectification. Twenty-five watts input with 30 mA. load. Unit supplies C voltages up to 50 volts. Price: $55.00

Valley, Model 60

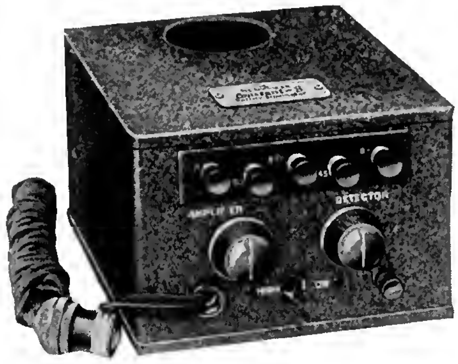
Maximum output voltage: High range—250 at 20 mA., 220 at 30 mA., and 175 at 50 mA.; Low range—200 at 20 mA., 180 at 30 mA., and 140 at 50 mA. Uses Raytheon BH rectifier. Two adjustable voltages. Two-section filter. Full-wave rectification. Eighteen watts input with 30 mA. load. Size: $5\frac{3}{8}$ x $9\frac{3}{4}$ x $9\frac{1}{4}$ inches. Price: $50.00, including tube.

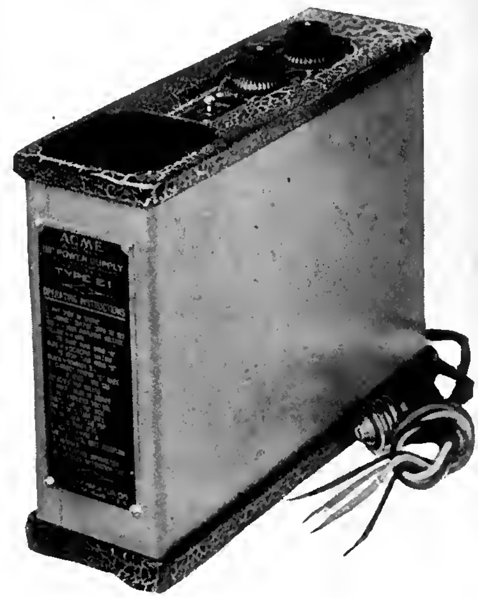
Valley, Model 40

Maximum output voltage: 170 at 20 mA., 145 at 30 mA., and 110 at 50 mA. Uses Raytheon BH rectifier. Two adjustable voltages. One-section filter. Full-wave rectification. Seventeen watts input with 30 mA. load. Size: 9 x $4\frac{1}{4}$ x $7\frac{3}{4}$ inches. Price: $37.50, with tube.

Compo, Model B-C

Maximum output voltage: 180 at 50 mA. Two-section filter. Full-wave rectification. Uses Raytheon BH rectifier. Uses Raytheon BR regulator tube to keep voltages constant. Unit supplies adjustable C voltages up to 50. Twenty-eight watts input with 30 mA. load. Size: $10\frac{1}{2}$ x $5\frac{1}{4}$ x $8\frac{1}{2}$ inches. Price: $57.50, with tubes.





THREE MORE LINE SUPPLY DEVICES

The Acme B power unit incorporating two variable resistances to compensate differences in load imposed on the device by different receivers is shown at the right. The All-American Constant B is illustrated at the center and contains a "high-low" switch to adapt the device to different loads and line voltages. The C potential as well as B potential can be obtained from the Valley unit at the left

Measuring the "GAIN" of *your* RECEIVER

Stromberg-Carlson engineers testing the audio-frequency characteristics of one of their No. 744 receivers. The apparatus consists of a "beat frequency" oscillator which produces the audio tones, and meters for measuring the extent to which these frequencies are amplified within the receiver

By KEITH HENNEY

Director of the Laboratory

OUR present broadcasting structure is made up of three intimately connected components, the broadcasting station, the receiving equipment, and the intervening medium. The broadcasting station has one *raison d'etre*—to translate sound impulses into electrical waves; the receiver's only purpose is to accomplish the opposite—to translate these electrical waves back into sound impulses. The intervening medium is the connecting link between the transmitter and the receiver, an inefficient link it is true, performing its task with many vagaries, and for reliability's sake it might be very well displaced by a metallic conductor. The radio medium, however, has the advantage that for broadcasting purposes, the communication is radiated in all directions, and is not confined to a direct path between two points.

We have already outlined in the November RADIO BROADCAST what the transmitter does when it lays down a "field strength" about the receiver, how this field strength is measured, how much is necessary for various degrees of service, and how field strength and the attributes of sets, selectivity, sensitivity, and fidelity, are related.

It was pointed out that the greater the field strength, or the more sensitive the receiver, the more powerful the corresponding loud speaker signal. We are now faced with the problem of ascertaining how sensitive a receiver must be to deliver a certain signal from a certain field strength, how selective a set must be to shut out unwanted signals in favor of the desired program, and what the degree of fidelity must be to furnish sufficient realism to make a receiving equipment no longer a "radio" but a musical instrument.

What we must do is to answer the following questions, presupposing a station to deliver a certain field strength at a certain point:

How loud will be the resulting signal from a certain receiver? How can it be measured? What will happen if another station a given number of kilocycles away goes on the air and lays down a certain field strength about the receiver? If the receiver is sufficiently sensitive and selective, how do these factors influence the fidelity?

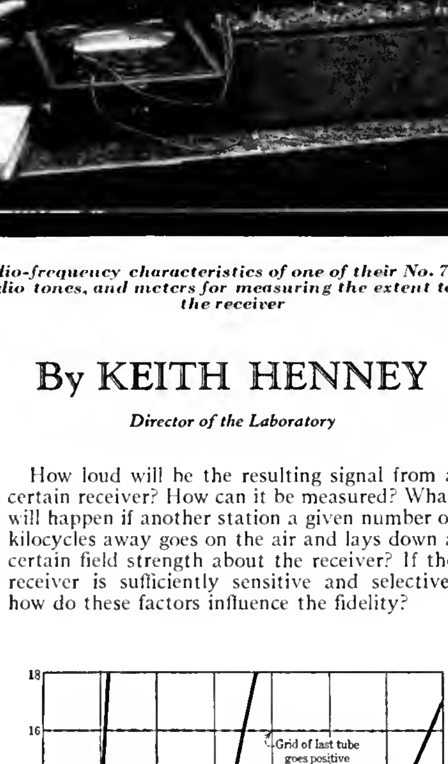


FIG. I

When one measures the output voltage of a receiver of several years ago as the input voltage is changed, he gets a curve similar to those shown above. Note the steep 1300-kc. curve indicating extreme sensitivity, and the decreasing sensitivity as the radio frequency is decreased

Since radio receivers were first made, qualitative answers to these questions have been the stock in trade of all engineers. It is only within the last year that quantitative answers have been generally available, especially when one considers the receiver as a single unit, and desires answers to his questions not with regard to the component parts that make up that receiver but with respect to the ensemble equipment. Methods for determining the characteristics of coils, condensers, transformers, and other individual units that go to make up a "radio," have been known and used for several years. In England great emphasis has been laid upon and many arguments built around such measurements as contrasted with those which include everything in a receiver between antenna and loud speaker. While it is true that the characteristics of such units can be combined to produce a fair approximation of what the complete receiver will do, an overall measurement carries much more conviction to the engineer.

An interesting experiment was carried out at station WOR some time ago, and more recently by WLW, to enable listeners to determine how low and how high in audio frequencies their receivers were responsive. At WLW, where a Wurlitzer organ forms part of the studio equipment, continuous tones varying from the lowest to the highest organ note were put on the air, First the pure note of the open diapason was transmitted and then it was played with various harmonics added. This enabled the listener to determine not only the acoustic limits of his receiver and loud speaker but the change in quality as the harmonics modulated the original pure note.

In laboratory the business of performing the same experiment or that of investigating the sensitivity and selectivity of the receiver under better controlled conditions consists in moving the transmitter nearer the receiver, and decreasing its power accordingly. This eliminates the vagaries of the intervening medium, and when the transmitter is finally connected metallically to the receiver a set-up results which is sufficiently flexible that everything can be varied and measured at the same time. A miniature broadcasting station is necessary. This must consist of an r.f. oscillator whose output can be regulated and measured, an audio-frequency oscillator variable from the lowest to the highest audio tone ordinarily broadcast and relatively free from harmonics, and some means of combining these two generators of electric and sound waves.

The Hazeltine Laboratories, under the direction of Chief Engineer MacDonald, made such tests on receivers which were under development there, and the results were published in the *Proceedings of the I. R. E.* in February, 1927, the first paper to be published in this country on such laboratory practice. The emphasis here, however, was more on component parts, such as radio-frequency amplifiers, coupling coils, and audio amplifiers than on the receiver as a whole. The data as published were most interesting.

In a discussion of this paper, appearing in the April, 1927, *Proceedings of the I. R. E.*, H. D. Oakley and Norman Snyder of the General Electric Laboratories described the methods used several years ago at the Schenectady Laboratory for measuring receivers.

The equipment was housed in two shielded rooms, one of which contained the radio and audio oscillators as well as a control device for regulating the voltage which was put on the receiver under test in the adjoining room. A standard Radiola 100 loud speaker was placed across the output of the receiver, and the voltage across it measured as the input voltage was varied.

To test the sensitivity of the set, that is, to tell how many output volts could be delivered with a given input radio voltage, the following procedure was carried out. The generator was set going at a certain radio frequency and this was modulated at 1000 cycles to a given degree of modulation. The input to the receiver was varied in small steps until the output tube overloaded. This was considered the upper working limit of the receiver. A specimen curve of output voltage plotted against input voltage is shown in Fig. 1. The receiver was a standard set of several years ago, and is not indicative of the better types of modern sets.

The data show that the receiver at 1300 kc. was roughly 6.5 times as sensitive as at 560 kc. and that to produce an output voltage of 16 at 1300 kc. required an input of only 51 microvolts compared to 335 required at 560 kc. At 1000 kc. the voltage required was roughly 175. The output voltage at 560 kc. divided by the input voltage gives a rough voltage gain of 46,000; at 1000 kc. the ratio is 102,000 and at 1300 kc. the gain is 300,000.

The data showed that the output voltage for each of the three frequencies was proportional to the input voltage squared, for which the detector tube is responsible.

TESTING SELECTIVITY

TO TEST the selectivity of the receiver, it was tuned to, say, 560 kc., and the output voltage read as the transmitting generator in the first of the two shielded rooms was varied in frequency but kept at constant amplitude. The receiver was then set at some other frequency and a similar set of data was taken. Specimen curves shown in Fig. 2, are taken from the *Proceedings of the I. R. E.*

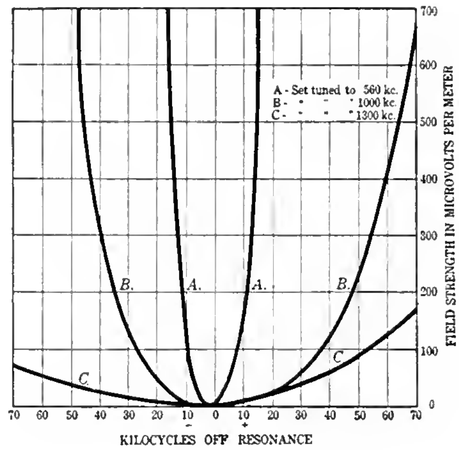


FIG. 2

These queer curves show the selectivity of a rather poor receiver. At 560 kc. the set is selective, at 1300 kc., curve C, it is as broad as the proverbial barn door. They are indicative of a poorly engineered receiver and were made on sets sold several years ago

The curves plotted from data obtained in this manner are given in Fig. 2, and show the field strength required to produce a given signal which differed from the frequency setting of the receiver by a certain number of kilocycles. For example, if the receiver were accurately tuned to 560 kilocycles, a signal 10 kilocycles off resonance, say 570 kc., required a field strength of 150 microvolts per meter to produce an interfering signal. At 1300 kc., a signal 66 kc. away, or 1366 kc., having a field strength of 150 microvolts per meter, would produce the same interference.

In other words the receiver was roughly one seventh as selective at 1300 kc. as it was at 560 kc. which, coupled with the fact that it was nearly seven times as sensitive at the same frequency, may demonstrate why the higher broadcasting frequencies were not so highly regarded by engineers of transmitting stations a year or so ago. There is no reason why a carefully designed and engineered receiver cannot be equally sensitive over the broadcasting band of 1000 kc. If the band were to be extended, in the direction of still higher frequencies, the problem placed upon design engineers would be considerable, but would not be insurmountable.

Receivers of the present day are better than these curves show. Methods of maintaining equal gain over rather wide frequency bands are well known, and up-to-date receiver manufacturers make every effort to include in their products the results of all well-known inventions. A receiver which squawks at 1300 kc. and is practically silent at 560 kc. is a poorly designed set, and should not be placed in the same class as others in which care has been taken to avoid just such criticism.

The method of measuring and rating receivers employed by the Radio Corporation of America was described in *The Proceedings of the I. R. E.* in May, 1927, by T. A. Smith and George Rodwin. An arbitrary loud speaker signal is set up and all measurements are made with a view toward determining the field strength required to produce this signal, which is that corresponding to an average audio-frequency (r.m.s.) voltage of 15 across a 5000-ohm resistance when a 400-cycle note modulates the transmitter to a degree of 50 per cent.

Having determined how much output voltage the receiver will deliver when a certain input voltage due to a certain field strength is impressed on it, mathematics will tell how much voltage or power will be delivered at other input levels, up to the overloading point of the amplifier tubes. The following relations express the manner in which transmitter antenna power, input receiver voltage, output voltage and power are interconnected:

Field strength $\propto$ transmitter antenna current.
Field strength $\propto$ square root of transmitter power.
Input receiver voltage $\propto$ field strength.
Output receiver voltage $\propto$ field strength squared.
Output receiver voltage $\propto$ transmitter power.
Output receiver power $\propto$ output voltage squared.
Output receiver power $\propto$ input voltage to the fourth power.

FIG. 3

The receiver is put through its paces in this shielded room at the General Electric Company. Only signals that are meant for the receiver arrive at its input via shielded wires; all others are excluded by the shielding surrounding the six room surfaces

Output receiver power α field strength to the fourth power.
Output receiver power α transmitter power squared.

The Greek letter alpha in the above relations means "is proportional to."

Doubling the transmitter antenna current multiplies the transmitted power by four, doubles the field strength, doubles the input receiver voltage, multiplies the receiver output voltage by four, and multiplies the power into the loud speaker by sixteen. These relations may be connected to what happens in one's receiver by the following facts. The average stage of audio amplification has a voltage gain of twenty-five, a two-stage affair having a voltage gain of roughly 300, or 50 TU, if a 171 type tube is used as the output tube. A good radio-frequency amplifier should have a voltage gain of about 50 TU, or 300, so that the overall gain in voltage from a modern well engineered receiver should be in the neighborhood of 100,000, or 100 TU. These figures in power amplification become respectively, for the two-stage amplifier and for the complete receiver, 30,000 and 10,000,000—truly enormous amplification.

In actual practice the R. C. A. engineers do not measure the voltage across the resistance in the output of the receiver while the input voltage is varied. An interesting short cut is used instead, which is possible from the phenomenon accompanying the function of detection.

When the receiver is tuned to a carrier wave, modulated or not, the average d.c. detector current changes, increasing when a C bias detector is employed, decreasing when the conventional grid leak and condenser method is used. Greater changes occur with greater field strengths, or the more nearly the receiver is tuned to the incoming signals. The change in detector plate current, then, is a measure of the effectiveness of the field strength or the sensitivity of the receiver.

To produce the arbitrary 15-volt signal across the 5000-ohm resistance in the receiver output requires a certain change in detector plate current. Once this is determined the audio amplifier can be dispensed with and all measurements may be made by noting the change in detector plate current. This method obviates the necessity of using modulated signals.

In the R. C. A. Laboratory the input voltages are fed to the receiver through a dummy antenna consisting of an inductance of 28 microhenries which has a resistance of 2 ohms, a capacity of 0.0004 mfd., and a resistance of 23 ohms. The curves obtained in this way show the same general characteristics as those given in the General Electric report, *i. e.*, low gain at low radio frequencies, high gain and poor selectivity at high frequencies. At the same time there is considerable loss of the higher audio frequencies at the longer wavelengths, due to the excessive sharpness of tuning, or selectivity.

FIG. 4

Signal generating apparatus used at the General Electric Laboratories for testing the characteristics of receivers. This apparatus is housed in a shielded room, and consists of a Heising modulated generator capable of oscillating at any frequency in the present broadcasting band modulated at any audio frequency between 40 and 10,000 cycles

While it is true that only a few of the larger and better-known receivers are engineered with these thoughts and these laboratory measurements in mind, it is a fact that more and more radio manufacturers are becoming aware that good engineering is a priceless asset. The article in this issue of RADIO BROADCAST on the Fada receivers, by John F. Rider, and others to follow on other well-designed receivers, proves this statement. The Laboratory is preparing data on manufactured sets using the methods of measurements mentioned above and as fast as the material is ready, it will be presented to RADIO BROADCAST's readers.

All About Patents

INVENTIONS AND PATENTS, THEIR DEVELOPMENT AND PROMOTION. By Milton Wright, LL.B. Published by the McGraw-Hill Book Company, Incorporated, New York. Price, $2.00. Pages, 225.

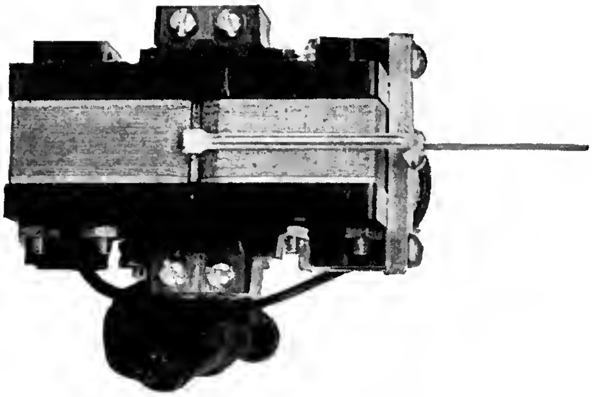
A VERY useful contribution to the bewildered inventor, throbbing with the thrill of a discovery, is the sage and practical counsel of Mr. Milton Wright, as embodied in his new book, "Inventions and Patents." There is nothing assuming about the writer's style; the work is not overburdened with technical legal arguments, although the subject is a highly technical one, and there is no obscure language to confuse the uninitiated.

The subject matter of the volume is devoted broadly to all the problems which face the inventor. He is told what is patentable and what is not patentable, what constitutes a practical invention, what steps to take to facilitate securing a patent and how to protect it after it is secured, how to select a good patent attorney, how a patent should be applied for, how to obtain financial support, what the problems of marketing and merchandising are, how to sell patents outright, on a territorial and on a royalty basis, and what steps to take against infringers. There you have it in one long sentence; certainly the scope of the book is broad enough to be a real aid to the floundering inventor.

Valuable cautions and dangerous pitfalls, which are the usual stumbling blocks to the uninitiated patent seeker and inventor, are disclosed. For example, how to keep records which aid in establishing date of conception and reduction to practice, is explained so that the inventor, heeding the advice given, will have no difficulty in later sustaining his invention in the courts. And again, the vital subject of how to select a patent lawyer and how to get the greatest value from his services is presented simply and clearly. The book abounds in practical illustrations which serve to clarify the force of the writer's arguments.

The reviewer does not hesitate to recommend a thorough reading of this volume to all those who believe they have a patentable idea and those who contemplate obtaining a patent. It is certain either to cause them to abandon the idea because it offers little or no possibility for profit, or else to secure a better and more easily protected patent. Considering that only one patent out of a hundred secured by hopeful inventors proves profitable, the discouragement of the impractical is as valuable a service as the encouragement of the promising. In this respect, Mr. Wright's dispassionate and constructive point of view differs materially from the flamboyant literature and booklets which unscrupulous patent lawyers distribute in the hope of inveigling misguided inventors to obtain patents, whether their ideas show promise or not.

—E. H. F.



A LOUD SPEAKER ELEMENT

This is the driving unit used in the type 20-20 cone speaker manufactured by A. H. Grebe. The speaker is priced at $35.00

A PACENT OFFERING

This well made instrument uses a balanced armature construction that insures quality reproduction. Price, $35.00

LOUD SPEAKERS

A POWER CONE WITH B SUPPLY

The perfectly free mounting used in this Magnavox combination is responsible for its excellent reproducing qualities. It contains a 210 power-amplifier and B supply. Price, $242.00

THE "ALGONQUIN" CONE SPEAKER

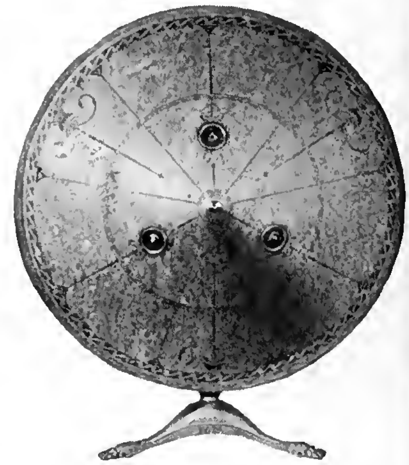
An artistically designed cone priced at $15.00, the product of the Algonquin Electric Company

THE "NEUTROWOND" REPRODUCER

An attractive loud speaker finished in American walnut. Price $35.00

AN INNOVATION

This interesting loud speaker made by Frank B. Porter, Washington utilizes the structure above the base to conceal a tonal chamber. The actual element is with base. Various models retail for from $50.00 to $150.00



FADA

This 17-inch table cone sells for $25.00, Model 315 A. Fada manufactures other more expensive models selling for up to $50.00

FOUR OR SIX-VOLT A-POWER
A combination storage hattery and full-wave dry rectifier availahle in four and six-volt models, made by Triple A Specialty Co., Chicago. Price: either model, $39.50

THE BASCO A-B POWER UNIT
This device cootains a B-Power unit and a storage battery-trickle charger combiuatioo. A visual indicator shows the state of charge of the battery. Price $75.

POWER DEVICES

A TWO AMPERE "TUNGAR" BATTERY CHARGER
A well knnwo product of the General Electric Company for charging A and B storage batteries. Price, $18.00

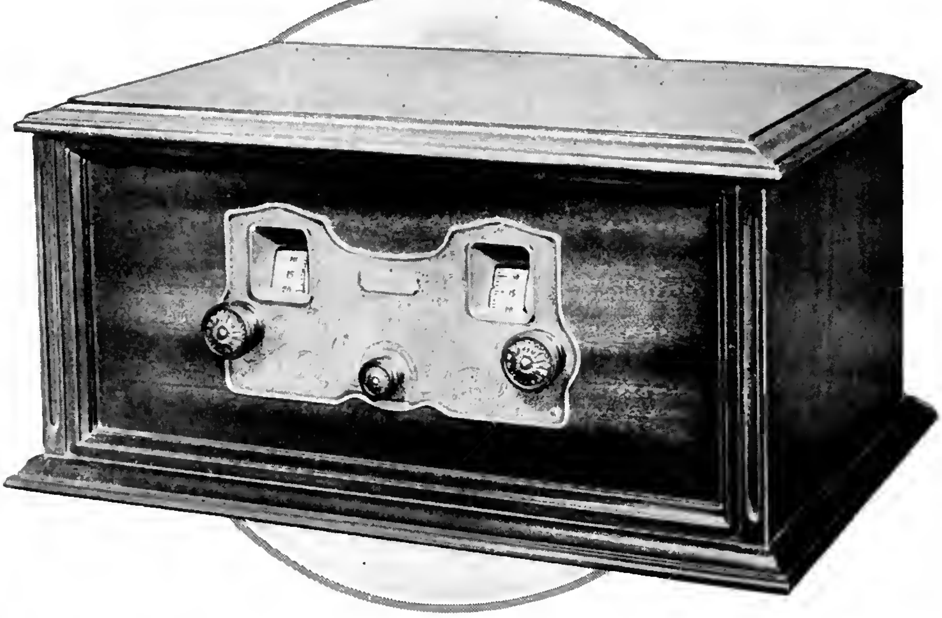
THE "ACME" B POWER UNIT
For use with receivers containing up to twelve tubes, including a 171 type power tube. A Raytheon rectifier is used. Price: $50.00

ANOTHER B POWER UNIT
This unit supplies up to 135 volts at a 60 milliampere load—more thao enough for most receivers. Manufactured by the All-American Compaoy aod priced at $27.50

A POWER AMPLIFIER AND B SUPPLY
An A-B-C power supply for receivers using a.c. tubes. The unit contains one stage of power amplification using a 210 tube. Manufactured by the Radio Receptor Co., New York, and priced at $60.00

FACTS ABOUT THE FADA "SPECIAL" SET

By John F. Rider



JUST as the research laboratory is the prime mover of every business, whether cheese, steel, or clothing, it is also the heart of the radio industry. The radio public is awakening to the fact that research is a prime mover in the radio industry; that research, and research only, can produce faithful reproduction, ample volume, satisfactory selectivity, ease of control, and perfect stability. The result is recognition of research as the paramount factor, and consistent with this recognition, is the gradual stabilization of the industry—its gradual ascension to an impregnable position.

Research is directly responsible for every good receiver and for every development in radio receiver design since the day KDKA commenced its broadcasting activities. A good radio receiver cannot be produced without a research background.

As an example, let us consider a typical receiver, the design of which may be laid directly at the door of research. This receiver consists of three stages of radio-frequency amplification, a non-regenerative detector and two stages of audio-frequency amplification. It is known as the Fada "Special." But before we can enter into the mechanics of the receiver, we must first ascertain why the electrical design used was selected.

The problem placed before the engineering department was the development of a radio receiver limited to six tubes. The apportioning of the tubes was the first problem. How many stages of radio-frequency amplification should there be; and how many stages of audio-frequency amplification? Having developed audio-frequency transformers with known response characteristics and known gain per stage, and knowing that a two-stage audio amplifying system using their transformers would give the proper amount of amplification, the engineering department decided upon two stages of transformer-coupled audio amplification. Since the detector unit utilizes but one tube, the remaining three tubes can be applied to the radio-frequency system.

The development of the radio-frequency system brings to light many interesting features. Should the stages be tuned or untuned or a combination of both? Should the stages be shielded, and what material shall be used for the shielding? Since the receiver utilizes an antenna as the pick-up system, the three stages of radio-frequency amplification will give a high degree of sensitivity. The demand for selectivity necessitates the use of tuned stages of radio-frequency amplification. But the development of a three-stage tuned radio-frequency amplifier does not mean a simple decision to use three stages. Consideration must be accorded to the wavelength response of such a system. The average system possesses wavelength characteristics which fall in amplification as the wavelength is increased *i.e.*, the amplifying power of the radio-frequency amplifier is high at the shorter wavelengths and as the tuning dials are manipulated to tune to the longer wavelengths, the amplification decreases, and at 550 meters is a fraction of that at 250 or 300 meters. This situation must be avoided; it is desirable that the receiver should possess equal amplification over the entire broadcast frequency spectrum.

Since the allocation of frequencies to broadcasting stations is such that excellent selectivity can be obtained with two stages of well-designed and shielded tuned radio-frequency amplification, the third stage can be utilized to balance the two tuned stages and give the system the desired wavelength response characteristic. The radio-frequency system would, therefore, consist of two stages of tuned radio-frequency amplification and one stage of untuned radio-frequency amplification.

The decision to shield the individual stages was immediate, since shielding, if properly carried out, is conducive to better radio receiver operation and consequently better radio reception and better stability is thus attained in the radio-frequency stages because coil interaction is eliminated. By the elimination of coil interaction, neutralization is made more effective. Better tone quality is also obtained, because by eliminating coil interaction, the side-band characteristics planned in the design of the tuned stages are actually obtained. Selectivity is augmented, because direct coil pick-up is precluded. The elimination of coil pick-up also means greater amplification in the radio-frequency system.

The selection of the shielding material is governed by the effect the shield has upon the inductances used in each stage. In order to minimize the electrical effect upon the coils, a material with a high conductivity must be used, since high conductivity means lower losses. Aluminum was decided upon, and the shield takes the form of a can, completely enclosing the radio-frequency transformer. With the shields of proper diameter and properly located with respect to the coils, the losses introduced are so small as to be entirely negligible.

In view of the fact that the radio-frequency coils are shielded, it is possible to make use of the most efficient type of winding—the single-layer solenoid. Without shields, a cascade system employing such coils would be quite difficult to control. The selection of the single-layer solenoid was also based upon the fact that it can be wound with the greatest degree of accuracy, particularly so when the winding form is grooved, and the turns are wound in these grooves.

The receiver is to be dual tuned, requiring two condensers controlled by one drum dial and another single condenser controlled by the other drum dial. Such control is simple because of the precision methods employed in the testing and matching of the coils and tuning condensers. Each tuned transformer consists of three windings, the primary, the secondary, and a neutralizing winding. Each of these windings is matched on a radio-frequency testing instrument, to within one eighth of one per cent. The coil under test is plugged into an oscillator circuit and a resonance point obtained with a standard condenser. This condenser is so graduated that a 10 per cent. variation in resonance is spread out across the 100-division dial. The dial settings for the resonance point for each winding are noted and the coils segregated according to these figures. The result is that each group of three coils consists of coils with windings which never vary more than one eighth of one per cent.

The same precision in testing applies to the tuning condensers, and because of the mechanical design of these condensers, full accuracy is maintained during the operating life of the unit. Each completed tuning condenser is made to within one per cent. plus or minus, of its rated capacity, and each condenser in a group of three is matched to within one eighth of one per cent of the others. The matching of the variable condensers is carried out by means of a special radio-frequency measuring instrument designed for the purpose.

The construction of variable condensers which will not vary more than one per cent. calls for detailed engineering. The brass used for the plates must be very accurate, the tolerance limit being 0.0005 of a mil in thickness. To assure perfect alignment of the condenser plates and a smooth rotary action, large bearings are used, these latter being approximately $\frac{5}{8}''$ in diameter. To further assure perfect alignment of the brass plates, each plate is individually stipled and leveled.

But the precision construction and matching of coils and condensers is not sufficient to assure perfect operation. It is necessary to assure perfect mechanical support for these units—supports which will be identical in every receiver of similar design. It is necessary to select a base for the condensers which will assure easy operation not for a short while, but for years to come

Again engineering comes to the fore, with a pressed steel chassis ⅜" thick, punched out on a 100-ton press. One operation punches all the holes necessary and also forms the chassis. The result is uniformity of mounting holes.

R. F. CHARACTERISTICS

WITH the condensers, coils, and shields on hand, we go back to the radio-frequency system. The overall gain curve of the three-stage radio-frequency amplifier, consisting of the two tuned stages and the one untuned stage, is shown in Fig. 1. Here we see a beautiful example of research and engineering. With the exception of the zone between 200 and 212 meters, (1500 and 1410 kc.) the amplification does not vary more than 11 per cent. from 212 to 550 meters. Between 200 and 212 meters, the curve rises with the increase in wavelength, and the difference between the lowest point, 200 meters, and the highest, 250 and 500 meters, is only 17 per cent. With such small variance in amplifying power, the owner can manipulate the dials of his receiver from 200 to 550 meters, and know that the sensitivity of the system is practically uniform over the complete scale.

But the design of a radio-frequency system does not consist solely of the development of an amplifier which will possess the wavelength response curve shown. It is also imperative to accord detailed consideration to the shape of the resonance curve of each individual tuned stage, since the resonance curve manifests a great influence upon the tone quality of the receiver. In this respect, there is a close association between the radio-frequency amplifier and the audio-frequency system. Many owners of radio receivers are unaware of the effect the resonance curve of the radio frequency stages has upon the tone quality obtainable with the receiver employing three stages of radio-frequency amplification. Fans are too prone to overlook the side-band characteristics of the radio-frequency stage. They forget that while the radio-frequency stage is tuned to the frequency of the carrier wave, it is also necessary to consider that this carrier wave is modulated by audio frequencies ranging from 30 to 5000 cycles. Also that the effect of these modulating frequencies is to create a modulated carrier wave whose frequency spectrum is 10,000 cycles wide. In other words, if the carrier wave (unmodulated) is 750,000 cycles (400 meters) when modulated, this wave is broadened to cover from 745,000 to 755,000 cycles. The 5000 cycles above the carrier and the 5000-cycle-band below the carrier constitutes the side-bands. Hence the resonance curve of the radio-frequency stage must be broad enough to cover this band of 10,000 cycles even though the circuit is actually tuned to 750,000 cycles. If the curve is too sharp, some of the higher side-band frequencies will be suppressed. If the curve is too broad, selectivity will be marred. Hence both selectivity and sideband suppression must be considered in the design of the radio frequency amplifier. With a known value of "Q", which is the factor of selectivity, being the ratio of the reactance to the resistance of the circuit at a certain frequency, it is imperative to know the side-band suppression in the radio-frequency amplifier and to give it consideration in the design of the associated audio-frequency amplifying equipment. An example of various degrees of sideband suppression in tuned circuits is

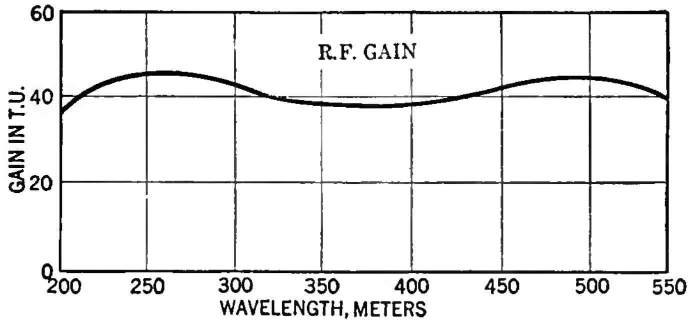


FIG. 1

The curve shows the gain from the antenna to the input to the detector. The sensitivity of the r. f. amplifier is high and the amplification flat

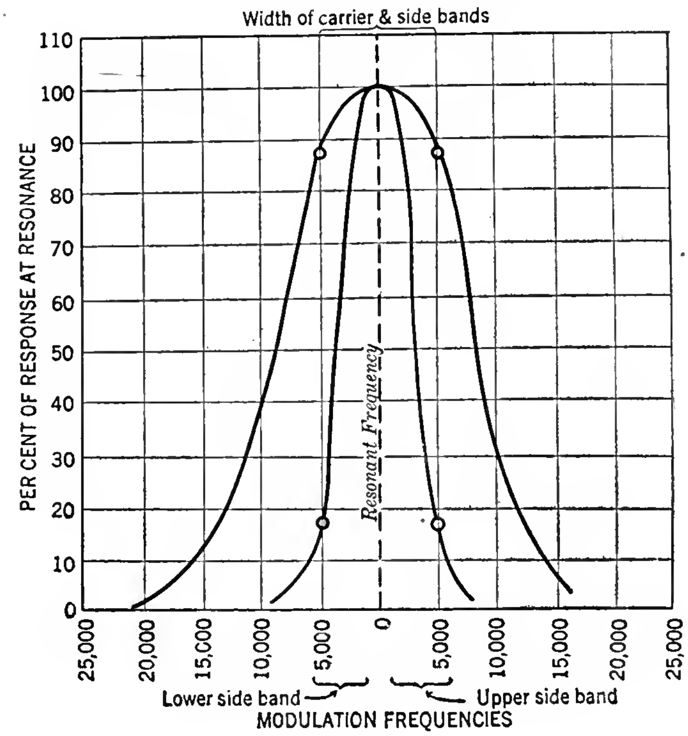


FIG. 2

Tuned circuits that are too selective impair quality. The outer curve shows the response in a well-designed circuit

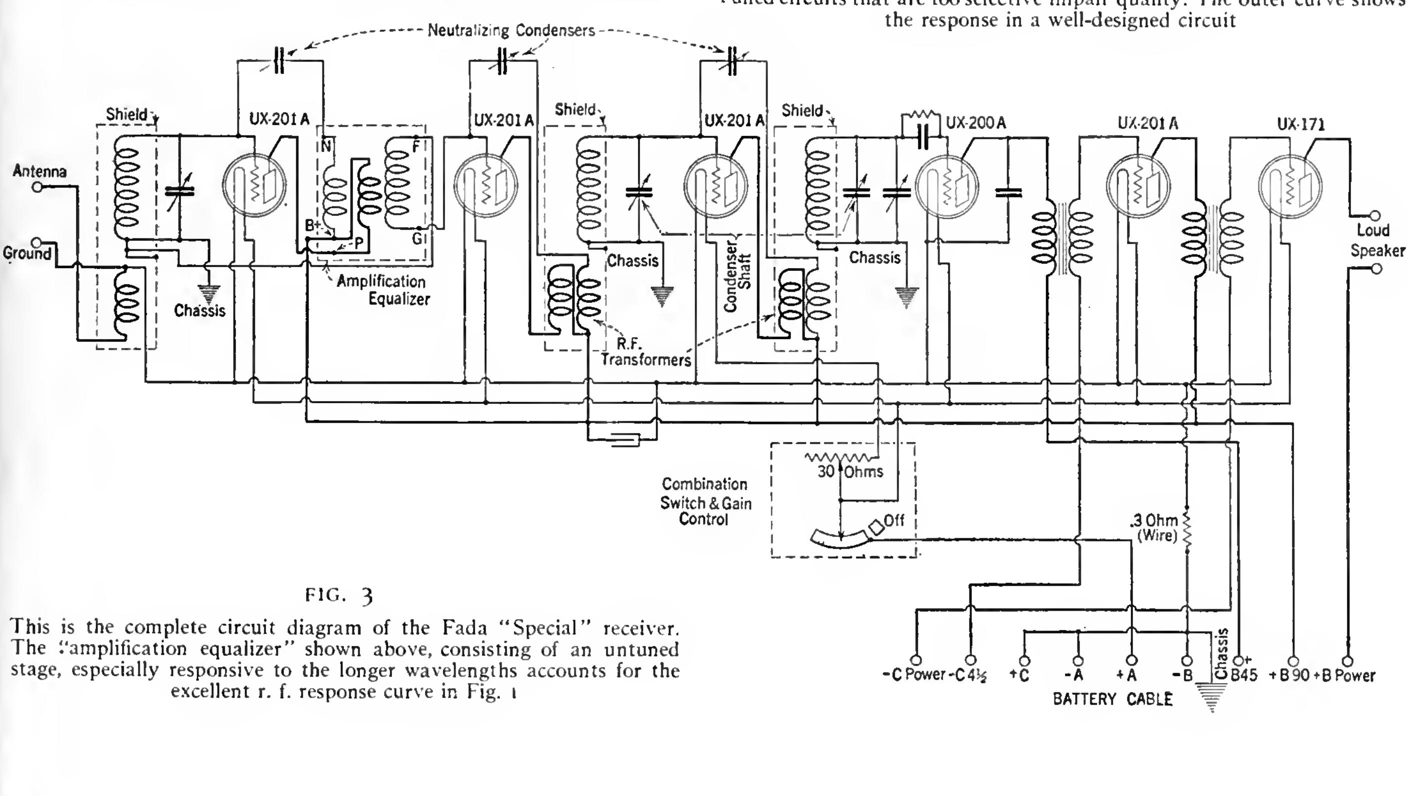


FIG. 3

This is the complete circuit diagram of the Fada "Special" receiver. The "amplification equalizer" shown above, consisting of an untuned stage, especially responsive to the longer wavelengths accounts for the excellent r. f. response curve in Fig. 1

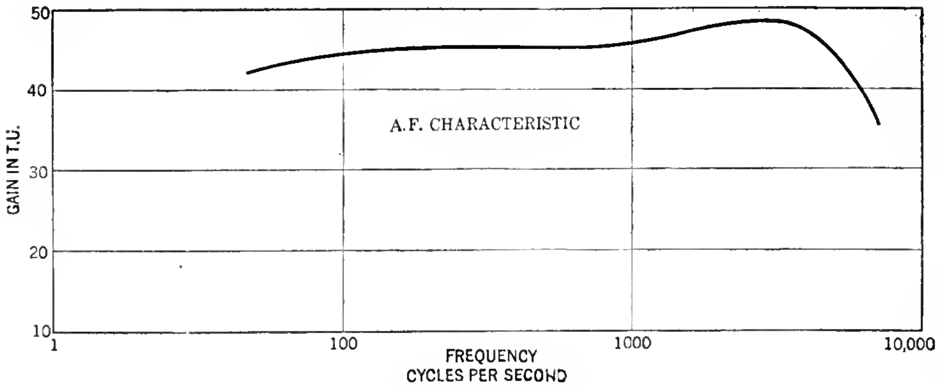


FIG. 4, OVERALL A. F. CHARACTERISTICS

shown in Fig. 2. Curve A shows 80 per cent. suppression on 5000 cycles and curve B shows 15 per cent. suppression at 5000 cycles. Curve B is broader than A, but the proper amount of selectivity is obtained by virtue of the cumulative effect of a number of stages.

THE DETECTOR

FROM the radio-frequency system we pass on to the detector circuit. A choice of two systems of detection is available—the grid bias method or the grid leak-condenser arrangement. Because of the increased sensitivity, resulting in greater output, the grid leak-condenser system is used.

From the detector we pass to the audio-frequency amplifying system. We made mention in a previous paragraph that transformers were used, but the design of a transformer-coupled audio amplifier cannot be consummated by simply deciding upon transformers. Sometimes these characteristics of the transformers to be used are exactly what the requirements call for; sometimes they are not. With specific requirements on hand, audio-frequency transformers must be designed to fill the need. The design is a detailed process. First the tubes to be used must be decided upon, and their electrical constants must be taken into consideration. The core material for the transformers must be selected, and the inductance of the primary and secondary windings must be calculated in order that the transformer possess certain predetermined characteristics. The method of winding must be decided upon so that distributed capacity is low and so that satisfactory response on the higher audio frequencies is obtained.

Detailed consideration must be accorded to the regeneration existing in the completed audio-frequency amplifier. This is very important. The overall response curve of a two-stage audio system with regeneration in the amplifier will differ from that of a single unit. If the single unit is designed to match the radio-frequency system, the operation of the completed two-stage amplifier will be entirely different. It is also essential to consider the loud speaker to be used. This unit, too, possesses operating characteristics which must be taken into account. The combined operating characteristics of the radio-frequency amplifying system and the audio-frequency amplifying system must be such as to produce best results with a particular loud speaker or with a group of good loud speakers.

The completed two-stage audio amplifier of the receiver under consideration—the Fada "Special" possesses the overall audio frequency characteristics shown in Fig. 4. The amplification is shown on the ordinate or the left vertical line. The audio frequencies are shown on the abscissa or the horizontal line. The frequencies are plotted on a logarithmic scale. As is evident, the curve is practically flat from 50 to 1000 cycles, rises from 1000 to 3000 cycles, and then falls gradually to 5000 cycles. The maximum difference in amplification between the lowest and the highest points is only 12.5 per cent., which difference is negligible, since the average ear will not discern intensity variations of such small proportions.

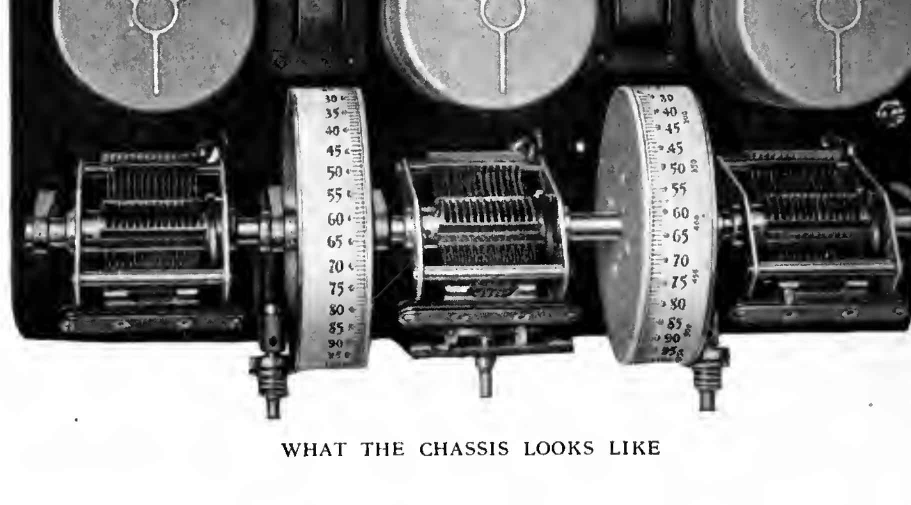
The development of the receiver is completed. Let us now consider the engineering involved in the testing of the receiver. Each receiver must undergo various tests during the process of production. The designing of this testing equipment is also in the hands of the engineering staff. Without testing equipment all the effort placed in the design of the individual parts and systems will have been for naught. Without a testing department the life of a radio plant would be very short.

The first test is a continuity test of the assembled chassis. This makes necessary testing with meters in each and every circuit, showing the voltage across the tube filament, the filament current, the plate current, the plate voltage and, continuity in the grid circuit. The filament current and filament-voltage meters show the operating action of the units incorporated in these circuits. The same is true of the plate-voltage and plate-current meters. Open circuits in the plate circuit will be shown on these meters. By simultaneously testing all the circuits, it is easy to select the faulty circuit if one is present in the receiver. The location of the fault is also noted. By having meters in every circuit it is unnecessary to hunt haphazardly.

The second test is to determine the efficacy of the neutralizing system, and the adjustment of the neutralizing units. In this test the assembled and wired chassis is connected to a series of meters, and the input system is coupled to a dummy antenna which obtains its energy from a local radio-frequency oscillator. The dummy antenna simulates an average outdoor installation. The meters show excessive regeneration in any of the tuned circuits, when these circuits are made resonant to the frequency of the oscillator. The neutralizing system is then adjusted until all signs of excessive regeneration in the radio-frequency amplifying system disappears. Incidentally, this same method of testing is employed to determine the overall gain of the radio-frequency amplifier.

When measuring the amplifying power of the radio-frequency system, from the grid of the first radio-frequency amplifying tube to the grid of the detector tube, a constant predetermined radio-frequency signal is fed into the radio-frequency system. The input voltage is held constant on all wavelengths covered by the tuning system. The voltage across the grid filament circuit of the detector tube is measured with a vacuum-tube voltmeter.

The third test applied to the receiver is the "air" test, *i.e.*, the receiver is connected to an outdoor antenna and outside broadcasting stations are tuned-in. This test is a final check of all the tests applied to the receiver during the process of manufacture. The overall gain of the radio-frequency amplifier and the audio-frequency amplifier is again ascertained. With respect to the measurements of the audio-frequency system and the transformers used, each transformer is individually tested against a standard before being placed into service in the amplifier. Then the completed two-stage unit is again tested under actual operating conditions. With a known constant input, the total gain is finally measured with a tube voltmeter—the last of a series of thorough and efficacious tests.



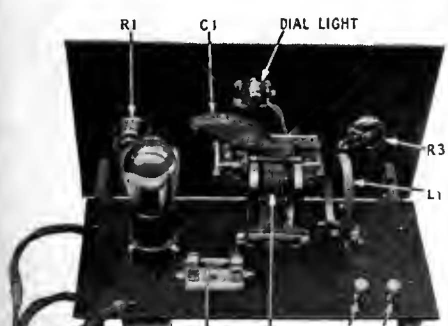
WHAT THE CHASSIS LOOKS LIKE

"Our Readers Suggest—"

TWO pages of RADIO BROADCAST *will regularly be devoted to publishing contributions from readers who have made interesting improvements in the use of ready-made radio products. These suggestions may deal with complete radio receivers, socket-power units, "kinks" in the placing of loud speakers, or slight circuit or mechanical changes in apparatus in general use. Our readers have a wealth of experience along these lines and these pages offer an opportunity for them to share their findings. Typewritten contributions from readers are welcomed which, if published, will be paid for at our regular space rates. In addition, a monthly award of $10 will be paid for the best contribution published each month. Address all contributions to Complete Set Editor,* RADIO BROADCAST, *Garden City, New York.*—THE EDITOR.

A Short-Wave Converter for any Radio Receiver

THERE is to-day sufficient material being broadcast below 100 meters (3000 kc.) to interest the serious fan and to justify the construction of simple apparatus for its reception. In some cases the use of a short-wave receiver will make possible the reception of important programs beyond the range of the conventional receiver. The construction of a short-wave receiver is often an expensive proposition, and converters heretofore described have been rather complicated affairs. It is the intention of the writer to describe a simple and inexpensive converter which, when attached instantly to any broadcasting receiver, makes it possible to receive on wavelengths between 15 and 125 meters (20,000 and 2400 kc.) No change is made in the present receiver but by means of the converter the former is alternately available for short- or broadcast-wave reception.



THE SHORT-WAVE CONVERTER

The short-wave converter takes the form of a very simple and incidentally highly efficient short-wave receiver, the output of which is connected to the audio-frequency amplifier of the present broadcast receiver. A simple plug-in arrangement makes the change a matter of a few seconds.

The following is a list of the parts used in the short-wave converter illustrated and described:

L_1, L_2, L_3—Set Aero Short-Wave Coils.
C_1—Amsco 0.00025-Mfd. S. F. L. Condenser.
L_4—Silver-Marshall Choke, No. 275
R_1—Clarostat 0-500,000-Ohm Resistor.
R_2—Amsco 3-Megohm "Grid Gate," with Mounting.
R_3—Amsco 20-Ohm Rheostat.
C_2—Tobe 0.00025-Mfd. Fixed Condenser.
C_3—Tobe 0.001-Mfd. Fixed Condenser.
Three Four-Foot Lengths of Flexible Wire.
Sub-Panel Brackets, Hardware, and Old Tube Base.
National Type C Dial.
Amsco Floating Socket.
7 x 12 x $\frac{3}{16}$ Inch Celeron Panel.
7 x 11 x $\frac{1}{2}$ Inch Wood Baseboard.
Two "XL" Laboratories "Push" Binding Posts.

THE FRONT PANEL

The construction of the short-wave converter is best described in the accompanying illustrations. However, a word regarding the connecting plug may be of assistance.

The three wires leading respectively from the radio-frequency choke coil, A-battery minus, and A-battery plus, are led to the base of a discarded tube, as made clear by reference to Fig. 1. The glass of the old vacuum tube is broken off and the base cleaned out. The three wires are soldered to terminals inside the base, one to the A-plus plug, one to the A-minus plug, and one to the plate terminal. These terminals may be identified by holding the tube base, bottom down and the side pin toward you. With the base in this position, the two rear posts are A plus and A minus respectively from left to right, and the left-hand front post is the plate terminal. The base of the tube is now filled with a wax compound, such as the top of a discarded B battery. This is easily done by placing small pieces of the wax in the tube base and melting them with a hot soldering iron. The receiver may be wired with bus bar, but the author found coded flexible wire more convenient. All leads should be made as short as possible.

The function of the choke coil is important. If the Silver-Marshall one is not available, one may be made by winding 100 turns of 26 d.c.c. wire at random on a wood spool, $\frac{1}{2}$ inch in diameter with $\frac{1}{4}$-inch wooden core.

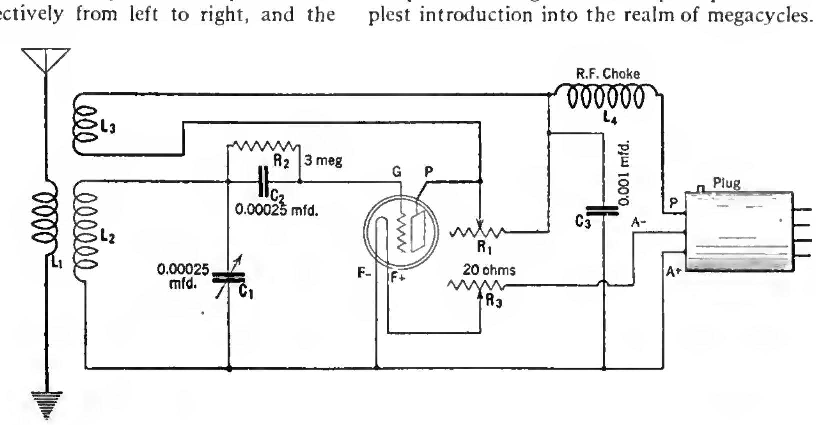
To operate the short-wave converter, remove the detector tube from the regular broadcast receiving set and place it in the tube socket of the converter. Next select the plug-in coil from the Aero set covering the wave band in which you wish to receive, and plug it into the coil jacks. Then insert in the detector tube socket of the regular broadcast receiver the plug made from the old tube base. When the antenna and ground have been changed to their respective posts on the converter, you are ready to listen-in. To do so simply leave the loud speaker where it is, or, if phones are used, these may be plugged in as usual in any stage for which a jack is provided on your particular receiving set. Turn the Clarostat until the receiver oscillates. Tune-in a station and clear up the signal by a further adjustment of the Clarostat or rheostat as required.

PERRY S. GRAFFAM.
Boston, Massachusetts.

STAFF COMMENT

WHILE the importance of short-wave reception cannot be overstressed, statements regarding its immediate and direct utility to the fan must be qualified. RADIO BROADCAST does not care to encourage the use of radiating short-wave receivers, and the more simple sets necessarily fall into this category. Serious experimenters, broadcast enthusiasts desiring to take up code work, and fans in isolated districts are, however, undoubtedly justified in conducting experiments along these lines. Mr. Graffam's inexpensive arrangement offers perhaps the simplest introduction into the realm of megacycles.

FIG. 1



Short-wave reception is by no means an unalloyed bliss as some avid publicity men would have us believe. Ninety-eight per cent. of the transmissions carried on below 100 meters is inter-communicative code work and the two per cent. of radio telephonic transmission is often marred by high speed fading.

Antenna Compensation in a Single-Control Receiver

ONE of the major problems in single-control multi-tuned circuit receivers is the elimination of the detuning effect of the antenna on the first radio frequency stage. Loose and variable coupling between the antenna primary and the first r.f. secondary is generally employed to compensate this influence. These arrangements, unfortunately, often lower the signal response of the receiver, and the set still functions best with antennas of definite electrical characteristics.

The arrangement proposed overcomes these difficulties and offers the following advantages:

It eliminates the antenna effect on any receiver.
It can be attached to any receiver without making more than one simple change.
No additional controls are required.
Sensitivity is never reduced. On the contrary it is often increased.
Any length antenna may be used with the receiver without making additional changes.
The device acts as a partial blocking stage in case oscillations are set up in the tuned amplifiers.

In brief, the device causes the radio-frequency impulses to be applied across a resistor to an extra radio-frequency tube, which is outputted to the original antenna primary.

The following is a complete list of parts necessary to make the change:

C_1—0.001-Mfd. Coupling Condenser. L_1—R. F. Choke Coil. Socket. 201-A Type Tube. R_1—¼-Ampere Ballast Resistor. Sw.—Battery Switch. R_2—1000-Ohm Resistor. Six Binding Posts.

This apparatus is easily wired on a baseboard in accordance with the diagram, Fig. 2.

The antenna is disconnected from the receiver and wired to post number one. The ground remains connected to the receiver and is also wired to post number two of the new stage.

Turn on the filaments to the receiver proper and the switch to the extra stage. Run a wire from the A battery plus post on the set to post number four. The extra tube will probably light. If it does not light, repeat the test with a wire from the negative A post.

If the extra tube lights with one side grounded and the other side connected to the A battery circuit, it is an indication that one side of the A circuit is grounded, as it will be in 90 per cent. of receivers. If this is the case, proceed as follows:

Leave the wire that lights the filament connected to post number four. Connect the antenna post on the receiver to post number five.

If, upon making the tests with the filament wires to post number four, the tube does not light, indicating that the filament circuit is not grounded in the receiver, the filament plus wire should be connected to post four and the filament minus wire to post three. The tube will now light, of course. Connect the antenna post on the receiver to post number five, and terminal six to the plus 90 volts, and the unit is ready for operation.

There is no change in the operation of the receiver whatever. If taps are provided on the antenna primary of the original receiver, slightly higher efficiency may be secured by experimenting with them.

If the experimenter is a bit more of an expert,

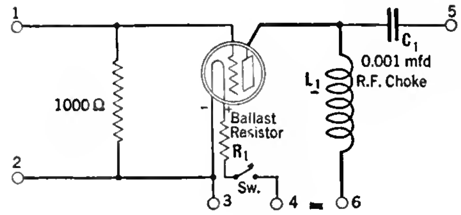
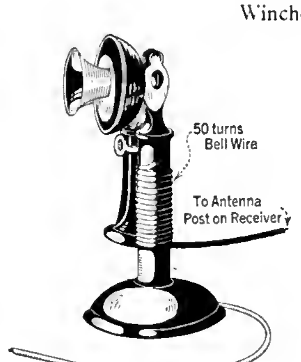


FIG. 2

the filament lead, or leads, to the antenna coupler tube may be led from the tube side of the set switch, making it possible to operate the antenna coupling tube by the same switch that controls the set filaments.

HAROLD BOYD.
Winchester, Virginia.



AN EMERGENCY ANTENNA
Fifty turns of bell wire are usually satisfactory

STAFF COMMENT

THE arrangement suggested by Mr. Boyd is quite practicable and is already used in several commercial and kit receivers. The tube coupling device is in the nature of an untuned radio-frequency amplifying stage, and, in some instances, may result in increased sensitivity. The r.f. gain, however, is generally small in comparison with the utility of the arrangement.

One thousand ohms is about the optimum value for the antenna coupling resistor. It seems to make little difference whether the resistor is inductive or not. The Lynch, Amsco "Metaloid," Carter, and Electrad are excellent resistors for this purpose. A variable zero to 2000 ohm resistor may be substituted for the fixed resistor recommended by Mr. Boyd and used as a volume control.

In a few cases it may be found that the load imposed by the coupling arrangement on the first r.f. transformer is no more favorable to tandem tuning than that of the average antenna. This can be compensated either by adjusting the compensating condenser across the first tuning section (if the main condenser is so equipped), or by winding a special primary over the first secondary. From six to ten turns of wire may be placed directly over the coil. One end is connected to post number five in Fig. 2 and the other terminal to plus 90 volts.

Increasing Response from a Loop Receiver

ALL receivers are more or less affected by location, but the loop set seems to be particularly susceptible to adverse conditions imposed by position. This is due to the fact that the loop is often surrounded by steel building framework and similar obstructions which the open antenna can rise above. Disadvantages of this nature were impressed upon the writer when moving from the top floor of a New York City apartment house to the second floor of the same building. The receiver, a Radiola super-heterodyne, worked perfectly in its original position eight floors higher up, but lost perhaps seventy-five per cent. in sensitivity when brought a hundred feet nearer the ground.

Its operation was brought up to normal by a simple device, thrown together in five minutes. A twenty-five foot antenna was strung on the roof of the building. Three turns of wire, harmonizing with the wire on the loop, were wound around the loop frame, twisting slightly about the original loop wire to keep it in place. One end of this extra wire was connected to the short antenna, while the other end ran to ground.

Sufficient energy is transferred to the loop circuit from the open antenna to compensate the losses imposed by an inferior location.

A. J. HOWE.
New York City.

STAFF COMMENT

THE device recommended by our contributor is, of course, a simple antenna coupler, the extra turns of wire functioning as the primary and the loop itself as the secondary. The arrangement is effective. On the ordinary super-heterodyne (that is other than the second harmonic type) the shortest antenna giving satisfactory reception should be used, to reduce the possibility of radiation.

The directional effect of the loop is largely eliminated by coupling to an open antenna in this manner. However, the selectivity of the super-heterodyne is such that this effect can be safely dispensed with.

A coupling device of this type is made commercially by the Jenkins Radio Company, Davenport, Iowa.

A Temporary Antenna for the Traveling Fan

EXTRA tubes and batteries are easily available in an emergency, but the occasion where a spare antenna would save the day is seldom provided for, so a word as to an excellent makeshift antenna may not be amiss.

A first class one, often equal to the average outdoor variety, may be secured by wrapping fifty turns of bell wire around a telephone desk stand. See Fig. 3. One end of the wire is connected to the antenna post on the receiver and the usual ground is used.

The writer, an inveterate radio enthusiast, discovered the possibilities of this arrangement when traveling across the country with a Fada neutrodyne, the operation of the receiver being somewhat limited by the facilities of the average hotel bedroom.

Subsequent experiments show this type of antenna to be equally efficacious with other receivers.

ALFRED A. MARKSON.
New York City.

STAFF COMMENT

THE use of the telephone as a substitute antenna is by no means a novelty, although the exact system of connection outlined here is not that generally advocated, but probably as efficient. The more widely used application of this idea is found in the use of a small metal plate upon which the telephone is stood, and which is connected to the antenna binding post of the receiver. Such metal plates, especially cut for the purpose, are commercially available. As the latter are not always immediately obtainable in an emergency, Mr. Markson's idea is a useful one.

HOW TO IMPROVE YOUR OLD RECEIVER

A radio set of other years can be brought up to date by improving the audio quality through new transformers, tubes and loud speakers or by the purchase of a complete power-supply-amplifier unit. These changes help greatly. R.f. Changes are not suggested

By EDGAR H. FELIX

THE articles appearing in the September and October issues of RADIO BROADCAST, dealing with the judging and attainment of good tone quality, resulted in hundreds of letters from readers, asking specifically how certain makes of receivers could be converted to give the high-grade tone quality described. It was the writer's intention to answer the letters directly in these columns, but their number grew so large that it would require an entire issue of the magazine to meet the demand for information. This article is based upon the questions raised in the letters and will serve as a concentrated answer to these letters.

Hundreds of thousands of radio enthusiasts are owners of receiving sets sufficiently selective to be satisfactory, but falling far short of the latest standards of tonal reproduction. So long as the receiver meets the simple requirement of being sufficiently selective, but not too selective, it can be converted to give good tone quality. The writer does not mean to imply that the radio-frequency end of the modern receiver is not as greatly improved as the audio end and that the most satisfactory measure, after all, is not to discard entirely the obsolete receiver. But not everyone is in a position to employ this remedy; some of us must reconcile ourselves to tuning with several dials and to great sensitiveness at the high frequencies, where it is not especially needed, and lack of sensitiveness at the low-frequency end, where it is most desired. Simplicity of control, and equal amplification throughout the wavelength scale, are features embodied only in the latest receivers. But, given satisfactory selectivity, an old receiver may be greatly improved so far as tone quality is concerned.

Exceedingly sharp tuning, such that high-power stations within fifty or a hundred miles are heard with considerable volume only when tuned-in precisely and always disappear with a whizz and hiss when detuned but one or two degrees from exact resonance, indicates selectivity too great for the attainment of good tone quality. Oftentimes a receiver behaving in this way can be made to tune more broadly, so that neither the low or high audio frequencies are cut off, by installing a somewhat longer antenna.

Having once determined that the radio-frequency end of the receiver does not tune too sharply, improvement of tonal quality is a matter of re-vamping the audio system. The essential requirements for good tonal quality are: (1) Audio-frequency transformers of sufficiently good quality to pass the entire tonal range; (2) tubes of sufficient power and emission to adequately handle signals of considerable magnitude (3) a power supply assuring correct A, B, and C voltages to every tube under actual operating conditions; and (4) a loud speaker capable of setting up sound waves throughout the audio scale.

Prior to recent developments in transformer design and material, resistance-, and impedance-coupled amplification were the only systems, within reach of the experimenter, capable of handling broad tonal range. These systems under proper conditions are not excelled in quality output by high-grade modern transformers, but require an extra stage so that they are not easily incorporated in a manufactured receiver, unless it is especially designed to accommodate them. During the last year, transformer development has reached such a point that two stages may be used to give the best of tone quality.

Transformers can be manufactured at a cost as low as forty cents, although the actual raw materials which go into the better transformers cost as much as eight times that figure. Expensive iron alloys, which magnetize and demagnetize rapidly, and high-inductance windings, are essential if the entire tonal range is to be amplified. Under no circumstances, can cheap transformers serve as well as well known expensive ones. In replacing transformers, to make the job worth while, confine yourself to the best. Some of the better receiving sets of earlier vintages, are not equipped with suitable transformers and the substitution of such makes as Amertran, Ferranti, Silver Marshall, Thordarson, General Radio, Rauland Lyric, Modern, All American, Pacent, Sangamo, and Samson, to mention some of the better ones, is decidedly worth while.

REPLACING OLD TRANSFORMERS

TO DETERMINE whether such substitution is feasible, open the cabinet and examine the audio-frequency transformers. See if they are easily removed and if the four terminals are so marked that you can put labels on the wires before you remove them, indicating the correct filament, grid, plate, and B+terminals. This will prevent confusion when you put the new transformers in place. Adhesive tape is a convenient form of label. Measure the space available for transformers because cheap transformers are often small. The high grade ones, with which you replace them, are likely to be somewhat larger and hence may not fit in the space provided for the old transformers. Where the problem requires moving of sockets and other parts, your local dealer can replace the transformers for you. His charge should be between two to five dollars, plus the cost of the transformers themselves.

The next link in the chain of audio reproduction concerns the tubes used. You cannot hope to secure good quality, if you do not use a power tube in the last stage. The UX-201-A (CX-301-A) tubes in the output stage are capable of only moderate volume with good quality. If you are attaining fair quality with such tubes now, after replacement of the transformers they may prove unsatisfactory, because the added energy in the low frequencies, impressed upon the output tube by the new transformers, will not be handled satisfactorily.

In the case of the storage-battery receiver, wired with but a single C battery connection, both the first and second stages are usually supplied with the same C battery voltage, generally $4\frac{1}{2}$. Re-wiring of the set, however, is not necessary to put in an UX-171 (CX-371) or a UX-112 or CX-312. Manufacturers such as Na-Ald, have developed special sockets with flexible cable connections, enabling you to add the necessary grid and plate voltages to operate power tubes, without any wiring changes.

There is one exception to the general rule that replacement of the transformers and addition of a power tube will bring you better tone quality. Certain reflex receivers, which enjoyed a fairly wide sale three and four years ago, are not adapted to this simple conversion. The use of a grid bias and plate potential satisfactory for audio purposes may render the radio-frequency amplifier of these reflex sets quite unstable. Many of these receivers are such heavy consumers of plate current that discarding them is an economy. It is not worth while to attempt to improve them. You must treat them as you would an inherited 1902 one cylinder-automobile.

With dry-cell tube receivers, the largest output tube available is the 120 type. This is a great improvement in power handling capacity over the 199 type, but it is still far from sufficient to attain really good tonal quality. The further down the tonal range the reproducing system goes—and that is what gives body and richness to music and naturalness to speech—the greater must be the power available in the output tube.

The owner of such a dry-cell tube receiver need not, however, abandon hope, because he may employ a one-stage power amplifier, receiving its filament, grid and plate potentials, directly from the light socket, and employing the UX-210 (CX-310) in the output. This tube is of even greater power handling capacity than the UX-171 (CX-371) and, hence, capable of magnificent tonal quality, provided good transformers and reproducers are used in connection with them. These light socket units may also be used with storage battery outfits and are recommended to B battery users. The use of a power tube in the output stage considerably increases B battery drain and, as a consequence, the use of a light socket amplifier unit is an economy.

Such power supply devices are manufactured by General Radio, Farrand, Radio Receptor, Pacent, National, Timmons, Amertran, and the Radio Corporation. They furnish A, B, and C power, not only for the 210 or 171 tube, but also B and in some cases C voltages for the receiving set itself. Adding these amplifier-power supply devices to the existing receiver is a simple matter. The tonal reproduction secured is still dependent upon the grade of loud speaker and first stage transformer used but, so far as available power is concerned, the purchase of a good power amplifier and B supply unit settles that question.

SELECTING A REPRODUCER

HAVING now supplied transformers which actually amplify the entire range of tonal frequencies, having installed tubes of adequate power handling capacity, and having supplied them with the correct A, B, and C voltages, it is next necessary to obtain a loud speaker capable of setting up sound waves throughout the entire tonal range. A loud speaker which is seemingly satisfactory with poor transformers and power supply, often fails when the high-grade transformers and tubes are wired into circuit, because of the larger load and greater frequency range thereby impressed upon it.

Remedying an audio system requires that the entire audio system be put in good condition, because any one weak link will destroy the effectiveness of all the other remedial measures. If you have four worn out tires on your car, replacing one, two, or three of them is not sufficient to give you immunity from tire trouble. Many a person, dissatisfied with tone quality, has replaced his loud speaker and then wondered why great improvement did not result. In fact, it often happens that an exceptionally good loud speaker will sound worse than a bad one with a poor set. The good loud speaker sets up sound waves in exact accordance with the electric signal furnished it. A poor loud speaker may be so designed as to exaggerate the low notes, thus providing for their deficiency in a defective audio system. When a good loud speaker is substituted, the absence of low notes, due to unsuitable transformers, becomes more conspicuously apparent.

Every reproducer has an actuating element which sets up the sound waves—a sort of paddle which sets up air vibrations. With good reproducing systems, the loud speaker must be capable of setting up low frequencies as well as high ones, and consequently the actuating element, vibrating diaphragm, or cone surface, must often be large if it is to be successful. The horn, if one is used, must also be of large size, so that it does not impede the radiation of low frequencies. A long, goose-necked horn chokes off the low frequencies, while a large exponential horn can give you much of the true magnificence of the organ.

The writer cannot attempt to list entirely all good cones and horns, but he has personally tested Western Electric, Farrand Sr., Balsa, Rola, and Amplion, and found them capable of handling the output of 171 and 210 type tubes throughout the tonal range attainable by the best of amplifier systems.

Inferior loud speakers fail not only because they are incapable of mechanically setting up waves by reason of small moving surface or confined tubular horn areas, but also because the electromagnetic unit is incapable of handling the large output which is necessary to secure good tone. With the 210 and 171 types of tubes, an output transformer or choke and condenser feed to the loud speaker is absolutely necessary to eliminate the direct-current component from the speaker winding. We desire only to have the audio-frequency fluctuations in the loud speaker winding so that magnetic saturation is avoided. Silver-Marshall, General Radio, Federal, National, Pacent, Samson, Thordarson, Amertran, Muter, Amsco, and others make output devices.

One question which appeared in many of the letters received was the demand for more volume, or specific questions to the same effect, such as whether the use of a 171 tube would increase volume. None of the measures described have for their purpose the increasing of volume output of the receiver. The use of large power tubes simply increases the amount of signal volume which can be handled without distortion due to overloading.

By using the grade of transformers, tubes, and loud speakers mentioned, a signal so weak that it can hardly be distinguished by the phones in the detector output circuit is amplified to comfortable living room volume. If the signal is not sufficiently strong to give such volume, the remedy does not lie in additional audio-frequency amplification but in the use of a more sensitive receiving set. The best results are obtained if the detector tube's output is a signal just strong enough to be discernible in the headphones. Those complaining of weak signals should look to improving antennas and to increasing radio-frequency amplification. The audio system should not be expected to make up for deficiencies in the radio-frequency amplifier.

As a matter of fact, most of the receiving sets, even those of two and three years ago, are adequately sensitive. Many complaints of reduced volume may be attributed to the continued use of depreciated power supply and tubes, whose filaments have lost their emission.

It is an essential requirement of good tone that the power supply be adequate and that the tubes have plenty of emission. There is only one way that this can be determined definitely and that is by measurement. Your dealer should have a tube checker which he can bring to your set, or you should take the tubes to a well equipped radio store for testing. By taking out one tube, substituting for it a plug, connected by a flexible cord to the set checker or tube tester, and placing the removed tube in a socket provided on the tester, the A, B, and C potentials, and the plate-current output of the tube, can be measured. The writer recently tested an elaborate set checker made by a concern in Detroit, equipped not only to make the four measurements mentioned, but also the voltage at the terminals of the A battery, the completeness of all the circuits and, the mutual conductance of the tubes by the manipulation of a few well marked switches. Every dealer should have some such device. The use of a voltmeter does not tell the full story and no dealer is in a position to service adequately without measuring devices such as those made by Jewel, Weston, General Radio, Quick-Test, Hoyt, Hickok and others.

There were many well-known and widely advertised makes of receivers which last year became known for their mediocre tone quality and which this season have effected extraordinary improvements. The importance of tone quality has been widely recognized and manufacturers have realized that they cannot remain in the radio market unless their receivers are capable of high-grade reproduction. Name, reputation, price, and the willingness to submit their product to the test and approval of the recognized set expert, are guides to the set purchaser. Many receivers, described in most alluring terms in general magazines, do not meet the laboratory inspection of the expert. It is best to confine your purchases to sets recommended by well-informed enthusiasts who have some familiarity with the technical phases of radio. In the October issue, the writer gave suggestions for tests which may be made at the dealer's store when a receiver is being demonstrated, to give indication of its tonal capacity. It is suggested that the reader go over both the September and October articles before making purchases.

To summarize, the conversion of an old receiving set to give good tonal quality requires:

(1). That the radio-frequency amplifier of the receiver does not tune so sharply that near-by signals are heard only when precisely in resonance.

(2). Audio-frequency transformers be used of a quality and price sufficient to assure that they will amplify the entire range of frequencies from stage to stage.

(3). The output tube be of sufficient power capacity to handle the required range amplitudes.

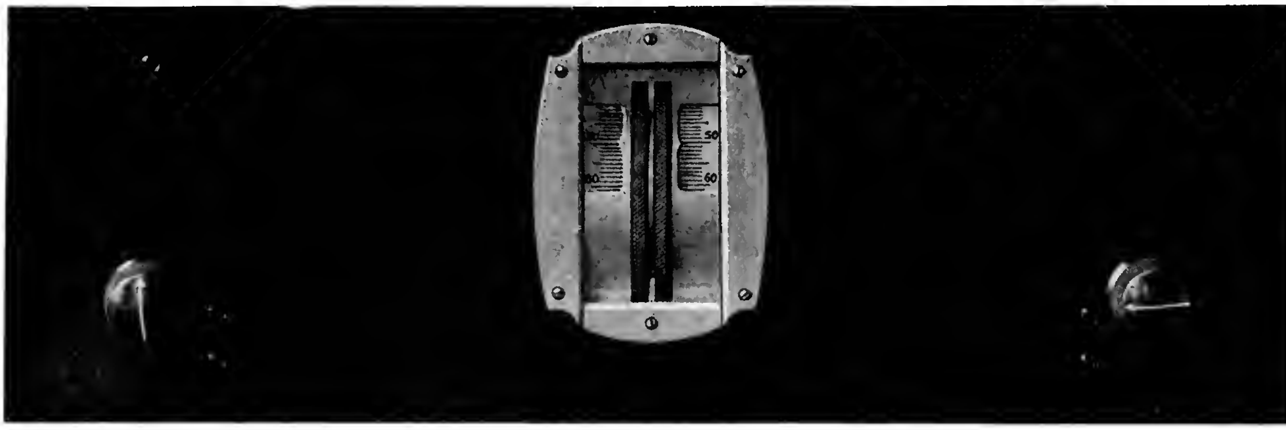
(4). The correct A, B, and C voltages be supplied to the tubes.

(5). That the loud speaker be capable of handling the tonal range.

In most cases, these objectives are attained by replacement of the audio-frequency transformers, installation of a power tube (in the case of dry-cell sets, the addition of a one-stage power amplifier and B supply which furnishes A, B, and C power for a 210 or 171 type tube), and finally, the use of a suitable reproducer.

A Quality Five-Tube A. C. Receiver

By JAMES MILLEN



FRONT VIEW OF THE RECEIVER

THIS article describes the construction of an a.c. operated receiver, the new type a.c. tubes being used to accomplish the electrification. In the preceding article in this series, published in last month's RADIO BROADCAST, some general information on a.c. tubes was given.

In explaining how to use these a.c. tubes with an actual receiver, we have chosen a circuit which embodies some of the features of the Browning-Drake receiver. Strict adherence to the instructions contained in this article will result in a light socket operated receiver equaling in sensitivity and selectivity a receiver operated on standard storage-battery type tubes.

Before going into details regarding the construction of this a.c. receiver, we will point out how the circuit differs from that of Browning-Drake sets. First, let us consider the r.f. amplifier. Most previous designs of the Browning-Drake receiver have used a 199 type tube as the r.f. amplifier, because the tendency for this tube to oscillate is less than with a 201-A type tube. A. c. tubes, however, have characteristics similar to the latter type, and since an a.c. tube is used in the r.f. stage of the receiver described here, it becomes necessary to devise some practical method of preventing this r.f. amplifier from oscillating.

In Fig. 4 is shown, at "A," the circuit of the original Browning-Drake radio-frequency amplifier using Hazeltine neutralization; at "B" we see the Browning-Drake circuit using the Rice system of neutralization. At "C" is shown the circuit arrangement for use of a 226 type a.c. tube. In the grid circuit will be noticed a non-inductive resistor, having an ohmic value of approximately 1000 ohms. It is the use of this grid resistor or, as it is more generally called, "suppressor," that makes possible the balancing of the circuit. As this resistor is not placed in the tuned circuit, it has no detrimental effect upon the selectivity of the receiver.

The arrangement shown at "C," Fig. 4, is used in the final model of the receiver illustrated in this article, and it will be noted that the plate voltage is fed to the plate of the tube through a choke coil, L_4, instead of through the primary winding of the r.f. transformer. The former method (feeding the voltage through a choke coil) tends to somewhat stabilize the operation of the receiver, especially when a socket-power unit is used for the B supply.

The antenna is coupled to the first coil in the usual manner, *i.e.*, through a 50-150 micro-microfarad midget variable condenser, to a center tap on the coil. If the antenna is over 40 feet in length, the connections should be as indicated in the diagram, but if a shorter antenna is used, the lead from the midget condenser may connect directly to the grid end of the coil instead of the center. In congested localities, excellent reception, with greatly improved selectivity, is obtained by using a 3-foot length of bus bar for an antenna. The bus bar should be attached directly to the grid end of the coil.

THE AUDIO AMPLIFIER

THE audio channel employed is capable of producing excellent tone quality and at the same time lending itself equally well for use with either the new a.c. tubes or the standard storage battery tubes. The wiring of the audio channel is shown in the complete circuit diagram. Fig. 2.

In the first stage is employed an impedance

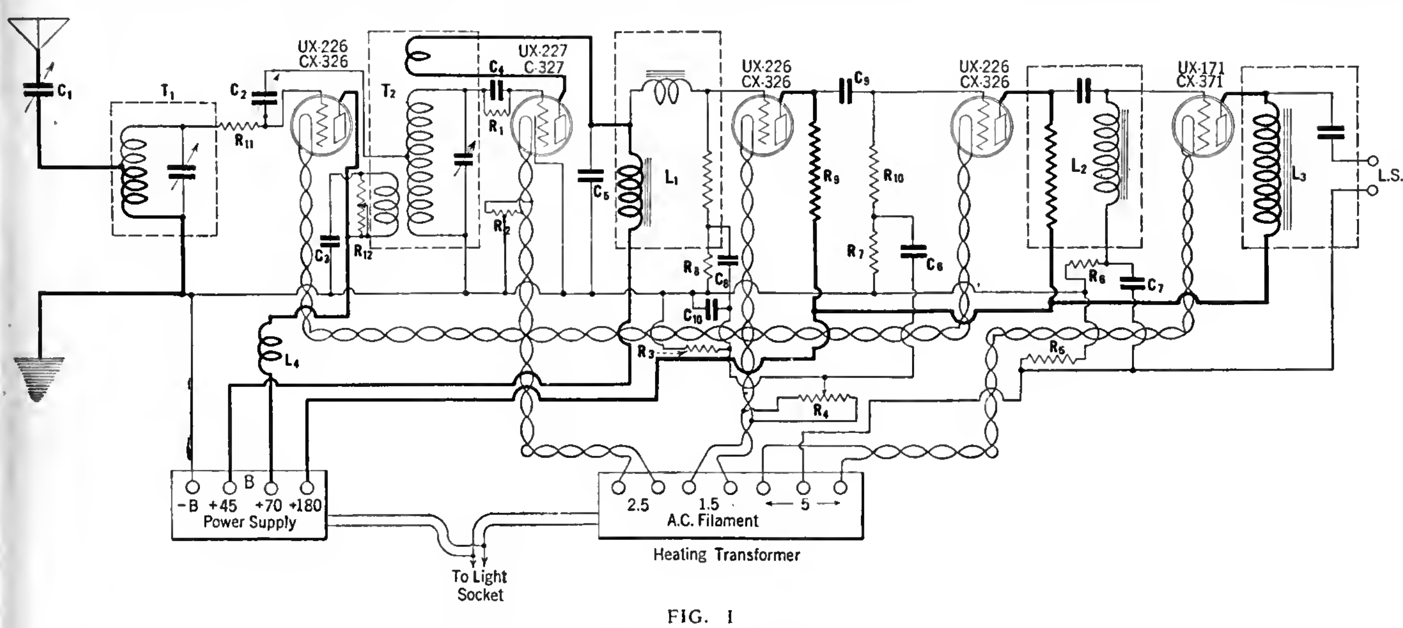
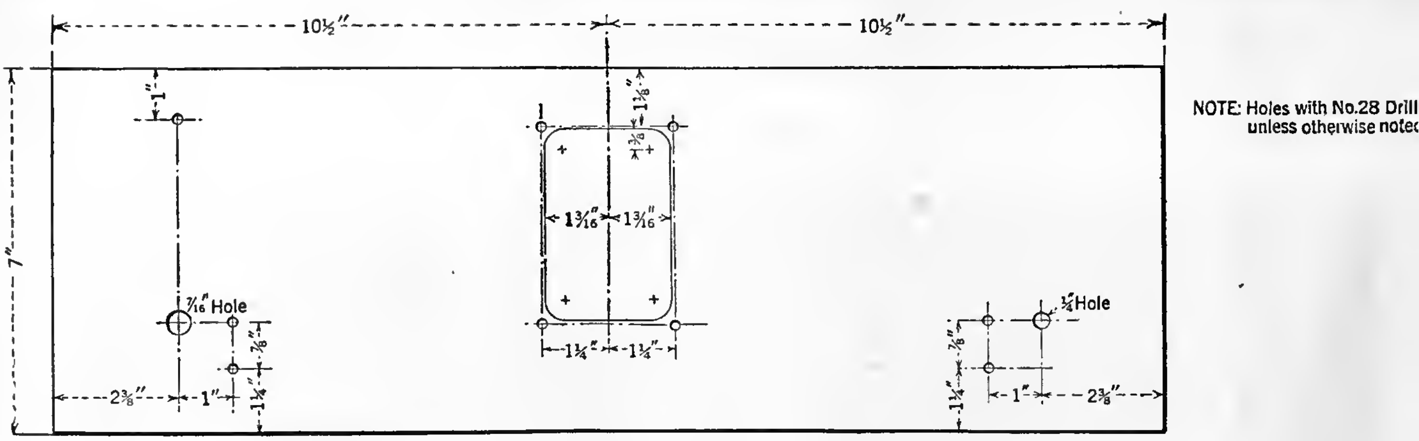


FIG. 1

Complete circuit diagram of the complete a.c. operated receiver



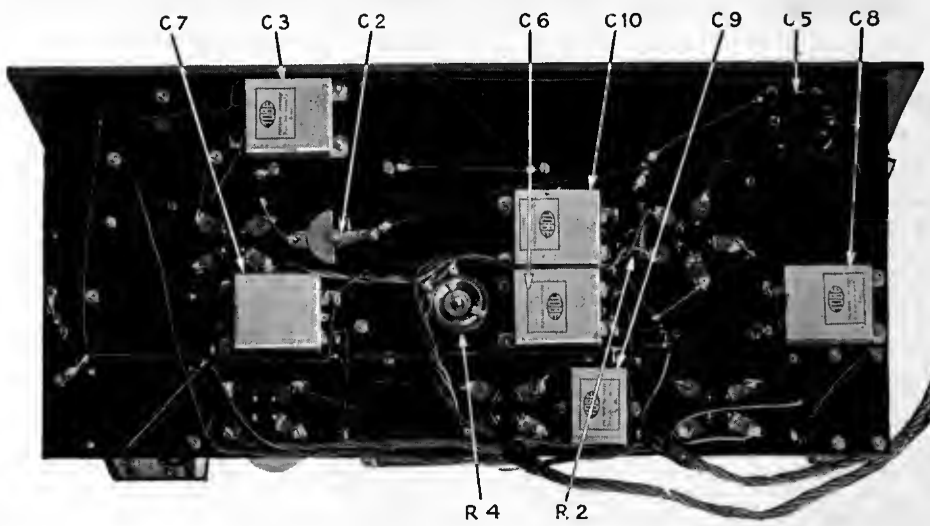
FRONT PANEL

FIG. 2
How to drill the front panel

coupling unit which is incorporated a radio-frequency choke coil; in the second stage, resistance coupling is used, while the third stage employs a special arrangement of resistance and impedance with the impedance in the grid circuit of the power tube so as to eliminate any tendency of the amplifier to "motor-boat" when used with some types of B power units. A tone filter, L_3, is incorporated in the output circuit as a protective device for the loud speaker.

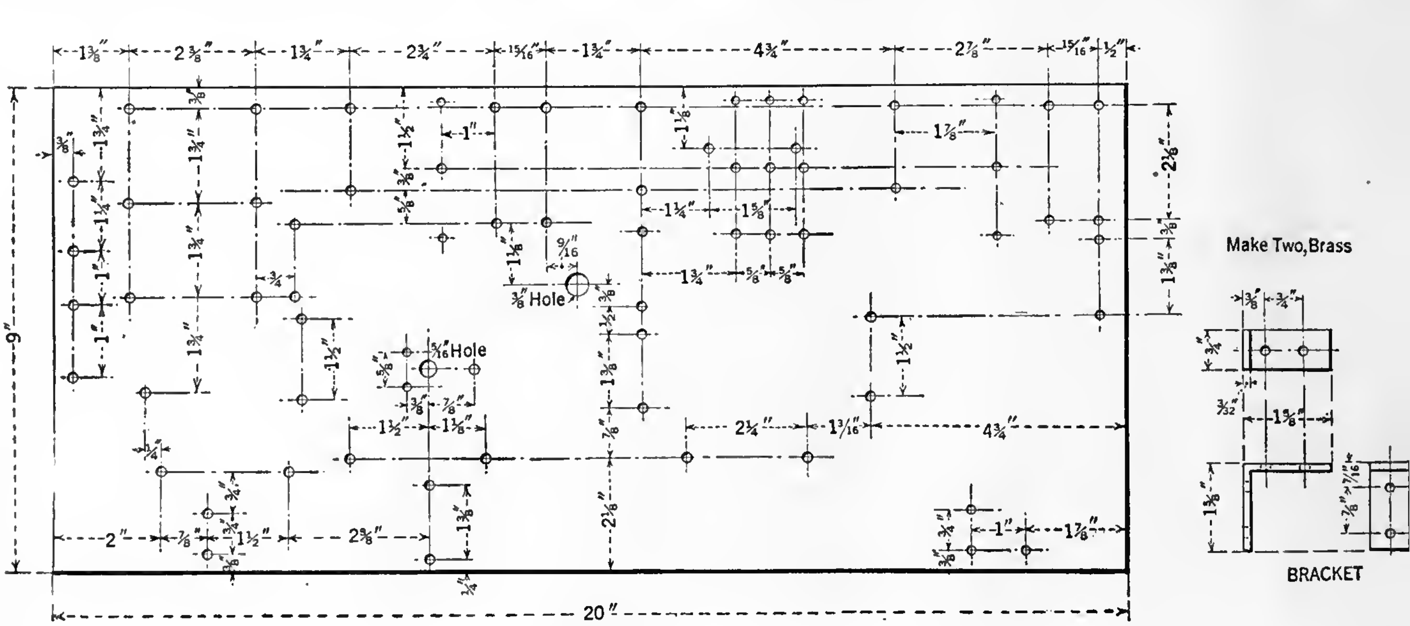
As will be noted from the circuit diagram, Fig. 1 resistance-capacity filters (R_6-C_7, R_7-C_6, and R_8-C_8) are employed in the grid circuits of each of the audio tubes. These filter circuits prevent "motor-boating" and make the operation of the audio amplifier entirely stable under all conditions. The grid bias resistances, R_3 and R_5, as well as the mid-tapped resistance, R_2, across the filament of the detector tube, are all of the fixed variety so as to eliminate needless adjustment and enable the home constructor to obtain the same excellent performance from his receiver as from the original laboratory model.

The various photographs, working drawings, and circuit diagrams accompanying this article give all the necessary details regarding the construction of this receiver and only a few ad-



FROM THE UNDER SIDE

The letters correspond with the parts list on page 137. On page 33 of RADIO BROADCAST for November, 1927, appeared a back panel view of this set to which reference may be made



BASE PANEL

FIG. 3
How to drill the base panel

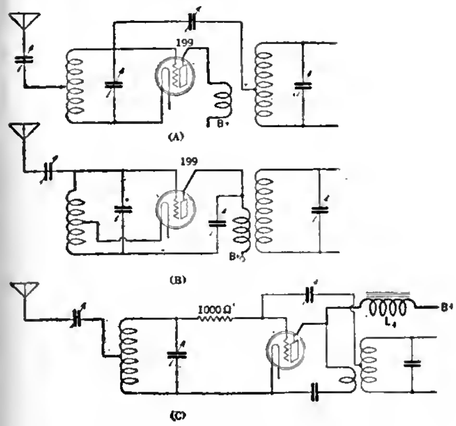


FIG. 4

The circuit of "C" is used in this set. This alteration in the usual Browning-Drake circuit is necessary because of the special problems arising from the use of a.c. tubes

ditional hints need be given in order to make possible the easy construction of the receiver.

As the illustrations show, the a.c. filament heating transformer is not built into the set, it being more convenient in this case to mount it as a separate unit within the usual battery compartment of the console if the latter is employed.

The first construction step is to drill the front and sub-panels in accordance with the details given in Figs. 2 and 3.

The next step is to mount the condensers, coils, sockets, and other parts on the sub-panel, as shown in the illustrations. Then, the sub-panel may be almost completely wired—all before attaching the front panel, which merely carries the dial, volume control resistor, and tickler adjustment.

The small General Radio neutralizing condenser should be disassembled and built right into the sub-panel after discarding the triangular bakelite back.

In the receiver shown in the illustrations, the resistor mountings and sockets were also disassembled and the contacts remounted directly on the sub-panel. Much needless work can be saved however by retaining the bases of the resistor mountings and sockets.

Instead of numerous binding posts the use of two cables is recommended. One cable should consist of the seven low-voltage a.c. leads to the filament transformer while the other cable should have four leads to the B power supply unit.

As the loud speaker cord may be plugged directly into the tip jacks on the front of the tone filter, it is necessary to provide but two binding posts—for the antenna and ground.

The wire to use for all connections as well as the cables should preferably be No. 18 tinned flexible rubber-covered wire. Such wire may be obtained from Acme and Corwin in different colors for making the cable and to facilitate the tracing of the set wiring itself.

With many UY-227 type detector tubes it will be found that the most satisfactory operation is obtained when the heater voltage is slightly below the rated 2.5 volts. For this reason it is recommended that a 6-inch length of resistance wire from an old 6-ohm rheostat be connected in series with one of the 2.5-volt a.c. leads, preferably right at the transformer terminal panel.

ADJUSTING AND OPERATING THE RECEIVER

THE adjustments necessary in order to obtain the best performance from the completed receiver are few and easily made. First, connect the antenna, ground, loud speaker, B-power unit, and filament heating transformer, and then turn on the 110-volt supply and wait for about a minute or so for the detector tube to reach its proper operating temperature. If a high-resistance voltmeter is available, the next step is to set the detector B voltage to approximately 45 and the r.f. B voltage to 70. Should a suitable voltmeter not be available, the r.f. and detector B voltage may be set by guess work and then readjusted for best results later. The next step is to set the potentiometer, R_1, for minimum hum. Generally this adjustment will be obtained when the contact arm is somewhere near the center of its arc. Occasionally, if the receiver should develop a slight hum, a slight readjustment of the potentiometer will remedy the trouble.

The antenna series condenser should be adjusted so that the two tuning condenser scales read somewhat alike.

The neutralizing condenser may now be adjusted so that the receiver does not oscillate at the shortest wavelength when the tickler coil is set for minimum regeneration. Generally the proper setting is with the movable plate of the neutralizing condenser turned in about a third of the way.

When making any of these adjustments, the volume control should be set for maximum volume in which position the receiver has the greatest tendency to oscillate. The following is a list of parts recommended for use in the receiver described in this article:

LIST OF PARTS

T_1—National B-D1E Tuning Unit (Without Dial)	$ 8.25
T_2—National B-D2E Tuning Unit (Without Dial)	11.75
National Drum Tuning Control	6.00
L_1—National Impedaformer, 1st Stage Type	5.50
L_2—National Impedaformer, 3rd Stage Type	5.50
L_3—National Tone Filter	6.50
R_2—General Radio No. 439 Center-Tap Resistor	.60
R_3—Lynch 500-ohm Suppressor	1.15
C_1—Precise No. 940 Midget Condenser, 50–150 Mmfd.	1.75
C_2—General Radio Midget Neutralizing Condenser.	1.25
R_6, R_7, R_8—Lynch 0.1-Meg. Standard Metalized-Filament Resistors	2.25
R_9—Lynch 0.1-Meg. Type C Metalized-Filament Resistors	1.00
R_{10}—Lynch 0.5-Meg. Standard Metalized-Filament Resistors	.50
R_{11}—Lynch 1000-ohm "Suppressor"	.75
R_5—Lynch 2000-Ohm Type P Wire Wound Resistor	1.25
R_1—Lynch 2-Meg. Standard Metalized-Filament Resistor	.50
C_3, C_6, C_7, C_8, C_{10}—Tobe 1-Mfd. By-pass Condensers	4.50
C_9—Tobe 0.1-Mfd. Bypass Condenser	.60
R_{12}—Electrad Royalty Variable Resistor, Type K	1.50
C_4—Sangamo 0.00025-Mfd. Mica Condenser	.35
C_5—Sangamo 0.001-Mfd. Mica Condenser	.40
L_4—Samson No. 85 R. F. Choke	1.50
R_4—Carter 20-Ohm Midget Potentiometer	.75
Two Eby Binding Posts	.30
Four—General Radio No. 439 UX Sockets	2.00
One General Radio No. 438 UY Sockets	.50
Eight Lynch Single Resistor Mountings	2.80
Bakelite Panel, 7 x 21 Inches	2.75
Bakelite Sub-Panel, 9 x 20 Inches	2.75
Wire, Etc.	.50
TOTAL	$75.70

ACCESSORIES

One CX-371 (UX-171) or Ceco J-71 Tube	$ 4.50
One CY-327 (UY-227) or Ceco R-27 Tube	6.00
Three CX-326 (UY-226) or Ceco R-26 Tubes	9.00
One UX-280 (CX-380)	5.00
One National No. F226 Filament Heating Transformer	10.00
One B-Power Unit, National Type M	40.00
TOTAL	$74.50

Looking Back

THE STORY OF RADIO. By Orrin E. Dunlap, Jr. Published by the Dial Press, New York. Price $2.50; pages, 226; illustrations, 15.

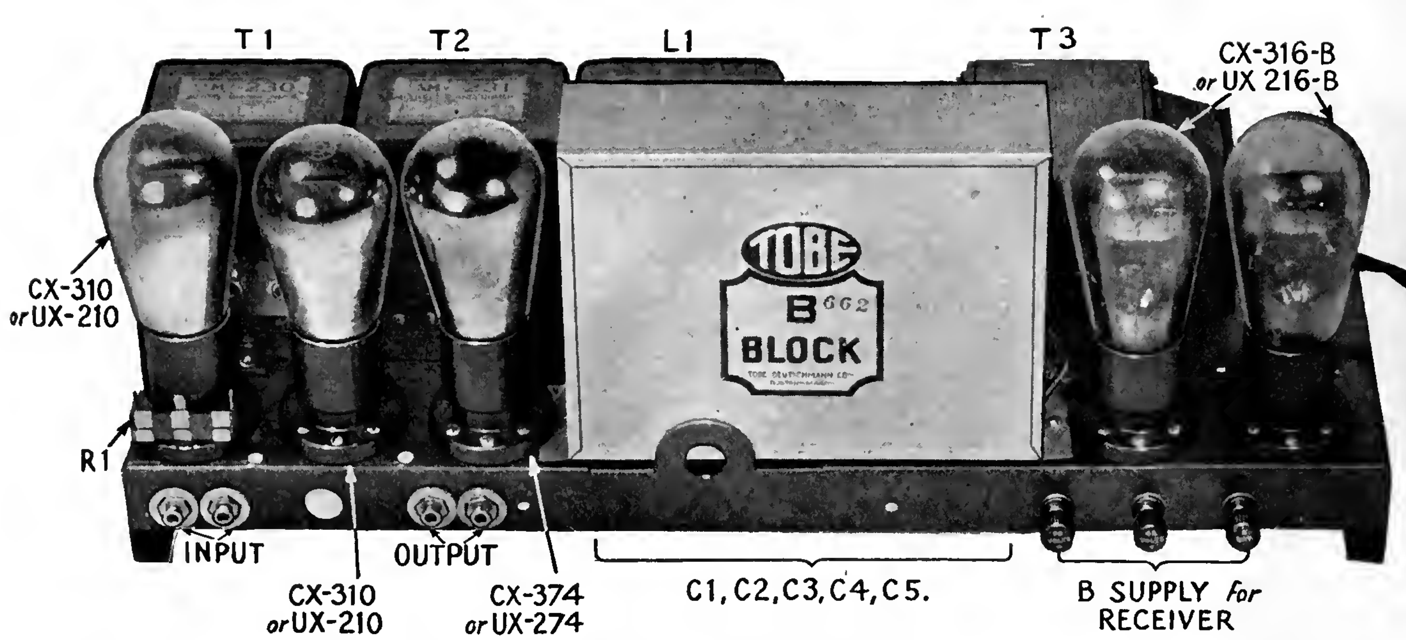
THIS book, by the Radio Editor of the New York *Times*, is a literary effort to squeeze some more thrills out of radio for the benefit of laymen who desire knowledge but do not want to struggle for it. There is nothing technical in its two hundred or so pages but, in a journalistic and often very interesting fashion, it gives a history of radio progress, and manages to touch on such topics as transmission theories, fading, radio direction finders, and piezo-electric control. The various branches of radio communication, such as aircraft work and transatlantic radio telephone circuits, are described; there are several pages on auditory phenomena; short waves and television are not neglected. The history of radio is told in the first person, presumably by the spirit of the ether, or some loquacious band of waves. The effort to sustain an appeal to the imagination results in some very silly passages, the worst one appearing in the introduction:

> Will the millions and billions of musical scores and countless numbers of spoken words ever return from the Infinite? Will the waves all roll back some day, all intermingled, the music of centuries, the works of all composers a hopeless jumble, a babel of voices, all so powerful electrically that the onslaught of invisible waves will burn up the ether and radio will be no more?

The answer is that this catastrophe will positively not occur, unless at that time God sees fit to suspend the second law of thermodynamics, retroactively.

But, with the exception of some of the chapter headings and captions, which have no conceivable relation to the text, this drivel is not representative of the contents of Mr. Dunlap's book. He is, in point of fact, an old radio man, and a Member of the Institute of Radio Engineers, and when he remembers that there is only one inimitable Judge Rutherford, he does a good job. What he says is, in the main, accurate, and jazzed up only within the limits permissible in such a book. He has at his fingers' ends, or in his scrap book, about all the interesting things that have ever happened in radio, and in "The Story of Radio" relates them for an audience to which they will be utterly new. The events of the war in the radio field dramatic, SOS episodes, the old Herald station, OHX, silent these fifteen years, all live again in Dunlap's pages, and it is pleasing to see their appearance in a more or less permanent record. Give the book to your son as a birthday present, if you have not already bestowed it on him for Christmas.

—C. D.



A PUSH-PULL POWER AMPLIFIER

The amplifier illustrated above is designed to give excellent quality reproduction of radio programs. The push-pull amplifier uses two CX-310 (UX-210) power tubes which are capable of supplying to a loud speaker large amounts of undistorted power. The entire amplifier is constructed on a pressed steel sub-base

A NEW "TWO-TEN" POWER AMPLIFIER

By William Morrison

THE combined push-pull power amplifier and light socket B power unit described on pages 163 and 164 of the July RADIO BROADCAST has recreated considerable interest in push-pull amplification. The device described consisted of a single-stage push-pull power amplifier built into a steel case and chassis assembly which also housed the power supply equipment. The latter furnished A, B, and C power to the push-pull amplifier and B power for the radio receiver as well. While this unit, termed for simplicity a "Unipac," possessed considerable merit, its power output, even with a pair of 171 type power tubes, would appear to be insufficient for really substantially distortionless reproduction, assuming that from 1.5 to 2 watts of power is required for good dance music volume, and that the amplifying system should possess a fairly flat frequency characteristic of from 30 to 5000 cycles.

The undistorted power output obtainable from the previously described unit is higher than is generally obtained from receiver output stages, and, in fact, is greater than is often obtained from some of the more popular power packs employing a 210 type tube, the operating voltages of which are often less than they should be.

As a result of the interest that has been displayed in this earlier push-pull "Unipac," a higher-powered model has recently been developed employing a pair of UX-210 (CX-310) type amplifier tubes capable of delivering from 3 to 4 watts of undistorted power to a good loud speaker. It is probably quite safe to say that this is one of the most powerful receiving amplifiers yet developed for the home constructor, and the quality of reproduction it provides is really remarkable. After listening to the push-pull amplifier of the type described here, the significance of the popular phrase "tube overloading," as applied to conventional receiving amplifiers, is really brought home.

This newer combination is illustrated herewith, and closely resembles the push-pull model previously described. The new "Unipac" consists of a full-wave rectifier, which may use either UX-216B (CX-316-B) or the new UX-281 (CX-381) type tubes, and a push-pull amplifier stage with the two UX-210 (CX-310) power tubes. A good idea of the details of the device may be gained from the detailed circuit diagram, in which the parts are lettered to agree with the list of parts on the next page.

The power supply uses a large, full-wave power transformer supplying 7.5 volts from two separate windings for lighting the rectifier and amplifier tubes. Its priimary is designed for 105- to 120-volt, 60-cycle, lighting circuits, while a split high-voltage secondary supplies 550 volts a.c. (r.m.s.) to the plates of the rectifier tubes. Due to good transformer design, the UX-216-B (CX-316-B) rectifier tubes will deliver from 500 to 530 volts of unfiltered d.c. at a 106 mA load. This voltage is about all that may safely be used upon 210 type amplifier tubes after a 40-volt drop has been allowed for in th filter system. The filter output is about 460 t 490 volts d.c., of which 35 to 40 are used for C bias on the amplifier tubes, the remaining 425 t 450 volts being actual plate potential supplie to the push-pull amplifier. The rectifier life wil be quite good since each UX-216-B (CX-316-B is called upon to furnish only 53 mA., while thes tubes are actually capable of supplying 65 mA A single UX-281 (CX-381) rectifier would delive nearly the same power output as the two 21 type tubes, but the use of a single half-wav rectifier, such as the type 281, is generally to b discouraged as increasing the filtration problem and almost invariably resulting in an excessivel high value of hum in the loud speaker. Two 28 type rectifier tubes, however, will give a highe output than two 216-B tubes by about 50 to 6 volts, and their use is recommended, not so muc because of the increased power output, but because of their probable longer life due to oxid coated filaments and rather generous design.

The filter system is substantially the same a is used in the smaller "Unipac," except for th use of 1000-volt condensers, which are necessar because of the high voltages used. A combinatio selective and "brute-force" filter scheme is employed, resulting in very good filtration at hig current values.

The amplifier stage consists of a split windin input transformer with a step-up ratio of 3:1 pe tube, and a split winding output transforme matching the impedance of the UX-210 (CX-310 amplifier tubes to that of a Western Electric o similar loud speaker at 30 cycles. The overall voltage gain of the amplifier is about 20 to 22 times.

Facts About This Amplifier

Circuit: Single stage push-pull power amplifier

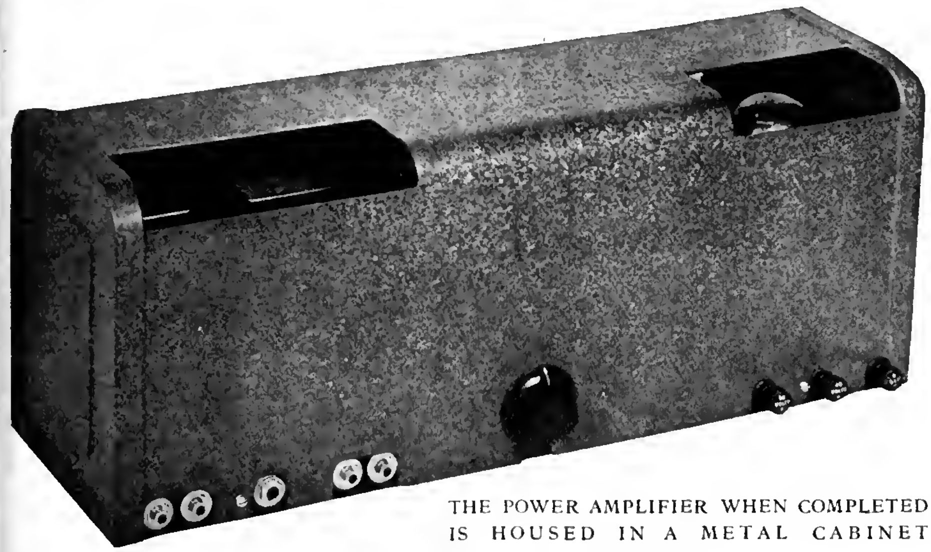
Tubes, Two CX-310 (UX-210) tubes in push-pull amplifier, two CX-316-B (UX-216-B) rectifiers, one CX-374 (UX-274) glow tube.

Cost: $83.25, without tubes. (Tubes: $38.50)

This power amplifier is capable of supplying 3 to 4 watts of undistorted power to a loud speaker. Complete A, B, and C power is obtained directly from the light socket. The rectifier and filter system are designed to supply the power amplifier tubes with about 500 volts for the plate and the necessary C bias. The unit is arranged to replace the second audio stage in a receiver. The unit is encased in a nicely finished metal cabinet

CONSTRUCTION

THE construction of the "Unipac" is quite simple, involving only the mounting of a number of standard parts upon a standard steel chassis, the wiring up of these parts, and the



THE POWER AMPLIFIER WHEN COMPLETED IS HOUSED IN A METAL CABINET

final attaching of the cabinet or ventilated housing after the unit has been tested. The parts needed are listed below:

T_3—328 Super Power Transformer	$18.00
L_1—331 "Unichoke"	8.00
T_1—230 Push-Pull Input Transformer	10.00
T_2—231 Push-Pull Output Transformer	10.00
Five 511 Tube Sockets	2.50
C_1, C_2, C_3, C_4, C_5—Type 662 Condenser Block	18.00
R_2—651 Resistor (Ward-Leonard) Set	7.00
Four Frost 253 Tipjacks	.60
R_1—Frost FT64 Balancing Resistance	.50
Van Doorn 661 Steel Chassis and Cabinet, with Hardware	8.00
Three Eby Binding Posts (B—, +45, +90)	.45
Twenty-Five Feet Kellogg Fabricated Hook-Up Wire	.20
	$83.25

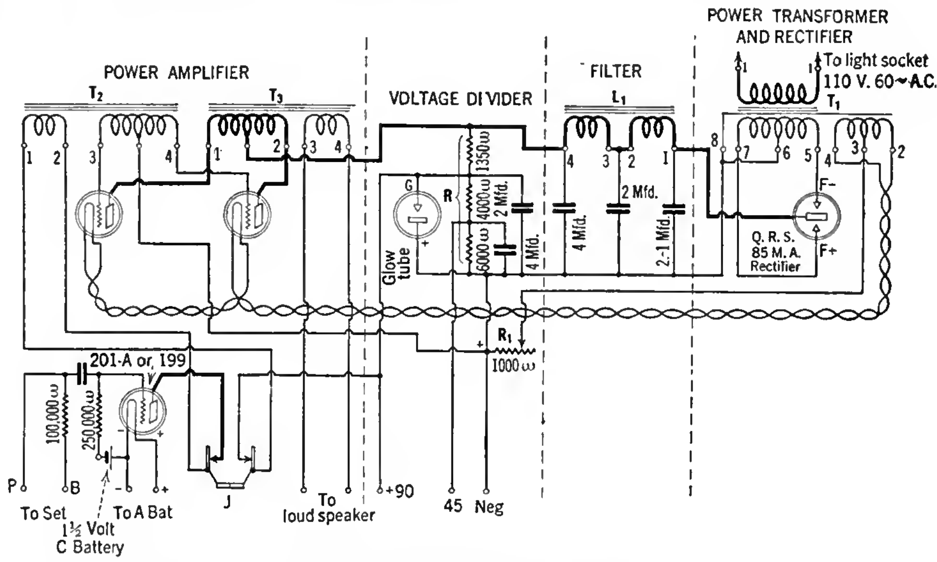
Unless otherwise noted, all the parts listed above are manufactured by Silver-Marshall.

The tubes required for the operation of the "Unipac" are as follows:

Two UX-216-B or CX-316-B Half-Wave Rectifier Tubes (CX-381 or UX-281 Optional)	$15.00
One UX-274 or CX-374 Ballast Tube	5.50
Two UX-210 or CX-310 Power Tubes	18.00
	$38.50

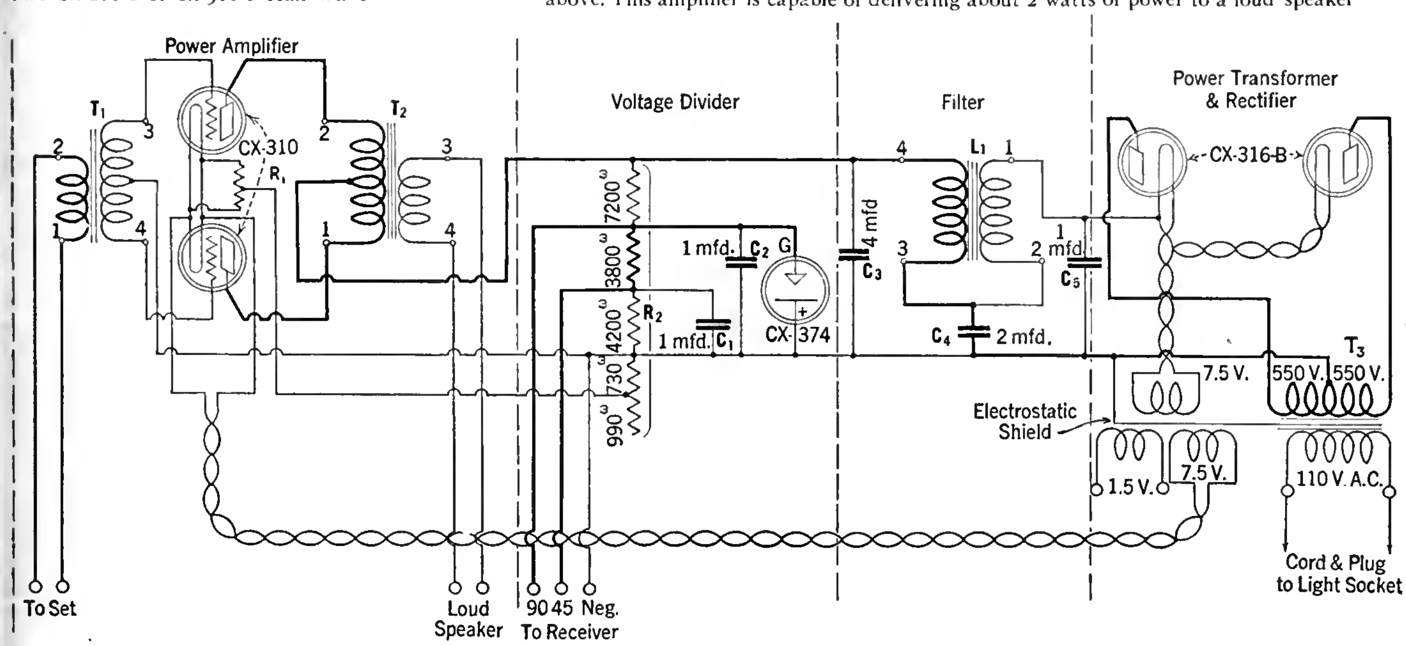
The "Unipac" will furnish ample power to a radio receiver at 45 and 90 volts with voltage held constant by a potential dividing resistance and a glow tube voltage-regulator, preventing high open-circuit voltages to develop, which might damage receiver condensers. The amplifier replaces the conventional second audio stage of a receiver, the input tipjacks connecting to the first audio stage output terminals of the receiver, and the loud speaker connecting to the output jacks of the "Unipac."

In operation, all tubes will get quite hot, as will the larger Ward-Leonard resistor. This is correct, as is a slight warmth noticeable in the power transformer core. It is necessary always to see that the B minus post is grounded, directly or indirectly through a condenser.



A 171 PUSH-PULL AMPLIFIER

The circuit of the 171 type push-pull amplifier described in the July, 1927, RADIO BROADCAST is given above. This amplifier is capable of delivering about 2 watts of power to a loud speaker



A 210 PUSH-PULL AMPLIFIER

The circuit diagram of the super-power amplifier described in the article given in this illustration. The 550-volt transformer, T3, at the right, supplies the two rectifier tubes with sufficient voltage so that when it is rectified and filtered each of the power amplifiers will receive about 500 volts each. A glow tube is incorporated in the circuit to maintain the voltages constant, independent of the load. The loud speaker is fed with energy through an output transformer.

The Listeners' Point of View

THE DX LISTENER FINDS A CHAMPION

By JOHN WALLACE

THE DX hound comes in for a lot of unwarranted disparagement. He is viewed askance by his more enlightened brethren as a benighted soul with a perverse idea of what radio ought to be used for. His greatest delight, as they picture it, is in attacking his receiving set with a screw driver and soldering iron, disemboweling it and putting it together a different way. He is said to prefer the faint whisper of call letters from some mission station in heathen Africa to hearing the Prince of Wales sing Frankie and Johnny from the local station. In his defense it has been iterated from time to time that his experimenting made radio what it is to-day. This vindication seems to us to be still a pretty sound one.

There are two types of DX hounds, the radicals and the conservatives. The extremists care for nothing but distance. They will labor into the small hours of the night to pick up the signal of a station half a continent away. Their standard of reception fidelity is not exacting—all they ask is that the *B*s be distinguishable from the *P*s. Once they have gained their quarry (which Mr. Webster describes as "the entrails of the prey, given to the hounds") their interest is over and they start in pursuit of some other station. We are in no special sympathy with this hunting breed of DX hound, but we will not have it said that he is quite useless. He has forced an increase in the range of receiving sets.

But the conservative hound likes to have a little sport with his catch after he's run it down. Once he has got a distant station he labors patiently at tuning it to shut off all extraneous noises. Not until he has the program coming in with the clarity of a local one is he satisfied. Then, if the program is a good one, he listens to it. With the pleasure he experiences from the program is an added stimulation in the realization that he is eavesdropping on a scene transpiring some hundreds of miles away with no connection between him and that remote city but some great open space and an assortment of ether waves. If a sympathy with his endeavours and an occasional emulation of them makes us a DX hound, then—we are a DX hound. Those who advance the protest that radio is now so much a matter of fact that they cease to marvel at its wonders present not half so good a defense of their attitude as they do a confession of their lack of imagination.

After all, the unique thing about radio is not that it brings music into your home—the phonograph did that years ago—but that it conquers distance. It was radio's ability to conquer distance that gave it its initial impetus, that seized the public imagination and bounded it along to an unprecedentedly swift success. It seems a bit of the basest ingratitude—a sort of biting the hand that feeds you—for radio to turn its back now on the characteristic that gave it birth. And, turning its back on it, it is, what with its two latest developments: chain broadcasting and wired broadcasting. Chain broadcasting, with its extended use of telephone wires has made the listener in large cities content to receive his distant programs from a station perhaps a few blocks away. Wired radio, while it still exists only as a rumor, is likely to come any time soon. Here the program will be circulated on the already existing electric power lines which enter almost every civilized household, and the program received will have spent no instant of its life bounding on an ether wave. This seems to us a distinct retrogression, technically at least. Of course we do not argue that a trip through the ether makes a program any better; under present conditions the wired program is frequently better in quality. But the one is genuinely *radio*, the other simply glorified telephony. In short, wired radio, and, to a lesser degree, chain broadcasting, summarily renounce the fundamental principle upon which radio was founded—space annihilation.

This renunciation seems to us premature. The possibilities of radio broadcasting have not been completely exhausted. Hardly a score of years of experimentation has been completed. Certainly the idea is worth a score more.

It may be very practically objected that atmospheric conditions, over which man has no control, simply render it impossible to extend further the range and reliability of radio reception. This is practically true. Theoretically it is false and since this is a theoretical article we will press our point further. A demonstrable increase in range has been effected within the past few years by increasing the power of transmitters and the efficiency of receivers. There has been no sign from heaven to indicate that this increase has reached its limit. So, having utterly no knowledge of the mechanical problems of radio, but an unbounded faith in the uncanny powers of its technicians we argue that they can further perfect it if they try. But if interest in long range broadcasting is abandoned it's a cinch they won't try.

Radio's unique contribution to what is drolly referred to as the "progress" of civilization is the conquering of space. We repeat ourself? As a follower of radio programs we are well aware that it has made an enormous contribution to mankind by making music once again part of his daily life. In this rôle it has been of incalculable benefit. However, this rôle, important as it is, is none the less a secondary one. It is possible for a man in his home to survive the evening without an after dinner concert, but a man at sea on a ship with a hole in it is dependent upon radio for his life. The city dweller can go to a concert hall when he craves music and entertainment, but the dweller at a lonely outpost in Canada is dependent upon radio for any break in the monotony of his existence. A catastrophe such as a cyclone or an earthquake may cut off wire communication with a devastated area but radio may still be able to penetrate and convey important, perhaps life saving, messages. Or, to cite a fanciful but none the less valid instance of the primary importance of radio as a long distance agent: in time of war an invading force could throttle all wired communication within the nation but a few well entrenched transmission stations could still reach the entire populace.

DAVID BUTTOLPH

The gifted young conductor of the National Concert Orchestra, regularly heard through the red network of the National Broadcasting Company

As we have said, further extension of the range of broadcasting, particularly in the face of the apparently unsurmountable difficulties it has already met, is dependent upon a sustained interest in achieving this end. So we think the vast army of DX hounds instead of being reviled should rather be looked upon as a desirable faction and, an important balancing element in radio's development.

While, personally, we are most frequently interested in the musical things radio has to offer, we look forward to the time when it will put us in easy touch with foreign shores. Perhaps some further use will be made of short-wave broadcasting and reception to this end. There would be a kick in that which not even the staunchest deprecator of DX could deny. But such an entertaining, and indeed instructive, state of affairs will not have been reached until after we first overcome the not inconsiderable distances in our own U. S. If we ever do this it will be due to the persistency of the DX hounds.

What We Thought of the First Columbia Broadcasting Program

SUNDAY, the eighteenth of September, witnessed the début of the long heralded Columbia Broadcasting System. The evening of Sunday, the eighteenth of September, witnessed your humble correspondent, tear stained and disillusioned, vowing to abandon for all time radio and all its works and pomps. We have since recovered and will go on with our story. The broadcast divided itself into three successive parts, descending in quality with astounding speed.

PART ONE: THE VAUDEVILLE

This program came on in the afternoon, after a half hour's delay due to mechanical difficulties—a heinous sin in this day of efficient transmission, but excusable, perhaps, in a half-hour-old organization. This opening program, at least, was auspicious. The performers were of superlative excellence. Bits from a light opera were well sung. A quartet gave a stirring rendition of an English hunting song. A symphony orchestra played some Brahms waltzes. A soloist sang "Mon Homme" in so impassioned a fashion that she must have swooned on the last note. Then a dance orchestra concluded the program with some good playing. The offerings were of such high quality that it was doubly disconcerting to have them strung together with a shoddy "continuity"—especially with such stupid and overdone continuity as the "and-now-parting-from-Paris-we-will-journey-to-Germany" type.

Continuity is a device used to bolster up weak programs. It is a bit of psychological trickery designed to keep the listeners listening even while their own good sense tells them that there is nothing being offered worth listening to. A good steak doesn't need to be served with sauce, but there's nothing like some pungent Worcestershire for camouflaging the defects of a bad one. The items offered on this afternoon program were good enough to serve ungarnished, and were cheapened by the introductory blah.

PART TWO: THE UPROAR

"Uproar," let us hasten to explain, is Major J. Andrew White's way of pronouncing Opera. We seek not to poke fun at this announcer; he is one of the best we have. (Though we think both Quin Ryan and McNamee outdid him in the recent fight broadcast). But his habit of tacking *Rs* on the end of words like Americar and Columbiar doesn't fit into a high-brow broadcast as well as it does in a sports report. The Uproar was "The King's Henchmen" by Deems Taylor. Evidently no effort was spared to make the broadcast notable. A good symphony orchestra was utilized, capable singers were employed, and Deems Taylor himself was intrusted with the duty of unfolding the plot. But after all it was "just another broadcast." Musical programs into which a lot of talk is injected simply will not work. One or the other has to predominate. Either make it a straight recitation with musical accompaniment—or straight music with only a sparing bit of interpretative comment.

Mr. Taylor's music for this opera is delightful, the singing was admirable, but the total effect was disjointed and unsatisfactory. The composer outlined the story, but, enthralling as it may be on the stage, it was impossible to visualize the action with any degree of vividness from his words. We felt continually aware that there was really no action taking place, and the effort at make believe was too strenuous and detracted from an enjoyment of the music. It was less effective, even, than a broadcast from the regular Opera stage. Here the piece is likely to be more familiar and it is possible to conjure up its pantomime from remembrances of performances seen.

It is our humble and inexpert opinion that program designers are barking up a wrong tree and wasting a lot of energy in their unceasing attempts to fit spoken words into musical programs. But if they will persist let us suggest that they are going about the job in a blundering way with no proper realization of its difficulty. All present essays in this line fall into two classes: those which attempt to relate starkly the necessary information in a minimum number of words, and those which attempt to give a spurious arty atmosphere by the meaningless use of a lot of fancy polysyllables.

Neither method works. The first is distracting and effectively breaks up any mood or train of thought that may have been induced by the music. The fancy language system, besides being obviously nauseating, takes up too much time.

Program makers may as well realize soon as later that the simple possession of a fountain pen doesn't qualify a man for writing "script" or other descriptive text. It is a job calling for the very highest type of literary ability and one that can't be discharged by just anybody on the studio staff. The properly qualified writer should be able to state the information tersely, *but*, with all the vividness of a piece of poetry. Each word he uses must be selected because it is full of meaning, and of just the right shade of meaning. Any word not actively assisting in building up a rapid and forceful picture in the listener's mind must be sloughed off. A further complication: the words can't be selected because they look descriptive in type, but because their actual *sound* is descriptive. Altogether an exacting job; it would tax the ability of a Washington Irving.

It is highly improbable that a genius at writing this sort of stuff will ever appear; the ether wave is yet too ephemeral a medium to attract great writers. But there is no question that scriveners of some literary pretensions could be secured if the program builders would pay adequately for their services. This they will never do until they realize the obvious fact that the words that interrupt a program are just as conspicuous as the music of the program itself. It is incongruous, almost sacrilegious, to interrupt the superb train of thought of Wagner or Massenet to sandwich in the prose endeavours of Mabel Gazook, studio hostess, trombone player and "script" writer.

PART THREE: THE EFFERVESCENT HOUR

O dear! O dear! Whither are we drifting!

You have all heard the ancient story of the glazier who supplied his small son with a sack of stones every morning to go about breaking windows. Comes now a radio advertiser who deals in stomach settling salts with a program guaranteed to turn and otherwise sour the stomach of the most robust listener. The Effervescent Hour was the first commercial offering of the new chain and far and away the worst thing we ever heard from a loud speaker. We thought we had heard bare faced and ostentatiously direct advertising before, but this made all previous efforts in that line seem like the merest innuendo. The name of the sponsoring company's product had been mentioned ninety-eight times when we quit counting. An oily voiced soul who protested to be a representative of the sponsoring company engaged with announcer White in sundry badinage before each number, extolling the virtues of his wet goods and even going so far as to offer the not unwilling announcer a sip before the microphone. Stuck in here and there amidst this welter of advertising could actually be discovered some bits of program! But such program material it was. First the hackneyed "To Spring" by Grieg. Then "Carry Me Back to Old Virginia." Next some mediocre spirituals followed by a very ordinary jazz band and culminating with a so-called symphony orchestra which actually succeeded in making the exquisite dance of the Fée Dragée from the "Nutcracker Suite" sound clumsy and loutish—no mean achievement.

One long interruption occured while special messages were given to soda jerkers the country o'er, inviting them to enter a prize contest for the best encomium to the advertiser's wares. But the most aggravating interruptions were the frequently spaced announcements: "This is the voice of Columbia—speaking." This remarkable statement was delivered in hushed and reverential tones, vibrant with suppressed emotion, a sustained sob intervening before the last word. It was positively celestial. We have given a rather complete résumé of this program, but it may be warranted by the fact that probably not a dozen people in the country, beside ourself, heard it. No one not paid to do so, as we are, could have survived it. Perhaps this indictment of Columbia's opening performance is unkind in the light of subsequent offerings. Our stomach is still unsettled. Furthermore we will *not* make use of any of the Effervescent Hour's salts to settle it!

THIS MONTH's prize for the ugliest and most cacophonous coined name plastered on any troup of radio performers is hereby awarded by unanimous and enthusiastic vote to wow's popular entertainers the Yousem Tyrwelder Twins!

A FAMILIAR WBZ-WBZA PROGRAM GROUP

The Hotel Statler Ensemble Group, one of the best of the dinner orchestras in the New England territory. From left to right: Helen Clapham, Hazel McNamara, Katherine Stang, leader, and Virginia Birnie

AS THE BROADCASTER SEES IT

BY CARL DREHER

Drawing by Franklyn F. Stratford

Radio As An Electro-Medical Cure-All

THAT electricity plays a considerable rôle in the physiological functions is a fact well known and already extensively investigated. But outside of the area of verified or verifiable observations there is, as in every other division of science, a penumbra of dubious ideas, and beyond that lies what Theodore Roosevelt called, in one of the most apt of phrases, the lunatic fringe. Roosevelt was concerned with the field of politics, but politics have no monopoly of lunatics—nor knaves. The two are frequently coupled.

I am forced to these melancholy reflections on re-reading a newspaper article which was clipped for me during the summer. Under the caption, "Metal Lingerie As Radio Shield," it related the adventures of an afflicted governess in the radio realm. It seems that for years the lady suffered from "mysterious burns, bruises, blisters, and internal pains," which, of course, the doctors were unable to explain or cure. Thereupon a learned scientist (non-medical) came to her rescue. He subjected the sick woman to extensive tests, including the effect of ultra-violet, infra-red and X-rays, as well as short and long radio waves. She was very sensitive to all these oscillations and the professor decided that they might be responsible for her pains. He designed for her some metal screen lingerie to act as a shield against the nefarious oscillations. The method of keeping a ground on this intimate shield, as the wearer moves about, is not disclosed. Nor, unfortunately, are the results of the treatment reported. The article does state, however, that the afflicted woman. while previously in hospital near a radio station, heard sounds like the wind whistling through the shrouds of a ship, she would awake in the night with pains in her neck and ears, and hear a "dream-like voice." At this time she spent ten weeks in an insane asylum in the hope of being relieved.

There she was probably on the right track, and the fact that she entered the asylum voluntarily indicates some degree of insight, with a favorable prognosis if the patient came under the care of a skilled psychiatrist able to give her the requisite attention. She is almost certainly a mental case. The fact that she was bothered in the tests by electrical oscillations proves precisely nothing. If, as part of her psychosis, she was convinced that electrical waves made her ill, she would exhibit symptoms during any tests in the course of which she knew or suspected such waves were being generated. Even skin maladies may be of hysterical origin; this is the modern explanation of the "stigmata" which, in the Middle Ages, were taken for crosses printed on the bodies of certain persons by divine intervention, just as people might be possessed by devils through the machinations of Satan. Both beliefs are still firmly held in some parts, although their influence as a whole has decreased inversely with the spread of scientific ideas.

If radio waves were capable of exerting physiological effects professional radio workers in transmitting stations would certainly manifest whatever symptoms could result. Spending eight hours or more each day in an atmosphere where the field strength is many volts per meter, some of them, after thirty years, should be lamentably corroded in sensitive regions. But I have never heard of a radio man quitting a transmitting station because the waves were hurting him. I have seen them quit because they did not like the cooking, or the shape of the superintendent's nose, or the movies in the near-by town, but not one of them ever seemed to realize that Hertzian oscillations were whizzing through him at a velocity of 186,000 miles a second and might cause his vital juices to curdle. This seems to me cogent evidence. While many individuals might be resistant, surely among some thousand of exposures a considerable amount of pathology, definitely traceable to the ether waves, would by this time have accumulated. As for the pitiably feeble emanations a few miles from a station, which cannot even be heard until they are amplified on a grandiose scale, doing a man any harm—that chance is about as great as One-Eyed Connelly's hopes of becoming President of the United States. And the possibility of benefiting a patient physiologically, save incidentally through entertainment or education, is equally large.

But some of the apostles of the late Doctor Abrams' medical credo know better. One of them relates in a learned journal of his cult the story of his efforts to benefit the human race by "Improvement in Electronic Diagnostic and Treatment Apparati; Broadcasting Electro-Magnetic Radio Treatment Waves." He has made his diagnostic circuit bigger and better, he feels, by adding "amplifying attachments" as follows:

1. A solenoid with its South attached to the dynamizer and its North connected by wire to the head-band electrode of the subject, thence, through subject and grounded plates, to a metal stob driven two feet into the earth.

2. The South end of diagnostic set is connected to a second metal stob. These stobs are set eight or ten feet apart *on the magnetic meridian* as ascertained by the compass.

3. A small high-frequency machine for increasing the electric tension to drive all possible of the radiant force of disease through the diagnostic set and subject; and to stimulate the subject's reflexes so that they will act with their highest efficiency. . . .

What the "stob" part refers to I cannot say. The word is not in the dictionary.

But the Doctor continues:

Later I added a one-stage radio amplifier to the above diagnostic outfit which multiplies its findings four times. Instead of carrying the wire leading from the last reflexophone to the head band of the subject, it is carried to the positive side of the one stage radio amplifier's transformer and then a second wire is carried from the negative side of the amplifier's transformer to the head-band electrode on the subject.

Now comes the actual radio application of the idea. A two-stage radio amplifier, according to the description, is attached to the "master oscilloclast." The electronic treatment is thus let loose on the world, first on a small scale:

In the electric store two doors away we secured specimens for electronic examination of four people and secured specimens from two people in a store in the same building with the treatment instruments. We then made electronic examinations of the six specimens and recorded what infections those people were carrying. After running the instruments some twenty days, we again secured specimens from the same people and made reëlectronic examinations. We found that four of the people were negative of their carried infections—the other two not quite negative but their infections had greatly reduced, showing that only a few more days of broadcasting would render them negative.

These experiments proving to us that infections could be destroyed at a distance of one hundred fifty (150) or more feet through air, brick walls, glass doors, windows, etc., we decided to broadcast the treatment waves out for a mile or more. We had made a five-stage radio-transmitting broadcasting instrument that multiplied the eighteen multiplication, of master machine, by fifteen hundred times making a total multiplication of master machine twenty-seven thousand (27,000) times—we then had erected a broadcasting aerial on top of a five story building and connected by wire the instruments, oscilloclast, two-stage amplifier, one treatment short circuited unit and the five-stage radio-transmitter to the aerial. We then started up the instrument. Then we secured a large radio receiving set (with loud speaker) from the electric company and set it up in a seven-passenger automobile and three of us,

"HE SUBJECTED THE SICK WOMAN TO EXTENSIVE TESTS" a skilled electrician and radio mechanic, chauffeur and myself, tuned at the curb in front of the electric company and could hear the working of the oscilloclast—we then drove five squares and tuned in and could hear the instrument and at intermediate points for a little more than a mile, showing that the treatment waves were being broadcast a mile or more.

We then secured specimens for electronic examination from a distance of half a block up to three miles and from many intermediate points. The number of specimens secured from beginning of broadcasting, from November 1, 1926, to present date, January 20, 1927, were thirty-three. We have found that out of that number twenty-three have been made negative—the balance, ten, have been greatly reduced, showing that it will only require a week or ten days further broadcasting of the treatment waves to render them negative.

The amplified treatment machines are run by batteries that are fed from the electric light socket and will last from four to six months; otherwise batteries only last a few days. The five-stage radio-transmitter is also fitted up with a large battery supplied by electric socket and it in turn supplies the dry batteries, making the apparatus very efficient and durable.

. . . In the last six weeks or more, with broadcasting outfit we have treated electronically a population of fifty thousand (50,000) on an average of two hours per day, making a total of one hundred thousand (100,000) hours per day. If the broadcasting electronic treatment waves have rendered negative two-thirds of the fifty-thousand (50,000) population and reducing the other one-third, as was proven in the thirty-three test cases (two-thirds made negative, one-third reducing) taken out of the same population we can readily see the great benefit and per day value to the people. Giving the value of one dollar per hour for treatment of each individual (which is a low tariff fee) we have a total of $100,000.00 per day.

If a transmitter fed from batteries can benefit the surrounding population to the extent of $100,000. per day, conceive of the value of a 100-kw. outfit devoted to the same philanthropic purpose! Why not make it 10,000 kw., while we are at it? Assuming that the professor's present equipment has a capacity of 20 watts, the 10,000-kw. set would be worth $50,000,000,000. a day to the citizens of the United States, on the valuation basis assumed in the first place. This is of the general order of the amount of business transacted in the country in a year. It is clear, therefore, that a stupendous wealth producing agency is in the hands of the electronic practitioner, which, I suppose, makes him feel very bad.

For my own part, I have some qualms. By broadcasting these electronic treatments, the learned Doc cures all the people within reach of their ailments. But why only the people? Any such general specific must also be good for animals. Horses will be cured of the blind staggers, tubercular monkeys will rise from their beds, sick cockroaches will report at the office fit for work. The rats, pediculi, and bed-bugs (*Cimex lectularius*) may benefit even more than human beings, who may thereby be crowded off the earth. I hope that the electronic broadcaster will consider this aspect of the matter and quiet my fears if he can.

Some Catalogues

BULLETIN No. 1 of H. F. Wareing and Associates, on *Modulator Reactors*, will prove of interest to some broadcasting stations. This company, whose address is 401 Pereles Building, Milwaukee, Wis., is in the business of supplying apparatus and service to broadcasting stations. The first bulletin includes a discussion of modulator reactor design, and a price list of types stated to be suitable for transmitters from 50-watt to 10-kilowatt size. The corresponding currents for which the chokes are built vary from 0.25 to 5.00 amperes, at d.c. voltages of 1000-5000. Ten- thirty-, and fifty-henry reactors are available. Bulletins on other broadcast station equipment are to be issued by H. F. Wareing and Associates at intervals, according to the announcement reaching us.

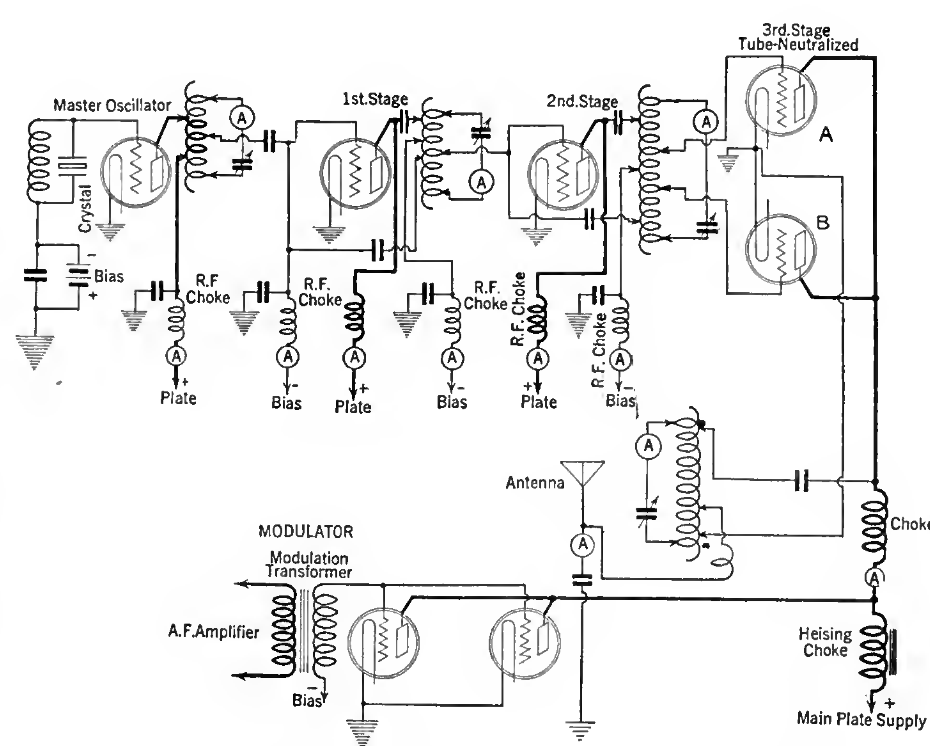
The Samson Electric Company of Canton, Massachusetts, distributes a "Radio Division Price List" including, besides the usual radio parts sold to receiver constructors, such items as microphone input transformers, tube-to-line and line-to-tube transformers, mixer equipment, and other specialized broadcast transmitter and public address material. They have made up a blueprint showing a small public address system assembled with their parts. Provision is made for microphone, radio set, and phonograph pick-up. There are three 0.25 ampere (filament) tubes, and apparently the output stage is push-pull, using 5- or 7.5-watt tubes. On this basis the volume capacity should approximately equal that of the Western Electric 3-A size P. A. system.

Design and Operation of Broadcasting Stations

18. *Piezo-Electric Control*

THE field of piezo-electric phenomena includes the generation of electrical potentials in various substances by the application of physical pressure, and, conversely, changes in physical dimensions directly correlated with electrical conditions. It is not a new division of physics; the piezo-electric properties of quartz, for example, were investigated by P. and J. Curie in 1889. The effect itself was discovered by the brothers some years earlier. Prof. W. G. Cady, about eight years ago, began the work which resulted in the application in the radio art of crystal frequency control. He reported his investigation of "The Piezo-Electric Resonator" in the *Proceedings of the Institute of Radio Engineers*, Vol. 10, No. 2, April, 1922. Oscillating crystals are used as frequency standards in wave meters and monitoring units, some practical forms much used by broadcasting stations being those produced commercially by the General Radio Company. RADIO BROADCAST has printed two comprehensive articles by M. T. Dow on crystal circuits and measurement applications (January and September, 1927). A direct form of frequency control of particular interest to broadcasters is that in which the transmitter functions as a radio-frequency amplifier, the master oscillator being a crystal-controlled tube. Some recent engineering publications on this aspect include three in the I. R. E. *Proceedings:* A. Crossley: "Piezo-Electric Crystal-Controlled Transmitters" (Vol. 15, No. 1, Jan., 1927); A. Meissner: "Piezo-Electric Crystals at Radio Frequencies" (Vol. 15, No. 4, April, 1927); and H. E. Hallborg: "Some Practical Aspects of Short-Wave Operation at High Power" (Vol. 15, No. 6, June, 1927). In the present article an attempt will be made to introduce the subject to broadcast operators who have not worked with crystal-controlled transmitters so that when they are called on to operate such equipment they will be in possession of some of the elementary facts.

In itself the use of a crystal is no guarantee of frequency stabilization to any required degree of accuracy. Some broadcasters seem to believe that the use of a crystal in almost any kind of holder, with some sort of radio-frequency amplifier following, will insure constant frequency radiation. Actually a crystal is of little use unless



THE CIRCUIT DIAGRAM OF A CRYSTAL-CONTROLLED TRANSMITTER

In actual practice, tubes A and B in the third stage generally consist of two banks of power tubes. The filaments of only one set of tubes are lighted and they deliver power to the antenna circuit while the other bank, with the filaments not lighted, acts as a neutralizing circuit to prevent the active bank from breaking into self oscillation. In operation, if an accident happened to the active bank, the filaments could immediately be turned off and the filaments of what was the inactive bank turned on. The latter bank of power tubes would then deliver power to the antenna while the other bank functioned as a neutralizing condenser very specific and delicate conditions of operation are maintained for it.

A piezo-electric substance for radio crystal control purposes must have certain internal atomic properties, and it must be hard, durable, and not easily broken down physically or electrically. Quartz is the best commercial product so far offered to fill these requirements. The manufacture of quartz crystals for radio purposes is a specialized subject and, as few broadcasters are likely to attempt grinding their own crystals, need not be discussed here. The crystal should be optically ground to oscillate at only one fundamental frequency. If the frequency is to remain constant, the crystal must be maintained under constant physical conditions as a prerequisite. This includes an unvarying contact pressure and temperature. When the temperature changes the dimensions of the crystal change and the natural frequency varies proportionately. The crystal must be kept clean; a drop of oil or water introduced between the holder and the quartz slab will usually stop oscillations altogether. It follows that in a broadcasting station installation the crystals are usually kept in a dust-proof box whose temperature is thermostatically controlled. Some commercial crystals, in addition, are sealed into small individual containers, provided with lugs designed to slip under binding posts. The actual contact with the crystal is inside the container. If springs or screw clamps are used to make contact with an open crystal care must be taken to secure parallel movement of the metal surfaces, so that the crystal is not subjected to pressure on part of its surface and left untouched elsewhere. A loose contact leads to brushing, heating, and possible cracking of the crystal. The capacity of the crystal holder should be small in order that its piezo-electric variations may exert the maximum governing effect on the circuit of which the crystal is a part. It will be noted that there is some design analogy between the old-style crystal detector stand and the quartz crystal holder of a modern tube transmitter; each has protean forms. Some illustrations of actual crystal holders will be found with the RADIO BROADCAST papers mentioned in the bibliography, and Crossley includes a detailed description of the contact requirements in his paper.

The radio-frequency energy in the initial crystal circuit may amount to a fraction of a watt, while the final stage may deliver many thousand watts to the antenna. It is clear that great care must be taken to prevent feed-back, parasitic oscillations, and unstable circuit conditions along the line. Under some conditions of circuit imbalance the crystal is likely to overheat and be damaged. The transmitter may stop oscillating. In the endeavor to control regeneration and secure circuit stability, designers have frequent recourse to shielding and neutralization of successive amplifier stages, and sometimes push-pull radio frequency amplification is employed, resulting in a series of balanced circuits analogous to those of low frequency telephone practice.

In a crystal-controlled telephone transmitter, modulation may take place in the final stage or at an intermediate point after the crystal but before the final stage. The advantage of modulation at a low power level lies in the possibility of securing ample modulator capacity relative to the radio frequency energy to be modulated. But if, for example, modulation takes place in one of the earlier stages at a power level of, say, 50 watts, care must be taken not to impair the audio-frequency characteristic of the transmitter by cutting of the side bands in successive tuned stages, and of course the power tubes must have sufficient capacity to handle the peaks of modulation. The Bell Telephone Laboratories engineers seem to incline toward low power modulation, while the Westinghouse and General Electric engineers prefer to wait until the full radio frequency power is developed before impressing the audio frequency on the carrier.

The power of successive stages depends on tube characteristics and the use to which the transmitter is to be put. Crossley shows a 150-600-kc. telegraph transmitter in which the crystal controls a 7.5-watt tube, which is followed by a 50-watt impedance-coupled amplifier, a 1-kw. tuned amplifier stage, and the final 20-kw. stage feeding the antenna. These figures and some others in this paragraph represent the nominal oscillator ratings of the tubes in question; the powers actually developed are generally less. Meissner mentions a telephone transmitter in which, after the crystal tube, 5-watt, 75-watt, 500-watt, and 3-kw. stages are found, the last named supplying 3 kw. to the antenna. The National Broadcasting Company's Bound Brook telephone transmitter (made by Westinghouse for R.C.A.) uses a 7.5-watt tube in the crystal stage, swinging a 250-watt tube, followed by two 250's in parallel (500 watts) before the final 40-kw. bank. Bellmore, built by General Electric for the N. B. C., uses more stages; the crystal, likewise governing a 7.5-watt tube, is coupled to another of the same size; then follow a 50-watter, two fifty-watters in parallel (100 watts), a 1000-watt tube, a single 20-kw. tube run at about a quarter of its rating, and the final 50-kw. stage. In both of these American transmitters, plate modulation of the final power stage is used. In the Bellmore transmitter the output of the crystal stage is purposely kept low as one of the design considerations, only about 0.5 watt being generated, while Crossley mentions getting 21 watts from a crystal-governed tube of the same type, in one of the U. S. Navy experiments. This divergence shows how design calculations determine operating conditions.

Fig. 1 is a schematic circuit diagram of a crystal-controlled telephone transmitter without the audio amplifier and the power supply to the modulator and r. f. output stage. The power ratings of the successive stages have been omitted because, as indicated above, various sizes of tubes might be employed in such a chain, according to the final output required, the tube characteristics, and other design factors.

The Small Broadcaster

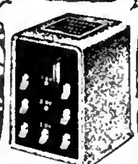
IN A letter of some length, which we should print in full if the space were available, Mr. Robert A. Fox, formerly owner and manager of Station WLBP of Ashland, Ohio, takes me severely to task for my past animadversions on incompetent broadcast technicians, which he apparently thinks were aimed exclusively at small stations, and then goes on to a penetrating discussion of the small stations' economic problems.

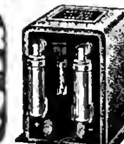
Mr. Fox points out that in arranging high quality programs the small station is at a disadvantage, "for the simple reason that musicians do not charge you for their time according to the power of your station, but in accordance with the number of hours required of them." The advertiser, on the contrary, will pay more or less proportionately according to the power. The members of the station staff are in the same position as the musicians. The result is that one man must sometimes assume the staggering burden of acting as "station monitor operator, announcer (doing a nemo job of it), operator; chief engineer as well as salesman, financier, publicity agent, and program director," all this with one assistant. Even then the structure collapses under the fixed expense, and Mr. Fox concludes, "The small broadcaster is economically doomed." But, he insists, the failure is economic, not personal—"the fellows who have been operating under 1000 watts have more brains than those above 1000 watts."

They may not have more brains—nature does not distribute brains according to antenna watts, either in direct or inverse ratio—but they certainly have more courage. And, while economically they may be sick, they may yet survive, on some other basis, to see a better day, No one can say, at this juncture, that the small neighborhood station will not find a place in community life, with some form of coöperative support, in a frequency band wherein it can serve local interests without interfering with the large stations and networks aspiring to national coverage, and be in turn protected from interference by them.

As to the less material matter of my own attitude toward such enterprises, it is a curious commentary on our American attitude toward criticism in general that when a man states baldly, in public, unpleasant facts about institutions or people, he is immediately suspected of being hostile to those institutions and people. That it is his right and duty, once he has set up as a critic, technical or social, to discriminate between what he finds good and bad, is a basic fact not sufficiently recognized among us, in radio and elsewhere. There is still a lot of bad broadcasting and incompetent operation going on. No one with a pair of ears and the tonal discrimination of a tomcat can think otherwise. There is also a large and growing element of good showmanship, efficient operation, and skilled personnel, among both large and small stations, and I have not been backward in giving credit to those responsible for such progress. The standards have been lower among smaller stations, because of the lack of resources and, sometimes, because of the lack of time and skilled personnel. All these factors go together. If a man tries to act as announcer, engineer, operator, program director, and publicity representative of a station he will inevitably turn out a half-baked job in each capacity. He may be a hero, but he is not a broadcaster by 1928 standards. One may admire his courage and still tell him what one thinks of his audio frequency band and the quality of his sopranos. As for constructive contributions, I have tried to do my part by writing technical articles which are of use largely to the smaller broadcasters, because the information contained in them is common property among the operators of the bigger stations. Let that be weighed against my refusal to be a member of a cheering squad.

NATIONAL





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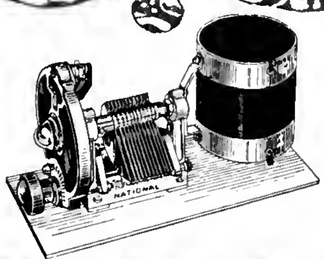
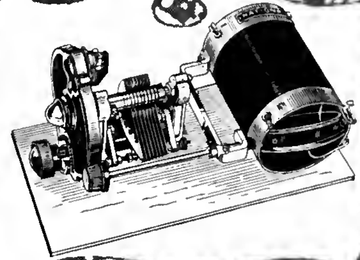
NATIONAL FILTER CHOKES - per pair in heavy case - Type 80, $10.00.





NATIONAL TUNING UNITS — THE HEAVENLY TWINS
More National Tuning Units have been used by set builders than all other similar components combined.
Standard since 1923 — *Approved By* — The OFFICIAL Design
BROWNING & DRAKE

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.

All of the 1926 issues of RADIO BROADCAST 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. 145 RADIO BROADCAST Laboratory Information Sheet **December, 1927**

Loud Speakers

GENERAL CONSIDERATIONS

IT HAS been realized for some time that a large diaphragm type of loud speaker is capable of giving somewhat better frequency response than can be obtained from a short horn. These large diaphragm loud speakers have generally been called cones because the large diaphragm in most cases takes the form of a right circular cone.

There are certain essential characteristics which must be striven for in designing a loud speaker of this type. What we desire in the diaphragm is to obtain a large surface of great stiffness or rigidity and, at the same time, extreme lightness. If such a material can be obtained, a very satisfactory loud speaker could be made consisting simply of a sheet of the material freely supported at the edge. Such a material having a high ratio of stiffness divided by mass is difficult to obtain, and it has been necessary to devise diaphragm shapes which will give the necessary stiffness and which will still be light. This is the reason why a cone shape has generally been used, for it will give the necessary characteristics.

Recently there was described in RADIO BROADCAST the Balsa wood loud speaker, which represents an attempt to obtain a large flat diaphragm using a light material, with the required stiffness obtained through the use of slats radiating from the center. Because of the extreme lightness of Balsa wood it is possible to obtain in this way a very high ratio of stiffness to mass.

It is, of course, essential that any loud speaker, if it is to radiate sound effectually, be made as light as possible so as to require only a small amount of energy to move it. It is desirable that the entire diaphragm shall move and that the major resistance it encounters in moving should be that due to the energy required to move the air about the diaphragm and set up sound waves in the air. Any of the available energy that is used for other purposes represents a loss.

An excellent book, *Wireless Loud Speakers*, is published in England by Iliffe and Sons and written by N. W. McLachlan. The author says, in speaking of cone type loud speakers:

"There is a wide field for mathematical and experimental work regarding the behavior of diaphragms of various shapes and sizes. By exact measurement, coupled with analysis, it will be possible to pave the way to better reproduction and to evolve a diaphragm with qualities superior to those now used. Until this is done we must remain in ignorance of the action of diaphragms at various frequencies. The human ear may judge one diaphragm to be better than another, but it cannot give exact data."

No. 146 RADIO BROADCAST Laboratory Information Sheet **December, 1927**

B Power Device Characteristics

TYPICAL CURVES

ON THIS Laboratory Sheet are given a group of curves, supplied by the Raytheon Manufacturing Company, which show how the output voltage of a typical B power unit varies with the transformer voltage. The circuit diagram of the rectifier and filter system used in making these tests is given on the curve. The curves apply when a type BH or similar tube is used as the rectifier.

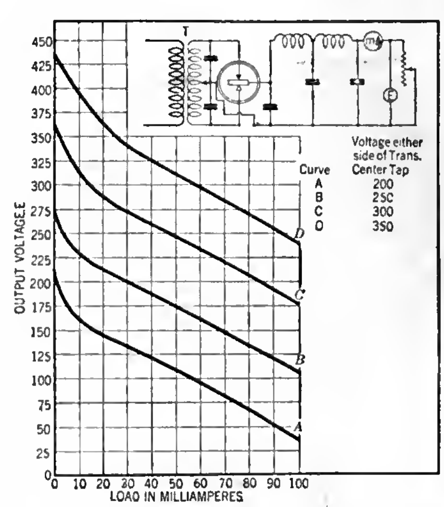
These curves indicate the following facts:

(A.) That the slope of all of the curves is the same. This is to be expected because the slope is determined entirely by the resistance of the circuit, which does not vary.

(B.) That an increase of 50 volts in the transformer voltage is effective in producing an average of 75 volts increase in the output voltage.

(C.) That the output voltages of the system at no load have approximately the same value as the transformer voltages.

(D.) That the total resistance of the rectifier-filter system is about 1340 ohms. (This value is determined by dividing the difference of any two voltages on the straight portion of any one curve by the difference of the corresponding load currents.) The resistance of the choke coils used was known to be 600 ohms so that the effective resistance of the rectifier is about 740 ohms.



Power

THE modern battleship, typifying power is a true symbol of the engineering genius, the mechanical and electrical precision embodied in Ceco Tubes.

MEMBER R.M.A.

Judge these triumphant Ceco Tubes by RESULTS achieved in your own set—Buy them by the name Ceco, choosing in consultation with your radio dealer the general or special purpose tubes best suited to your set.

You may justly expect more of Ceco Tubes and you'll GET more.

Steadier Performance—Longer Life.

FOR UNDISTORTED POWER IN YOUR SET USE

CeCo Type "E" (120)

A power amplifier tube for the last stage of audio frequency. For use with dry cells.

Fil. Volts .... 3.
Fil. Amp .... .125
Plate Volts 90-180.
UX Base—Long Prongs.

List Price $2.50

CeCo Type "F" (112)

A power amplifier tube for the last stage of audio frequency. For use with storage battery, or A. C.

Fil. Volts .... 5.
Fil. Amp 5
Plate Volts 90-180.
UX Base—Long Prongs.

List Price $4.50

CeCo Type "J-71" (171)

Out-put tube will handle the largest loud speaker at full volume. At ninety volts it will handle twelve times the undistorted volume of the ordinary "A" type.

Fil. Volts .... 5.
Fil. Amp 5
Plate Volts 90-180.
UX Base—Long Prongs.

List Price $4.50

CECO RADIO TUBES

There's a CeCo Tube for Every Radio Need

General Purpose Tubes
Special Purpose Tubes
Power Tubes
Filament Type Rectifiers,
A. C. Tubes

Ask your Dealer for Complete Data Sheet

C. E. MFG. CO., Inc.
PROVIDENCE, R. I.

Largest plant in the World devoted exclusively to making of Radio Tubes

No. 147 RADIO BROADCAST Laboratory Information Sheet December, 1927

"Gain"

SIMPLE MATHEMATICAL CALCULATION

THE diagram on this Sheet shows an ordinary tuned circuit with a source of high-frequency voltage, e, in series with it. The voltage e can be considered to be the voltage induced in the tuned circuit from another coil, the primary of a radio-frequency transformer for example. This voltage will cause a current to flow in the tuned circuit and the ratio of the voltage E, developed across the entire circuit, to the voltage e, induced in the circuit, is known as the "gain" of the tuned circuit. The more efficient the tuned circuit is, the greater will be the "gain." We will now derive a mathematical expression for the "gain" of a tuned circuit.

The current, I, flowing in a tuned circuit at resonance is:

$$I = \frac{e}{R} \qquad (1.)$$

where e = the voltage induced in the circuit and R = resistance of the circuit. The current flowing through the inductance coil, L, generates a potential across the coil, determined as follows:

$$E = \omega LI \qquad (2.)$$

where ω = 6.28 times the frequency of the current, L = inductance of coil in henries, and I has the same meaning as in equation (1.) Substituting in equation (2.) the value for I given in equation (1,) we have:

$$E = \frac{\omega Le}{R} \qquad (3.)$$

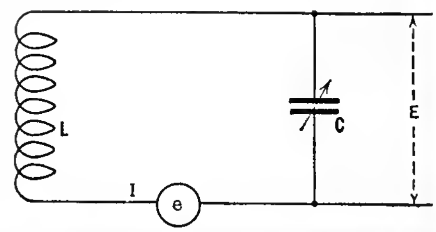
and dividing through by e we get:

$$\frac{E}{e} = \frac{\omega L}{R}$$

But, as stated previously, the ratio of E to e is the gain of the circuit. Therefore:

$$\text{Gain} = \frac{\omega L}{R} \qquad (4.)$$

This final expression indicates that, to obtain greatest efficiency from a tuned circuit, it is essential that the ratio of the inductance reactance (ωL) to the resistance of the coil should be made as large as possible.



No. 148 RADIO BROADCAST Laboratory Information Sheet December, 1927

An A. C. Audio-Frequency Amplifier

WHAT PARTS TO USE

THE introduction of the new a. c. tubes makes possible the construction of an a. c. audio amplifier with the necessary A, B, and C voltages supplied directly from the light socket. The list of parts necessary to construct such an amplifier is given on this Sheet. The circuit diagram is given on Laboratory Sheet No. 149.

An amplifier of this type is well suited for use with a small receiver consisting of one or more stages of radio-frequency amplification and a detector. The circuit has been so designed that B voltages for the r. f. and detector tubes can be obtained from the audio amplifier device.

The following parts are necessary to construct this amplier:

A—A. C. Tube, Type UX-226 (CX-326) or Equivalent.
B—UX-171 (CX-371) or Equivalent.
T_1, T_2—Two High-Quality Audio Transformers.
T_3—Filament-Lighting Transformer to Supply Tube A.
T_4—Power-Supply Transformer Designed for use in 171 Type B Power Units.
L_1, L_2—Filter Choke Coils.
L_3—Output Choke Coil.
C_1, C_2—1-Mfd. Bypass Condensers.
C_3, C_4—2 Mfd. Filter Condensers.
C_5—4-Mfd. Filter Condenser.
C_6, C_7, C_8—1-Mfd. Filter Condensers.
C_9—2-4-Mfd. Fixed Condenser.
R_1—30-Ohm Center-Tapped Resistance.
R_2—1500-Ohm Fixed Resistance Capable of Carrying 4 mA.
R_3—2000-Ohm Fixed Resistance Capable of Carrying 20 mA.
R_4—Tapped Resistance for Use in Output of B Power Units.

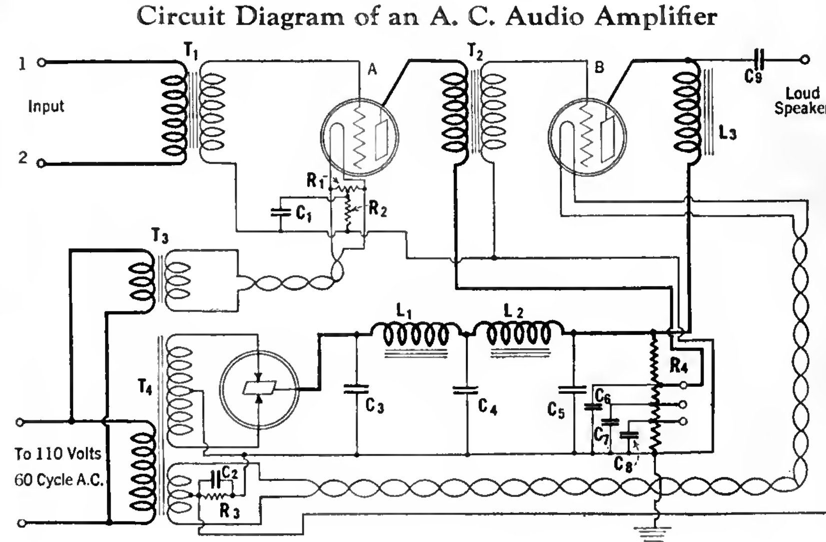
In wiring this amplifier, be sure to twist the filament leads to the two tubes, to prevent hum. C bias for the first tube, A, is obtained from resistance R_2, and resistance R_3 supplies the output tube with grid bias.

The input terminals of the amplifier should connect to the output of the detector tube, terminal No. 1 connecting to the plate and terminal No. 2 to the detector B plus.

To prevent hum it is essential that the negative B be carefully grounded.

No. 149 RADIO BROADCAST Laboratory Information Sheet December, 1927

Circuit Diagram of an A. C. Audio Amplifier



Here is the circuit diagram of an all a. c. audio amplifier. The list of parts is given on Sheet No. 148.

Silent Magic

Here is the Eveready Layerbilt "B" Battery No. 486, Eveready's longest-lasting provider of Battery Power.

TURN your radio dial, and presto! you turn your home into a theater, a concert hall, a lecture room, a cabaret, a church, or whatever you will. Turn the dial and your attentive ear does the rest. That is all there is to this magic of radio.

Or almost all. If a radio set is to work at its very best, attracting no attention to itself, creating for you the illusion that can be so convincing, you must pay a little attention to the kind of power you give it. There is but one direction, a simple one—use Battery Power. Only such power is steady, uniform, silent. It is called by scientists pure Direct Current. Any other kind of current in your radio set may put a hum into the purest note of a flute, a scratch into the song of the greatest singer, a rattle into the voice of any orator.

Don't tamper with tone. Beware of interfering with illusion. Power that reveals its presence by its noise is like a magician's assistant who gives the trick away. Use batteries—use the Eveready Layerbilt "B" Battery No. 486, the remarkable battery whose exclusive, patented construction makes it last longest. It offers you the gift of convenience, a gift that you will appreciate almost as much as you will cherish the perfection of reception that only Battery Power makes possible.

Radio is better with *Battery* Power

NATIONAL CARBON CO., INC.
New York UCC San Francisco
Unit of Union Carbide and Carbon Corporation

Tuesday night is Eveready Hour Night—9 P. M., Eastern Standard Time

WEAF–*New York*	WOC–*Davenport*
WJAR–*Providence*	KSD–*St. Louis*
WEEI–*Boston*	WCCO–{*Minneapolis* / *St. Paul*
WFI–*Philadelphia*	WDAF–*Kansas City*
WGR–*Buffalo*	WRC–*Washington*
WCAE–*Pittsburgh*	WGY–*Schenectady*
WSAI–*Cincinnati*	WHAS–*Louisville*
WTAM–*Cleveland*	WSB–*Atlanta*
WWJ–*Detroit*	WSM–*Nashville*
WGN–*Chicago*	

WMC–*Memphis*

Pacific Coast Stations—
9 P. M., Pacific Standard Time

KPO-KGO–*San Francisco*
KFOA-KOMO–*Seattle*
KFI–*Los Angeles*
KGW–*Portland*

EVEREADY
Radio Batteries
-they last longer

The air is full of things you shouldn't miss

No. 150 RADIO BROADCAST Laboratory Information Sheet December, 1927

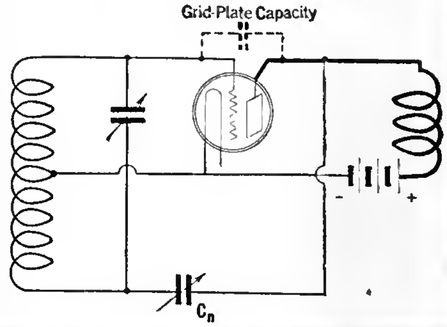
Oscillation Control

THE USE OF NEUTRALIZATION

IT HAS been pointed out many times that an ordinary three-element tube has an inherent tendency to oscillate due to the feed-back that occurs from the plate circuit to the grid circuit through the grid-plate capacity, indicated by dotted lines in the accompanying diagram. This diagram represents the circuit of a single-stage of tuned radio-frequency amplification, using the Rice system of neutralization, and the following explanation will make clear why the tube tends to oscillate and why the tendency to oscillate can be overcome by using some system of neutralization.

When a tube acts as an amplifier, the voltage developed in the plate circuit is greater than the voltage originally impressed on the grid circuit and, consequently, if the plate circuit is coupled to the grid circuit in any manner whatsoever, current will tend to flow from the point of high potential, that is the plate, to a point of lower potential, in this case the grid. If this current flowing to the grid circuit has the same phase as the original signal impressed on the grid, then the grid voltage will become somewhat greater and will be equal to the original signal in the grid circuit plus the voltage induced in the grid circuit from the plate. An increase in the grid voltage again produces an increase in plate voltage which in turn reacts back on the grid until the voltage is increased to a point where the losses in the circuit are overcome, and then the tube breaks into continuous oscillation.

It should be evident that if we can place in the circuit some device that will impress a potential on the grid kind of an equal and opposite to that caused by the coupling between the grid and plate, then the resultant effect will be zero and the tendency for the circuit to build up and break into continuous oscillation will be nullified. The Rice system of neutralization is one way of doing this, the circuit for which is shown in the accompanying diagram. The grid-plate capacity is shown in dotted lines and this is the capacity through which current flows from the plate to the grid circuit and which ordinarily causes the tube to oscillate. This capacity is neutralized in the Rice system by connecting condenser Cn as indicated.



No. 151 RADIO BROADCAST Laboratory Information Sheet December, 1927

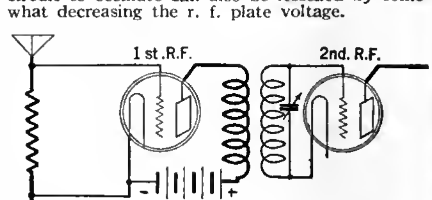
Single-Control

BOOSTING SENSITIVITY

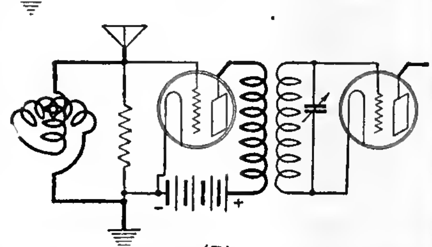
ON LABORATORY Sheet No. 33, October, 1926, some facts were given regarding the tandem tuning of several condensers, to decrease the number of controls. It was pointed out that, to obtain single control, it is necessary to overcome the effect of the antenna circuit in some manner, and that a common method of doing this is as indicated in sketch A on this Sheet. The owner of a receiver of this type may greatly increase its sensitivity by connecting a variometer between the antenna and ground posts as indicated in sketch B. This, of course, adds one more control to the set but in those cases where greater sensitivity is necessary, the additional control is justified.

The increase in sensitivity that results when the variometer is used in the antenna circuit is due to the fact that it brings the antenna into resonance with the signals being received and the resultant gain in amplification is practically equal to that which would be obtained from an additional stage of radio-frequency amplification.

In some cases when this variometer is used, it will be found that the receiver tends to oscillate, or actually does oscillate, when all of the circuits are brought into resonance. Fortunately, however, most single-control receivers have a volume control in the radio-frequency system and it will be found that, by cutting down the volume control, a point will be reached where the set will stop oscillating and usually the actual volume obtained with the antenna circuit tuned will be much greater than that obtained before with the volume control turned to the "maximum" position. The tendency of the circuit to oscillate can also be lessened by somewhat decreasing the r. f. plate voltage.



(A)



(B)

No. 152 RADIO BROADCAST Laboratory Information Sheet December, 1927

Speech

SOURCES OF INFORMATION

THE nature of speech has been the subject of many scientific inquiries and many of the investigations in connection with speech have been recorded in various scientific journals.

Back in 1873, Alexander Graham Bell, familiar to us as the inventor of the telephone, did considerable work in analyzing speech and in "devising methods of exhibiting the vibrations of sounds opticallly," and much of the recent research has been done by engineers and physicists associated with the laboratories of the telephone companies.

A bibliography is given below of some of the important articles and books on the subject with which we are familiar. This bibliography is by no means complete in itself but if the references given are studied it will be found that some of them contain many references to other papers on the subject. I. B. Crandall's article, in the October, 1925, *Bell System Technical Journal*, in particular, contains about twenty-six references to other sources of information on speech and related subjects.

REFERENCE SOURCES

Bell System Technical Journal

C. F. Sacia and C. J. Beck; "The Power of Fundamental Speech Sounds." July, 1926.

I. B. Crandall: "Sounds of Speech." October, 1925.

C. F. Sacia: "Speech Power and Energy." October, 1925.

Irving B. Crandall: "Dynamical Study of the Vowel Sounds." January, 1927.

C. R. Moore and A. S. Curtis: "An Analyzer for the Voice Frequency Range." April, 1927.

Journal of the American Institute of Electrical Engineers

Jones; "The Nature of Language." April, 1924.

Martin and Fletcher: "High-Quality Transmission and Reproduction of Speech and Music:" March. 1924.

Maxfield and Harrison: "Method of High Quality Recording and Reproducing of Music and Speech Based on Telephone Research." March, 1926.

Books

Miller: *Science of Musical Sounds.* Second Edition. Macmillan.

Sabine: *Collected Papers on Acoustics.* Harvard University Press.

The great improvements in radio power *have been made by* Balkite

Licensed under Andrews-Hammond patent

Balkite "A" *Contains no battery.* The same as Balkite "AB," but for the "A" circuit only. Enables owners of Balkite "B" to make a complete light socket installation at very low cost. Price $35.00.

Balkite "B" *One of the longest lived devices in radio.* The accepted tried and proved light socket "B" power supply. The first Balkite "B," after 5 years, is still rendering satisfactory service. Over 300,000 in use. Three models: "B"-W, 67-90 volts, $22.50; "B"-135,* 135 volts, $35.00; "B"-180, 180 volts, $42.50. 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 higher West of the Rockies and in Canada.*

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 the set is in use. The great improvements in radio power have been made by Balkite.

The famous Balkite electrolytic principle

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. 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. It is this principle that does away with the necessity of using tubes for rectifying current—that makes all Balkite Radio Power Units, including the new Balkite "A" and "AB," permanent equipment with nothing to wear out or replace.

Balkite has pioneered—but not at the expense of the public.

Licensed under Andrews Hammond Patent

Balkite "AB" *Contains no battery.* A complete unit, replacing both "A" and "B" batteries and supplying radio 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, $64.50; "AB" 6-180, 180 volts, $74.50. Special model for Radiola 28, $63.50.

Radio power with batteries or without

Today, whatever type of radio set you own, whatever type of power equipment you want (with batteries or without) 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.*

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Balkite

Radio Power Units

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 168. 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 168)

Vital Factors

in attaining

High Quality Reproduction

Type 285
Audio Transformer

The Type 285 transformers give high and even amplification of all tones common to speech, instrumental, and vocal music. Available in two ratios.

Type 285-H Audio Transformer. **Price $6.00**

Type 285-D Audio Transformer. **Price $6.00**

Type 367
Output Transformer

This unit adapts the impedance of an audio amplifier to the input of any cone type speaker, thus promoting better tone quality and protecting the speaker windings against possible damage from A. C. voltages. Similar in appearance to the Type 285.

Type 367 Output Transformer. **Price $5.00**

High quality reproduction depends upon three things: correctly designed coupling units, proper use of amplifier tubes, and an efficient reproducing device.

For over a decade the subject of audio frequency amplification has been extensively studied in the laboratories of the General Radio Company with particular attention given to the design of coupling units.

As a result of this exhaustive research the General Radio Company has been, and is, the pioneer manufacturer of high quality Audio Transformers, Impedance Couplers, and Speaker Filters.

The latest contribution to quality amplification is the type 441 Push-Pull Amplifier, which is mounted on a nickel finished metal base-board and is completely wired.

If the amplifier of your receiver is not bringing out the rich bass notes and the mellow high tones as well as those in the middle register why not rebuild your amplifier for *Quality Reproduction* with *General Radio* coupling units?

Write for our Series A of amplification booklets describing various amplifier circuits and units.

GENERAL RADIO COMPANY
Cambridge, Mass.

Type 373
Double Impedance Coupler

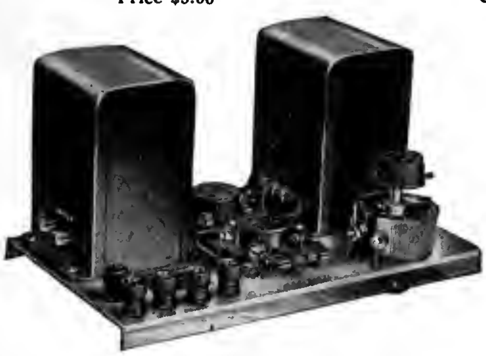
Many prefer the impedance coupling method of amplification to resistance coupling as lower plate voltages may be used and greater amplification may be obtained. The Type 373 is contained in a metal shell and connected in a circuit in precisely the same manner as a transformer.

Type 373 Double Impedance Coupler. **Price $6.50**

Type 387-A
Speaker Filter

The Type 387-A consists of an inductance choke with condenser. It offers a high impedance to audio frequency current and forces these currents to pass through a condenser into the speaker, thereby improving tone quality and protecting the speaker windings.

Type 387-A Speaker Filter. **Price $6.00**

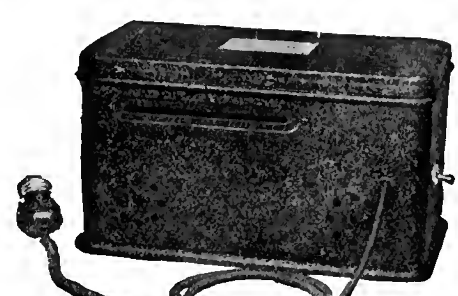


Type 441 Push-Pull Amplifier

The Type 441 is completely wired and consists of two high quality push-pull transformers, with necessary sockets and resistances mounted on a nickel finished metal base board. It may be used with any power or semi-power tube to increase the undistorted output of the amplifier with the result that better quality is reproduced from the loudspeaker with more volume than is obtained from other methods of coupling.

Licensed by the R. C. A. and through terms of the license may be sold with tubes only.

Type 441 Push-Pull Amplifier	**Price $20.00**
Type UX-226 or CX-326 Amplifier Tube	" **3.00**
Type UX-171 or CX-371 Amplifier Tube	" **4.50**



Type 445 Plate Supply and Grid Biasing Unit

The Type 445 meets the demand for a thoroughly dependable light socket plate supply and grid biasing unit that is readily adaptable to the tube requirements of any standard type of receiver. Any combination of voltages from 0 to 100 may be taken from the adjustable "B" voltage taps. A variable grid bias voltage from 0 to 50 is also available. The unit is designed for use on 105 to 125 volt (50 to 60 cycle) A. C. lines and uses the UX-280 or CX-380 rectifier tube.

Licensed by R. C. A. and through terms of the license may be sold with tube only.

Type 445 Plate Supply and Grid Biasing Unit	**Price $55.00**
Type UX-280 or CX-380 Rectifier Tube	" **5.00**

GENERAL RADIO

LABORATORY EQUIPMENT

Parts *and* Accessories

"RADIO BROADCAST'S" DIRECTORY OF MANUFACTURED RECEIVERS

¶ A coupon will be found on page 172. 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, 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. 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. Milliammeter 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 60¼ 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. 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. 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 2¼ x 16½ inches. Prices: $215; with tubes, $250.

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 7¾ 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. 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 7¾ 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. 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. 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: 25⅛ x 7⅞ x 8⅛. Price: $130 without accessories.

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. 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. 542. PFANSTIEHL JUNIOR SIX

Six tubes; 3 t.r.f. (01-A), detector (01-A), 2 audio. Pfanstiehl circuit. Volume control: variable resistance in r.f. plate circuit. One dial. Shielded. Battery cable. C-battery connections. Etched bronze panel. Antenna: outdoor. Cabinet size: 9 x 20 x 8 inches. Price: $80, without accessories.

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, $50 console, $65 including loud speaker.

FACTORY PRICES~SAVE 50%
Choice of beautiful cabinets offered

3 Year Guarantee

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ALL METAL SHIELDED CHASSIS

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8 tube~one dial MIRACO
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MAGNIFICENT TONE~SUPER SELECTIVE~POWERFUL DISTANCE GETTER

All Electric~or Battery Set!

MIRACO Users Say:

Reports from users everywhere leave little for us to add. These are only a few of the many in our files and which we receive daily. Send coupon for plenty of additional proof and testimony of nearby users.

TRIED MANY SETS—MIRACO BEST
Miraco is best set I've ever heard. It's just the set I've always wanted and I've had so many sets I got just a little hard-boiled about believing there were any sets perfect. I sure got my wish. I've had just 104 stations. There's about a station to each number on dial. I get KFI (Cal.) every night. Had PWX last night and got 6KW tonight good and loud.—FRANCIS ARMBRUSTER, Cleveland, Ohio.
P.S. You pack your sets wonderful.

HE KNOWS SETS—READ THIS
I have built radios since they first made their appearance and it has been my pleasure to build, repair and sell them. For quality, selectivity and sensitivity it is my firm belief that the Miraco cannot be excelled. I have proven beyond any shadow of doubt that it will outperform any other radios. I bring in the farthest distance with little or no effort. The Miraco also gives me tone quality.—URBAIN BARIL, Jr., Fall River, Mass.

MIRACO EXCELS EXPENSIVE RADIOS
The Miraco set and loud speaker beat anything around here, regardless of price. Have tried them out against a $200 outfit. Have logged 140 stations, coast to coast.—E. J. CARRIFRE, Bathgate, N. D.

HEARS CUBA, CANADA, MEXICO
A friend visited here that has close to $300 in a radio—but no better tone and no plainer than the Miraco. Have gotten 118 stations. We get Mexico City, Winnipeg, Canada and Havana, Cuba—all of these so plain.—MRS. CLEM CORRELL, Morristown, Ind.

CUTS THRU NEW YORK LOCALS
I can get distance thru the locals when they are all on early in the evening.—J. F. LOGAN, Rockaway Beach, New York.

America's big, old, reliable Radio Corporation* (8th successful year) **guarantees** in its big, powerful, latest 6, 7 and 8 tube Miraco sets "the finest, most enjoyable performance obtainable in **high grade** radios." Unless 30 days' use in your home fully satisfies you 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.** Save or make lots of money on sets and equipment—write for testimony of nearby users and **Amazing Special Factory Offer.**

Miraco's work equally fine on "AC" electric house current or with batteries. Take your choice. Many thousands of Miraco users—who bought after thorough comparisons—enjoy programs Coast to Coast, Canada to Mexico, loud and clear—with the magnificent cathedral tone quality of costliest sets. Don't confuse Miraco's with cheap, "squawky" radios. Miraco's have finest parts, latest approved shielding, metal chassis, etc.—as used in many $200 sets.

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Your Miraco reaches you completely assembled, rigidly tested, fully guaranteed. Easy to connect and operate. **30 days' trial free.** 3 year guarantee if you buy. 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. 8th successful year in the radio manufacturing business.

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MIRACO "Powerpluss" sets—both in 8 and 7 tube models—have magnificently beautiful, clear cathedral tone quality. Turn one dial for stations everywhere. Ultra selective. Miraco multistage distance amplification gives "powerplus" on far-off stations. Latest all-metal shielded chassis. Illuminated dial. Fully guaranteed. *Try one free for 30 days!* Choice of beautiful cabinets.

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Electrify Any Radio with MIDWEST NO-BATTERY "AC" 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, fully guaranteed.

BIG DISCOUNT TO User-Agent

Dealers Write!

USER-AGENTS! Make big profits showing Miraco to friends. Get Our Special Wholesale Prices!
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USERS' REPORTS PROVE THAT MIRACO Radio gets 'em Coast to Coast

BEAUTIFULLY ILLUSTRATED CATALOG AND AMAZING SPECIAL OFFER
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SEND NO MONEY—30 DAYS' TRIAL, Special Wholesale Price Offer to User-Agents, Bank References, testimony of nearby Miraco users—*all the proof you want*—sent with catalog.

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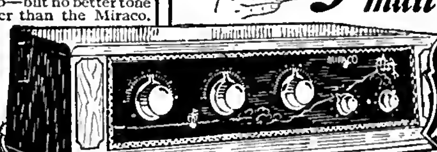

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ADDRESS

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 7¾. 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 24 mA. Volume control: rheostat on r.f. Coils shielded. Battery cable. C-battery connections. Headphone connection. Antenna: outdoor. Cabinet size: 20½ x 13¾ x 10½ 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, 25¾ 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. 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: 22½ 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 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. 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. 543. ATWATER KENT, MODEL 33

Six tubes; 3 t.r.f. (01-A), detector (01-A), 2 audio (01-A and 71 or 12). One dial. Volume control: r.f. filament rheostat. C-battery connections. Battery cable. Antenna: 100 feet. Steel panel. Cabinet size: 21¼ x 6¾ x 6¼ inches. Price: $75, without accessories.

NO. 544. ATWATER KENT, MODEL 50

Seven tubes; 4 t. r. f. (01-A), detector (01-A), 2 audio (01-A and 12 or 71). Volume control: r.f. filament rheostat. C-battery connections. Battery cable. Special bandpass filter circuit with an untuned amplifier. Cabinet size: 20¾ x 13 x 7¾ inches. Price: $120.

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 8¼ 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: 7¼ x 25¼ 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: 7¼ 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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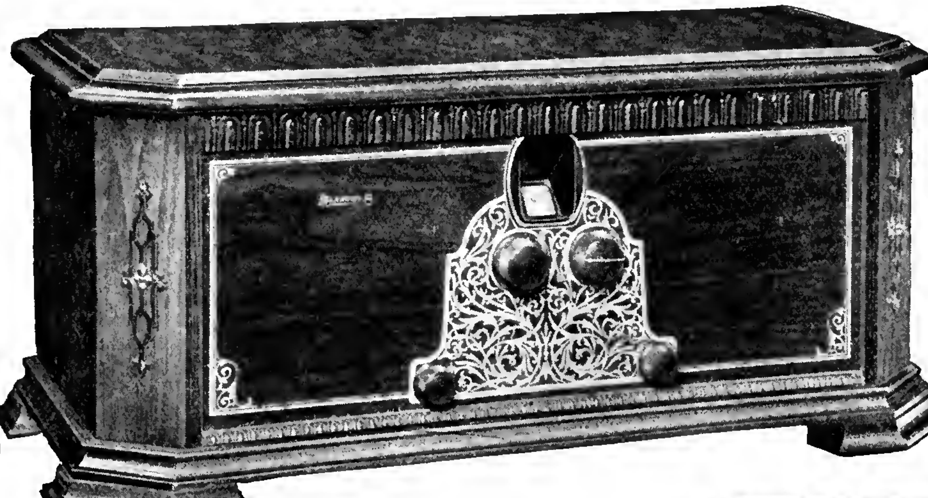

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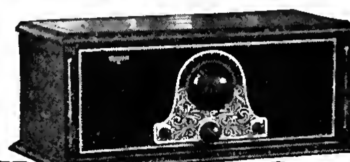

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NO. 531. KOLSTER, 8A, 8B, AND 8C

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, $101.50.

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 14½ inches. Price not established.

NO. 542 RADIOLA 16

Six 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. 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. 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 11½ x 13⅞ inches; No. 710 console, 29¾ x 42 x 17¾ 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, 22⅛ x 40 x 14 ½ 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 ½ x 50 ⅞ 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, 27⅛ x 16¾ x 14⅞ inches; No. 602, 28¾ x 51½ x 19⅝ inches. Prices: No. 601, $225; No. 602, $330.

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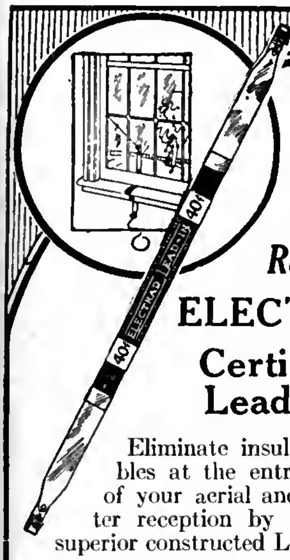

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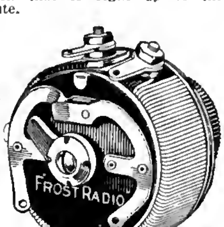

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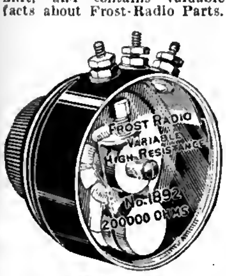

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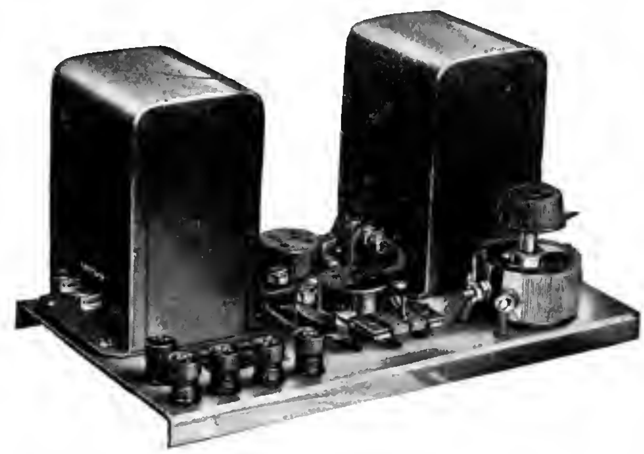

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RADIO BROADCAST

WILLIS KINGSLEY WING, Editor

JANUARY, 1928

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Director of the Laboratory

EDGAR H. FELIX
Contributing Editor

Vol. XII, No. 3

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AMONG OTHER THINGS. . .

IT IS a sad duty to record the death of the Chairman of the Federal Radio Commission, Admiral W. H. G. Bullard, which occurred in Washington on Thanksgiving Day. Admiral Bullard, who served in the United States Navy for thirty-six years, for a very long time was close to the center of radio in almost all of its branches. His loss will be keenly felt, not only by those who knew him as a likable and able individual but especially by the Radio Commission itself. When the Radio Commission went to work on March 15, two of its members had a background of technical radio experience. These two men were Admiral Bullard and Colonel Dillon. Death has removed both. The Commission at this writing now consists of Acting-Chairman E. O. Sykes, O. H. Caldwell, Sam Pickard, and H. A. Lafount. Not one of these members has a technical radio background which would enable them to better struggle with the complicated problems which confront them.

THE reports of international conferences, on whatever subject, usually make rather dull reading for the general public and the Washington Radio Conference has been no exception to this rule. The proceedings may not be exciting, but the results are certainly important. There has been no revision of international agreement since the London conference of 1912, and radio progress has been so rapid since then that the articles of that Convention were hopelessly inadequate to meet present needs. There have been many rocks and shoals in the way of the present conference, which, at this writing, has just wound up its work, but through good management and a praiseworthy desire for general accord, the delegates have succeeded in drawing up a Convention which well meets the needs of radio today. Not the least important decision reached at Washington was that dealing with the international assignment of channels in the frequency spectrum. In that respect, we are glad to note, the future needs of short-wave communication, broadcasting, commercial, and amateur work were provided for. The amateurs had a hard fight, but room has been saved for them—a result of which the broad-minded directors of the American Radio Relay League may well be proud.

THE issue of RADIO BROADCAST before you contains some extremely interesting articles. The story by Howard Rhodes on the problems of push-pull amplification is distinctly helpful and should cast much light on a form of amplification which is again being revived after several years of comparative disuse. . . . Those who are anxious to know what the new screened-grid tube will do will find Keith Henney's article very valuable indeed. As soon as possible, RADIO BROADCAST will give its readers data on receiving circuits which can be used with the tube; the latter has just been released for general sale.

THOSE of our readers who would like to have their names forwarded to the manufacturers of the special apparatus necessary to construct a Rayfoto receiver may send letters to the undersigned, and printed matter containing detailed information will be sent them. . . . The next RADIO BROADCAST will contain an article describing a new super-heterodyne, entirely operated from a. c., which has much to recommend it, both from the design and appearance point of view. There will also be many other articles of interest.

—WILLIS KINGSLEY WING.

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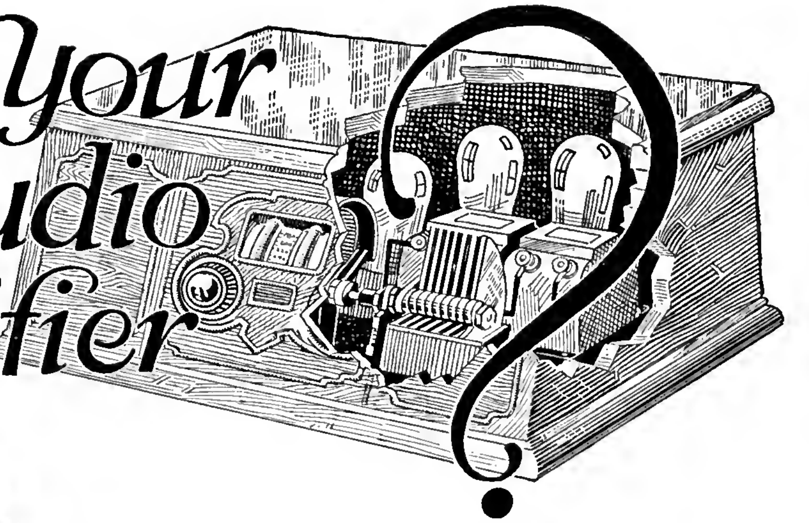

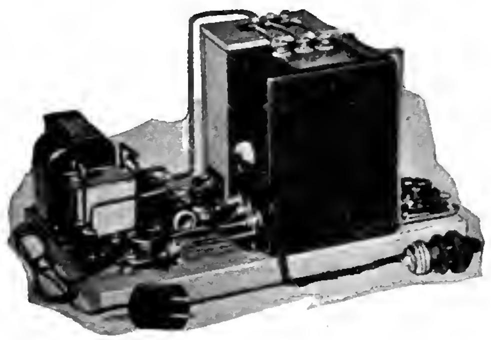

THORDARSON 171 TYPE
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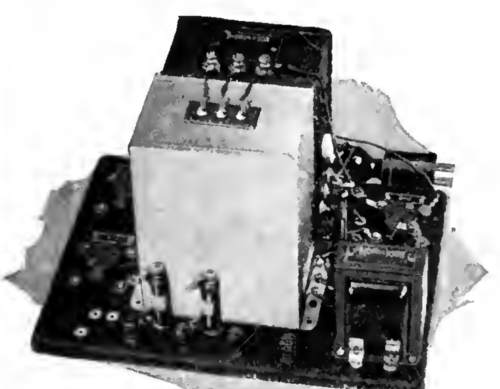
Built around the Thordarson Power Compact R-171, this power amplifier supplies "A," "B," and "C" current for one UX-171 power tube and B-voltage for the receiver. Employs Raytheon B. H. rectifier.



THORDARSON 210 TYPE
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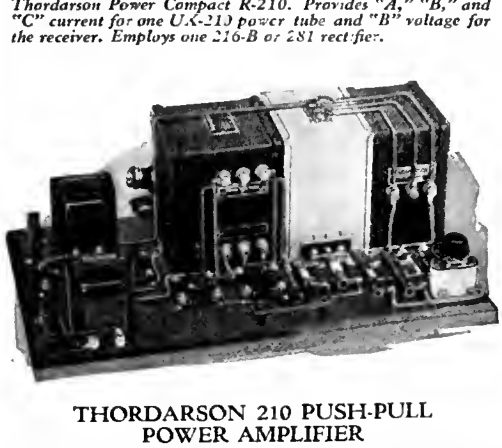
This amplifier, mounted on a special metal chassis, uses the Thordarson Power Compact R-210. Provides "A," "B," and "C" current for one UX-210 power tube and "B" voltage for the receiver. Employs one 216-B or 281 rectifier.



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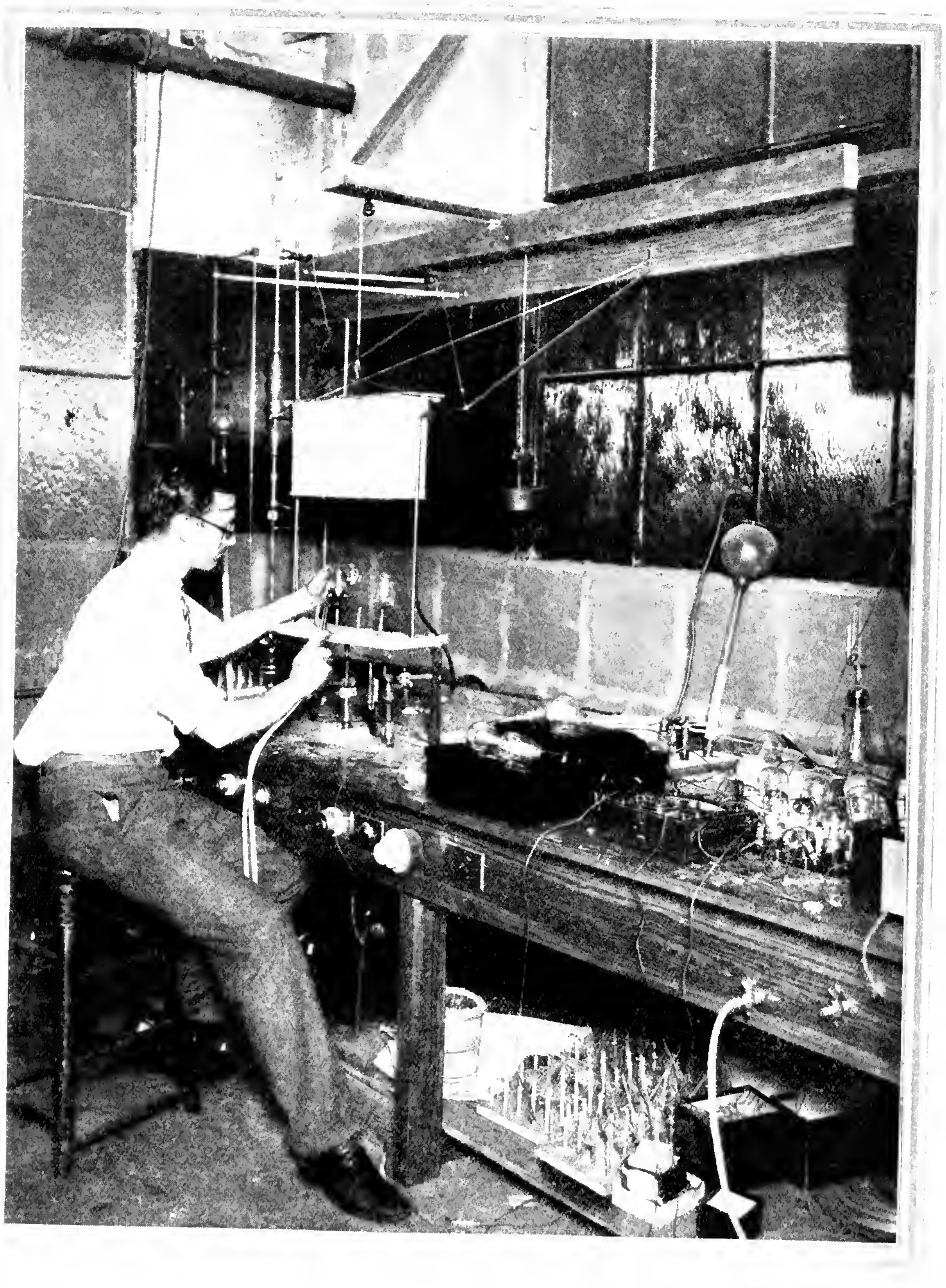
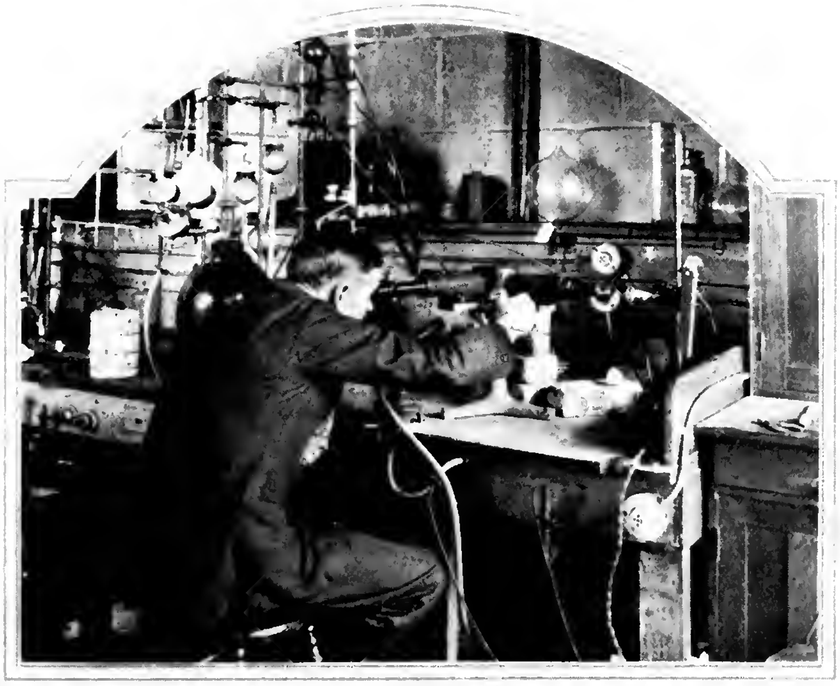


In the Laboratory of a Tube Manufacturer

Where diligent investigation precedes production of any new kind of tube. The particular laboratory here shown is given over to the study of rectifier tubes—the kind you are accustomed to use in your power-supply devices to rectify the a. c. of the house supply. This investigator is shown engaged in the construction of an experimental tube, which will afterwards be tested and, as likely as not, discarded. It is said that about 99 per cent. of these hand-made experimental tubes are discarded without even being put into production. When we consider the expense of such tireless research, more and more do we recognize the logic of the statement, that it is only the larger and more "moneyed" manufacturers who are capable of producing dependable radio equipment



STUDYING GASES IN THE LABORATORY
Looking into the depths of ionized helium atoms with a spectroscope. Charles Grover Smith, who is shown in this picture, spends considerable of his time studying gases, especially helium

RADIO ENLISTS THE HELIUM ATOM

By VOLNEY G. MATHISON

"IT'S all so useless, that's why I'm quitting," complained the young college graduate to the chief of the laboratory in which he had lately gotten a job. "What can ever come out of measuring the ohmic resistances of a cubic millimeter of about a million different substances under a couple of hundred different temperatures? That's the job you've given me—nothing but an endless measuring of ohms. If this is what you call scientific research——"

"It is," interrupted the electro-chemist. "It's the backbone of it—prolonged patience at tedious work."

"Seems tedious enough. But I could stand that if I could see some results ahead. I can't see any."

"Well, there may be no directly important outcome of what you're doing. You are simply adding to the stock of scientific knowledge in a prosy way, working on a huge book of temperature-resistance tables. You can't tell in advance what it may lead to. Take, for example, the helium-gas rectifier tube used in radio B-supply devices. It was never invented, it just grew out of a lot of laborious work like this. American factories are turning out about 20,000 of these tubes a day at present and the patent profit is close to a dollar and a half apiece. There's a return to pure research at the rate of something like $30,000 a day. That soon pays for a lot of slow laboratory grinding, doesn't it?"

"Yes," reiterated the young graduate, "but that tube wasn't developed by any such work as I'm doing here—measuring the resistances of rust, rocks, roots, cocoanut shell, and the end years away. It's all so discouraging!"

As a matter of fact, the helium-gas tube for B-devices *was* the result of a great amount of purely scientific work of the tedious and rather unfocussed sort that this discouraged young chemist was assigned to, though, perhaps, the experiments involved were a good deal more technical. A few years ago we began studying the actions of electrons in gases. At that time nobody knew much about electrons—maybe we don't yet—and the experiments were entirely general in kind. The aim was to find out something, not to invent something. One young fellow had the job of finding out definitely whether or not electrons emitted from a cathode into a tube of gas passed through the gas without colliding with its atom centers.

An atom of any kind of substance, as nearly every one now is aware, consists of a group of protons and electrons surrounded by planetary electrons. The space in between seems to contain nothing but electric tension, though now late in 1927 we are about to believe that this tension consists of a flurry of particles called etherons that are so small they make an electron look like a balloon in comparison with an apple, and move almost twice as fast as light. Matter, even solid steel, is nearly all emptiness, and it is the crudeness of our undeveloped physical senses that makes us think otherwise.

So this young man set about trailing a lot of wandering electrons through a wilderness of gases to find out what they did in there. He had a photographing outfit that would show the paths of the electrons. Many gases and pressures had to be tried. In one series of experiments each photograph showed the flight of 200,000 electrons, and that young man took 100,000 photographs separately, one after the other, before he got one collision of an electron with the middle of an atom of the gas under test. He kept on, and got a total of eight collisions in 400,000 photographs. Even when it is possible to use a fast automatic machine to take such photographs, they all have to be individually and laboriously examined.

The photographer found out something else. He found out that when an electron hit an atom of gas square in the middle, it blew the atom to pieces, producing a shower of unattached electrons, and unsmashable groups of electrons and protons that were named alpha particles. Alpha particles were identified with a spectroscope as being the same as a mysterious gas which had been seen by astronomers pouring over the sun, and which they had named helium—a "sun" word.

The alpha particles or helium atoms can be quite easily robbed temporarily of one planetary electron, but they cannot be further broken up except with the most extreme difficulty. Helium gas was therefore recognized as a valuable electrical conducting medium that would tend to act at all times with unchanging properties and that would refuse to eat, corrode, or combine in any way with the metal tips of the electrodes by which electricity would be fed into the gas. No particular electrical use for this gas had yet been thought of, though it was proposed that metal-ended glass cartridges of helium might be valuable as ultra-stable resistors capable of withstanding enormous currents and pressures.

In photographing the flights of electrons through helium gas, it was observed that, when an electron struck an atom of helium, the electron ran off with one of the planetary electrons of the helium atom, carrying it to the anode.

A sketch of this performance would be almost inconceivably out of proportion since there would have to be represented the trillions times trillions of atoms in the tube, while electrodes about the size of the state of Georgia would be necessary to preserve the proper scale if the atoms were one half inch across. If the helium nucleus were drawn the size of a pea, the planetary electrons would properly be placed a quarter of a mile away. Such is the ghastly emptiness of matter—of even the "solid" walls of a glass tumbler from which we drink billions of electrons and protons in the peculiarly ordered state we call water; and of the stout iron bars upon which the jail-bird leans his head. But solidity, although physically an illusion, is nevertheless real because it is a manifestation of a powerful electrical condition.

To return now to the story of the doings in the helium tube under electrical pressure, we learn that the unfortunate gas atom that has lost an electron is said to be "ionized." This is all that ionization means, *i. e.*, a breaking away of electrons from gas atoms. It, the ionized atom, is over-positively charged and flies with terrific force toward the negative or cathode element, which it strikes violently and from which it extracts an electron from the inflowing stream in the wire leading to the cathode—the entrance element from the outside supply. The gas atom, now once more in a normal state, rebounds from the cathode and flies about jubilantly until it is again robbed of an electron, when it instantly goes through the performance just described all over again.

One remarkable thing about this action which is not yet understood is the fact that the bombardment of the cathode by ionized gas particles causes a liberal release of free electrons—of extra electrons beside those taken to balance the ionized atoms. In other words, by hammering a negative electrode with positively charged gas particles, we get a discharge of electrons. Perhaps the "yanking" out of the electron needed by the atom for itself is so violent that several extra electrons are hustled out along with it.

Some of these extra electrons in their flight to the positive or exit element collide with other gas molecules, and the action, the pounding of gas particles on the cathode and the emission of electrons, is continuous as long as electrical pressure is applied to the device. A current consequently flows through the tube. In this manner electricity gets through a cold-electrode rectifier tube.

HOW A TUBE RECTIFIES

THE foregoing does not explain how current gets through the tube in only one direction. It would seem that, when the tube is put in an a. c. circuit, each element would become alternately an anode and a cathode, an exit and an entrance, and that the flow would be equally back and forth through the gas in the tube. But since the current flow depends upon hitting an electrode with gas particles, it becomes apparent that, by making one electrode big and the other one little, you can facilitate the hitting in one direction and minimize it in the other. When the larger electrode is negative, it will get thoroughly hammered with gas particles and will release many electrons; consequently, a large current will flow through the device. On the other hand, when the smaller electrode goes negative under the reversing a. c. current, it will not be battered so much by the flying gas particles as the other electrode was and therefore will not emit many electrons. A small current will, however, flow. The big electrode is a better emitter because it has more surface for the gas particles to "rip" electrons out of. When the big electrode is positive and the small electrode is negative, the ionized gas atoms do fly toward the small electrode but most of them miss it because it is comparatively hard to hit. Some particles strike the small element while it is negative and release electrons which fly across to the large electrode. This produces a "back-current" through the tube. All helium-gas rectifier tubes have this "back-current." The amount of it determines the efficiency of the rectifier and it usually is but a small percentage of the current in the other direction.

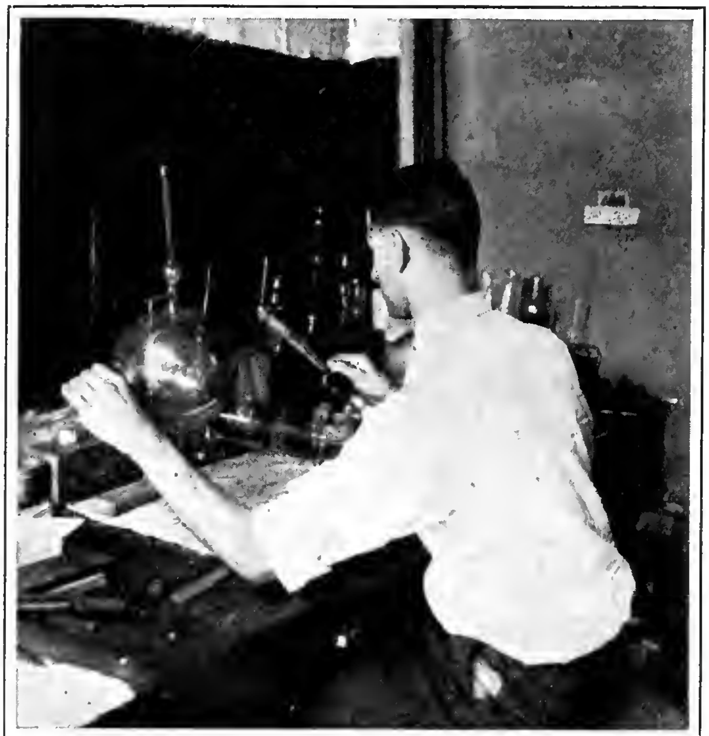
The "back-current" is reduced by making the anode small and hard, while the other large electrode is treated with radioactive earths to encourage it to release electrons. Besides the difference in size of the bombarding areas of the two elements, the electric field produced by the smaller electrode is less attractive to the ionized gas particles than that of the larger one, with the result that it is hit less violently.

Both of the elements are made principally of nickel, which has been purified in a hydrogen furnace to remove all impurities.

The description so far has dealt with a tube in which there are only two elements. The usual helium-gas rectifier tube has three elements—a hat-shaped or tubular cathode and two anodes. This is simply two rectifier tubes in one, using a common cathode, and enables both halves of the a. c. wave to be used. The action here is exactly the same as that already described, except that the emission of electrons is alternately from the cathode to first one anode and then to the other—to each one as it becomes positive in turn. And the cathode is almost continuously under bombardment, because it is always negative with respect to one anode or the other. At the same time that the flight of electrons takes place from the cathode to the positive anode, a "back-current" emission travels from the temporarily negative anode toward the cathode. Some electrons also fly between the two anodes, causing "leak" current. These "leak" and "back-currents," while not wanted, cannot be entirely eliminated, and as long as they are small, cause no serious trouble. In the factories, each tube is tested on a machine that measures the "back-current," and if excessive, the tube is discarded. Too much "back-current" through a tube will cause a B-device to hum.

It is worth pointing out that the popular conception of the movement of electricity through a B-device rectifier and filter system is erroneous. The general idea is that a "positive current" gets across the rectifier tube into the filter where it is tanked and choked into smoothness. But it should be remembered that current is purely electronic flow—it consists only of moving electrons in a conductor—and these electrons flow only from negative to positive. It is very confusing to the novice and entirely unnecessary to say that the current flows one way and the electrons the other. There is no such current flowing against the movement of the electrons. It simply doesn't exist. In the early days of electrical science, long before any kind of a radio vacuum-tube had even been thought of, experimenters misunderstood some of the actions of electricity, and the positive-to-negative idea of current flow was one of the consequences of their lack of knowledge. In the business of science, there is no sensible reason for compromising with mistakes or twisting them around to meet new facts, as is being attempted all the time in religion; they should be simply left out of the story.

The electrons flowing in a B-device circuit enter the negative wires, pass direct to the filaments of the vacuum-tubes in the radio receiver, are emitted from the hot filaments to the plates, pass from the plates through the various circuits to the positive lead of the B device, thence through the chokes to the cathode element of the rectifier tube, and from this point they are



BEHIND THE SCENES IN THE LABORATORY

Preparing a globe of pure helium for research experiments. This kind of work never stops, and in every progressive tube concern, the laboratory is always ahead of the factory—is always working on "something better."

sprayed alternately to the anode elements as these become positive in turn under the inductive action of the a. c. current in the primary power-supply windings. The filter chokes and tanks prevent a voltage and current fluctuation in the line during the intervals between the spraying or emission surges through the rectifier tube.

So deeply ingrown is the current-flow conception that in a recent issue of a well-known radio magazine there was a cut of a helium-gas tube with the hat-shaped cathode marked "anode" and the two anodes marked "cathodes." The accompanying text used the same terminology, which was wrong even in the light of the old theory. It should be clear that the positive side of a B-device filter is of negative potential compared to the ends of the secondary winding of the power transformer to which the rectifier-tube anodes are connected. The large cathode of a helium rectifier is equivalent to the incandescent filament of the filament type tube.

WHY A TUBE DETERIORATES

SINCE the helium-gas rectifier tube contains no heated filament emitter to burn out or become lifeless through deterioration, many users of the device feel that it ought to last almost forever—for years and years at any rate, and wonder why it sometimes has a short life.

As a matter of fact, the developers of the tube themselves thought at first that it would have a life of 10,000 hours or more of continuous use, but soon found that such was not the case. The principal thing that brings the life of a helium-gas rectifier tube to an end is the fact that the helium gas in the bulb disappears. Helium gas is inert, it will not combine with anything, so far as we know at present; it is genuinely strange, therefore, that it should disappear from a hermetically-sealed bulb. It seems that the ionized gas particles pound the cathode with such force that some of them are driven deep into the metal and stay there—become occluded or imprisoned.

After a certain length of time so many gas atoms are bound in the metal that the tube becomes very hard, the vacuum rises, and the bombardment of the cathode becomes meager, owing to the reduced number of molecules of gas to do the battering. The current output of the tube then falls off to such a point that it must be discarded.

The life of many a good helium-gas tube has been quickly brought to an end through the breaking down of condensers in filter circuits. Cheap inferior condensers in both home-made and factory-built power devices usually go to pieces after a few weeks or months of use, with the result that the rectifier tube is placed in a dead short-circuit. The heavy current flow quickly burns off the tips of the anodes in the tube. The helium gas itself cannot be injured by any current. Helium gas will carry currents so great that they will instantly explode copper conductors of the same cross-sectional area; but under such currents the gas particles quickly drive themselves deep into the negative electrodes and are as good as lost.

Some of the cheaper helium-gas tubes now on the market may be short-lived through the presence of impurities in the helium, which would destroy the electrodes. Extremely pure helium must be used. This gas is purified by passing it through copper tubes filled with cocoanut charcoal and maintained at the temperature of liquid air—more than 250° below zero, Fahrenheit; then to a steel reservoir; then to a second battery of tubes of charcoal surrounded with liquid air to remove oxygen or nitrogen which might come away from the walls of the reservoir. The helium is admitted until the charcoal is partly loaded with it; next it is pumped off with vacuum pumps and the impurities remain in the charcoal, which is itself purified and used over again.

It is interesting to consider that absolute purification of anything, liquid, gaseous, or solid, is almost impossible. Imagine for a moment that you could mark molecules in some such way that you could identify them when you saw them again. Assume that you took a glass of water with the molecules of water all thus marked and stirred it into the waters of the oceans of this earth, that you waited a couple of million years for thorough mixture, and that you then walked up to the nearest hydrant in your vicinity and casually drew a glass of water, you would find about 2000 of your marked molecules in it! Of course, we may be a few molecules out on this estimate, but that is roughly the correct mathematical number, because there are 2000 times as many molecules in a glass of water than there are glasses of water on the earth.

Again, molecules of air, if admitted into a highly-evacuated 25-watt electric light bulb through a hole so small that they had to flow in single file, would take about 100,000,000 years to fill it to atmospheric pressure. A little reflection will show that "purity," like everything else, is probably only a relative condition. "Some of 'em is more pure, and some of 'em is less pure, but none of 'em is *all* pure," said the sour cynic, and while he wasn't speaking of gases, and was not a scientist for that matter, he was uttering profound truth.

THE TIN "HAT"

WHAT is the queer tin "hat" for in the modern gaseous rectifier tube? Nobody outside of the research laboratories seems to know. Even some of the "bootleggers" making these tubes don't know.

In the early experimental forms of the helium-gas tube, great trouble was met with owing to the disruption of the cathode element under the hammering of the ionized gas atoms. The earlier tubes had disk shaped cathodes, and the gas atoms pulled out electrons with such violence that tiny pieces of solid metal were often ripped loose from the electrode. These metal bits were thrown against the glass walls of the tube, blackening it, and resulting in the speedy destruction of the cathode.

For this reason the peculiar tin-hat form of cathode was evolved because, with this arrangement, the bombardment of the cathode and emission of electrons is entirely internal. The action all takes place inside of the electrode. If a bit of metal is torn from the cathode at any point, it is hurled across the inner chamber and thrown back onto the element somewhere else. There is no loss of metal because the cathode is continually built up as fast as it is torn down.

It seems that, if we, as human beings, could be temporarily reduced to the size of, say, an atom, together with a corresponding ability to see small objects, and were then placed upon the cathode of an operating helium-gas rectifier tube, we would have an impression of standing among ranges of heaving mountains of metal in a state of furious convulsion and uproar, bombarded with enormous meteors of helium and full of volcanic upheavals and earthquake-like shocks, while electrons would arise like clouds of steam on all sides, or spurt out like fiery sparks.

A VIEW OF THE LABORATORY IN WHICH THE HELIUM-GAS RECTIFIER TUBE WAS PERFECTED

THE MARCH OF RADIO

NEWS AND INTERPRETATION OF CURRENT RADIO EVENTS

Can The Serious Problem of Radio Patents Be Settled?

THE recent adjudication of several important patents, such as those of Hazeltine and Alexanderson, has forced upon the radio industry the long deferred day of reckoning with inventive genius. Conscientious and established manufacturers have proceeded promptly to obtain licenses under Radio Corporation patents which make available to them the work of some of the world's greatest laboratories. By assuming an annual royalty guarantee of one hundred thousand dollars a year, charged at the rate of $7\frac{1}{2}$ per cent. of the cost of radio receivers, they become licensed under R. C. A., A. T. & T., Western Electric, General Electric, Westinghouse and Wireless Specialty patents.

Having assumed this substantial burden, the licensees considered their patent difficulties disposed of. But some quickly found that licenses under Hazeltine and Latour patents are also necessary to freedom from patent difficulty and, probably quite reluctantly, signed the Hazeltine licenses with the additional burden of a $2\frac{1}{2}$ per cent. royalty and an annual guarantee of thirty thousand dollars a year. This duty performed, the manufacturer dismissed patent trouble and consecrated himself to the problem of selling newer and better radios.

And then came the independent inventor to disturb his peace of mind. Old patents were dug up, demanding recognition. New patents, just issued, added to the swarm. Some of these inventions are as worthy of recognition as those covered by the Radio Corporation license. Others may be worthless and which will not withstand the test of adjudication.

The weary manufacturer's answer to those demanding additional royalties is becoming less and less courteous. He is now paying all that the traffic will bear. Unless some remedy is offered, his answer to patent holders soon will be: "A plague upon your patents!"

The Prospects of a Patent Pool

SOME manufacturers have united in defensive groups to protect themselves against the swarm of inventions which now confronts them. They foresee the necessity for so great an increase in the price of radio receivers by reason of patent royalties that the public will no longer be able to afford them. Faced with the alternatives of excessive royalties or occasional injustice to the legitimate inventor, the manufacturers have, quite naturally, tended to the latter course.

No doubt, some of the inventors, whose claims for royalties are being disregarded or opposed, will eventually win adjudications, and triple damages, if they are sufficiently patient and prosperous to afford the protracted legal battle which must precede such a result. It is quite possible that combined resistance to the inventor may, in some cases, prove costly, because it is not reasonable to assume that Radio Corporation, Latour and Hazeltine patents are the only ones which will be favorably adjudicated.

Combined resistance, however, is the only course open to the manufacturer because there are too many unadjudicated patents demanding attention. It would be suicidal to agree to a license under all of them; the cost of radio sets to the consumer would double and sales resistance would fourfold.

Most of the executives in the radio field wish to concentrate their attention on the design, manufacture and merchandising of radio equipment, but patent problems now require an alarming proportion of their time. Naturally, the leaders of the radio industry are nervous. At every trade convention and meeting, we hear talk of an all-inclusive patent pool.

Unfortunately, no patent pool can be successfully organized unless it has the unanimous support of all radio manufacturers and patent holders. To relieve the patent situation economically and painlessly, there must be a single, powerful, radio trade organization. Nevertheless, the N. E. M. A. and the R. M. A. still—to all outward appearances—indulge in shortsighted rivalry. An unofficial canvass of ninety per cent. of the membership of one of these organizations reveals that all but two were in favor of consolidation. To make a consolidation possible, one or two leaders in the R. M. A. must for a moment forget that their organization has the largest number of members and the youngest blood, and one or two members of the N. E. M. A. must forget some remarks made several years ago over matters long since settled. And both groups must cease suspecting each other.

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CHANGES IN THE FEDERAL RADIO COMMISSION

Henry A. Bellows, Sam Pickard, and Carl H. Butman. Commissioner Bellows was appointed from the Minneapolis district where he had long ably managed WCCO. His resignation, effective November 1st, left a vacancy which was filled by the President in appointing Sam Pickard who has been Secretary to the Commission since its appointment. Carl Butman is the new Secretary succeeding Mr. Pickard and has many years of experience in Washington as news correspondent, specializing in radio, to aid him in his new post. Mr. Butman has for some time been Washington correspondent for RADIO BROADCAST

The industry is headed for one of the most dangerous shoals in its career. Doubtless, it will weather it successfully. But how long the shoal will impede its progress depends upon how successful it is in placing the ship in the hands of one pilot, instead of two squabbling deck hands, to guide it past the patent whirlpool. It will require leadership of the highest order to establish a patent pool.

In the future, there will be a new and greater industry, much greater than we imagine to-day. The radio receiver is but a nucleus of a home entertainment device which will rival the automobile in usefulness and entertainment value and, in the end, its gross sales figures will be as large as those of the envied motor car industry. The radio receiver, the phonograph, the motion picture machine and the television receiver will, some day, be available in a single, compact, home-entertainment device. The public will pay as much for a versatile means of home entertainment as for an automobile to take them away from home. The more the leaders of the radio industry concentrate upon the development of radio and the establishment of its true market, the sooner they will have a five-billion-dollar industry. At present, the most vital aid in that objective would be turning over radio's patent problems to a patent pool. The alternatives are continued squabbles, continued patent fights, and a radio market still limited to about ten per cent. of the American public.

The Commission Announces a New Policy

THE Federal Radio Commission recently announced a long list of allocation changes which have been made with the purpose of improving the channels of a few of the leading stations of the country. The Commission it is rumored, will hereafter work on the theory that there are a few leading, national stations, which are the favorites of listeners all over the country and therefore deserve clear channels, entirely free of interference to the limit of their range. This is the basis upon which several years ago Secretary of Commerce Hoover worked out the plan of Class A and Class B broadcasting stations and urged on the commission in these columns for more than a year.

Following this plan, WHAZ, which shared time with WGY, was shifted to share time with WMAK, giving powerful and popular WGY a full channel. WJAR, Providence, was shifted from 620 kc. to 800, eliminating widespread heterodyning with WEAF, ten kc. off, experienced throughout southern New England. WEEI, Boston, was shifted from 670 to 650 kc., avoiding a heterodyne imposed upon it by a Chicago station. WTRL, a little station in Tilton, New Hampshire, formerly occupying a channel adjacent to WJZ, was shifted downward in order to eliminate a whistle which it thrust on WJZ's carrier in large parts of New England. WDWM of Asbury Park, New Jersey, was shifted so as to eliminate conflict with WSAI's carrier. WNAC of Boston and WEAN of Providence, Columbia chain members, were made channel-sharing stations, probably in the interests of better management, and moved quite far into the unpopular higher frequency region. WCAU, a Philadelphia advertising station and now a member of the Columbia network and WKRC of the same chain were demoted from the lower frequency region. WOR now has WOS of Jefferson City, Missouri, as a channel neighbor instead of WSUI, Iowa City. We believe the Missouri station is more powerfully received in Newark and will therefore accentuate slightly the whistle which already mars WOR's programs.

Another station to benefit by the Commission's reallocation is KSD, St. Louis, which is given full time. KSD is one of the pioneers of broadcasting and is deserving of the consideration which the Commission has shown.

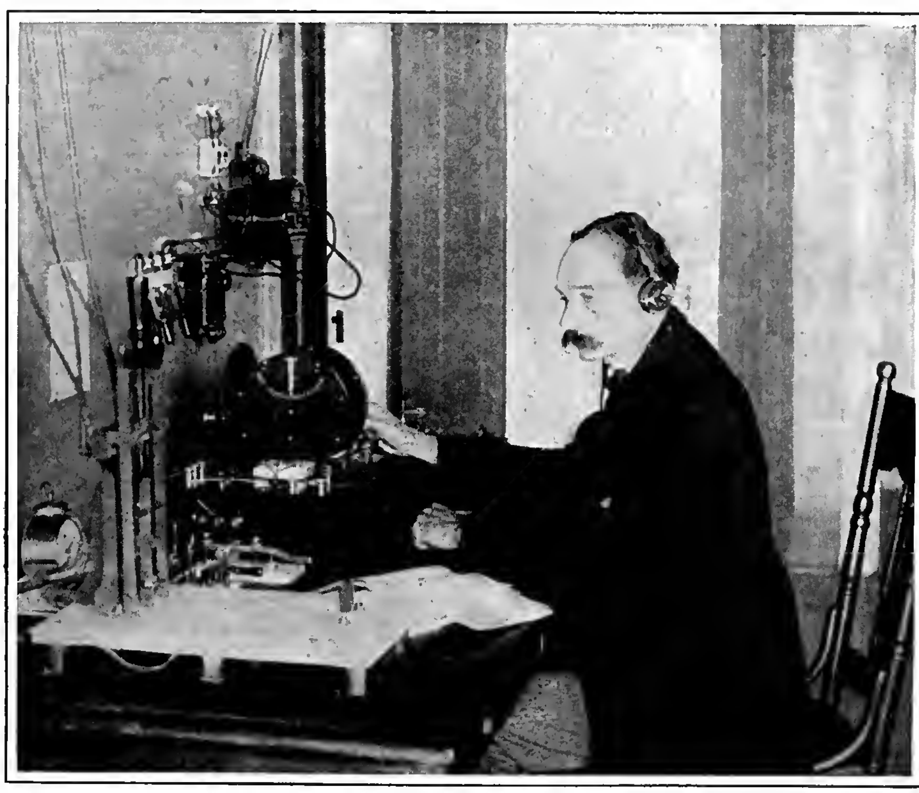
The conclusion that N. B. C. stations have fared better than Columbia chain stations is inescapable, but it must not be forgotten that the former do include most of the pioneer stations of the country which have served faithfully and well for years, while most of the latter have not yet won their spurs in public estimation. Clearing the channels of the N. B. C.'s leading stations cannot be criticized, but it might have been better policy to have concentrated less on Columbia stations when the demoting process was begun.

The Commission Suggests Synchronization Schemes

IN A speech before the American Institute of Electrical Engineers, Commissioner O. H. Caldwell made some remarks about the problems of maintaining a broadcasting station on its assigned frequency. He mentioned three methods of accomplishing this purpose, one well known and widely used, one successfully used experimentally but economically prohibitive, and a third which is a rather unfortunate suggestion. It is the Commissioner's idea that, if complete frequency stability could be secured and the heterodyne interference between stations now assigned to the same channels eliminated, more stations could safely occupy the same channel. While this is true, it must be realized that the audio-frequency components of two stations on the same channel also affect each other. When the distant station does not come in with sufficient volume to cause cross talk, it often causes irregular distortion.

Cyrstal control, the first method suggested for synchronizing carriers, is not sufficiently stable to solve the problem. Temperature and humidity changes affect the frequency of the crystal and, consequently, it does not give the absolute regulation necessary for successful occupancy of the same channel by two broadcasting stations whose carrier ranges overlap.

The second method suggested, the use of a wire circuit for the transmission of a con-



A WIRELESS STATION IN 1904

A 35-kw. spark transmitter was erected by the old De Forest Company for the Navy near San Juan, Porto Rico. The illustration shows the receiving installation with Mr. Irodell, operator for the De Forest Company using the receiving equipment which consisted of a "pancake" tuner and an electrolytic detector. It was not until 1906 that a carborundum detector was substituted for the electrolytic one. The call signal of this station, which may be recalled by old-timers, was SA.

trolling frequency, which has been successfully employed by WBZ and WBZA at Springfield and Boston, has the disadvantage of being prohibitively expensive. For example, if WOR attempted to eliminate the heterodyne whistle caused by WOS at Jefferson City by this method, it would probably cost some fifty thousand dollars a year. To stabilize the whole broadcasting structure would require perhaps five years to erect sufficient telephone channels for the purpose and an expenditure of perhaps twenty million dollars a year in maintenance.

The third suggestion made by the Commissioner was prompted by a suggestion from WDRC of New Haven, Connecticut, a 500-watt station. A heterodyne whistle, originating from the carrier of WAIU, a 5000-watt station in Columbus, Ohio, about 500 miles distant, had been sufficiently annoying to require drastic measures. To solve this problem, a receiving station was installed five miles from New Haven, connected by wire lines with WDRC's transmitter. By tuning this receiving set carefully so that the heterodyne whistle is eliminated, WDRC's carrier is adjusted to coincide with that of WAIU. So long as the operator is vigilant and skillful, there is no heterodyne whistle.

But, if the whole broadcasting structure depended for frequency stability upon manual control, it would become a sorry mess. One need but recall the days of the regenerative receiver, with its heterodyning carrier of but a tiny fraction of a watt. Then imagine manually controlled broadcast transmitters with hundreds and thousands of watts power, trying to establish zero beat with each other. The incident again emphasizes the fact that the Commission is sadly in need of technical assistance which will help the members to grapple more wisely with their problems. Any competent engineer could have pointed out the dangers of this ingenuous panacea.

What Readers Say About Broadcasting Conditions

THE following are quotations from readers of these editorials. George Madtes, Radio Editor of the *Youngstown Vindicator*, writes: "I have no doubt that the re-allocation of frequencies has materially helped stations in New York and Chicago, but it has not attained the Commission's apparent goal—an arrangement which would permit listeners everywhere to enjoy the stations nearest them. We are within fifty miles of stations in Cleveland, Pittsburgh and Akron and depend upon them for local service. Our four main stations in these cities, WTAM, KDKA, WCAE, and WADC are often heterodyned and WADC and WCAE are almost invariably useless at night."

W. W. Muir of Lockport, New York writes: "One cannot help but notice the difference between the stations which are operating in the few wave bands on which there is only one station and those operating on the frequencies on which there are more than one station. The stations which are operating on exclusive channels are usually free from distortion, the signal being strong and clear. The stations which are operating on wavelengths on which there are more than one station show a decided tendency to be mushy and weak, and have a wide variation in signal strength from moment to moment.... One cannot help speculating what is apt to take place in the future. We know that the American public have had lots of things put over on them without complaint. It is hard to believe that they will be willing to stand for the huge joke that it is possible to successfully operate more than one powerful broadcasting station on a single frequency without serious interference."

Another correspondent writes from Wyoming to the effect that KOA, Denver, is the principal reliance for summer and winter reception of the entire state. The Federal Radio Commission has ordered that station to cut its power in half after seven in the evening. Continuing, he writes: "Practically every strong station near the east coast is located on the same frequency as some powerful station on the west coast. While probably they do not interfere in their home territory, the heterodyne of the two completely ruins reception in the Rocky Mountain region. Before the recent changes, we could usually depend on WOC, Davenport, and WCCO, St. Paul, for WEAF programs, but have been unable to locate either fo a long time."

Another correspondent writes from Ohio tha he is located "forty-eight miles air line fron WTAM, 102 miles from WWJ, and 95 miles fron WAIU . . . WTAM fades so badly at night that i is worse than useless. WWJ is 'crowded to death on both sides. There is not one station in thi group, or any other station, that can be receive here without heterodyning. Yet the Chairman o the Federal Radio Commission reports the dis trict very much improved. It is all bunk. Som stations must be eliminated."

INTERNATIONAL CONFERENCE CHANGES BROADCASTING BANDS

THE International Radio Telegraph Con ference at this writing is still in session i Washington. Very few of the articles of the nev international agreement have yet been adopted Some opposition has appeared to the America proposal that no more spark stations shall b licensed and that steps be taken to eliminat gradually those in existence with a view to thei complete disappearance in 1935. The eliminatio of spark transmitters is proposed largely in th interests of the broadcast listener.

In the matter of frequency allocations, th amateurs, as usual, have defended their positio with great heat. The Japanese delegation, i particular, was far from cordial in its attitud toward amateurs. The British, French and Ger man governments sought lower frequenc channels for broadcasting in the 1000-, 1300- 1500- and 1800-meter regions, in addition to th usual bands in general use. It was finally decide to consolidate these requests for a longer wav broadcasting band of setting aside 1500 to 155 meters (200 to 194 kc.) for the purpose, provid ing about two channels with ten-kc. separation At this writing, this band is not yet officiall approved, but is likely to stand.

The Committee on frequency allocation, whil favorably inclined toward the recommendation of the American delegation for the broadcastin band, does not, at this writing, plan to devot the entire 500- to 1500-kc. region to broadcastin purposes. In the plan announced, it proposes t utilize the lower 200 kc. (i.e. from 1300 to 1500 kc or 230 to 200 meters) for both broadcasting an ship stations. This does not mean that the 27 American broadcasting stations, now occupyin that part of the band, will have to get off, but i is likely that ship interference will develop a this end of the broadcasting channels. This mov on the part of the International Telegrap Conference will undoubtedly accentuate stil further the need for curtailing the number o broadcasting stations on the air in the Unite States.

BROADCASTING NOTES

THE National Broadcasting Company and th British Broadcasting Company will coöper ate in several short-wave international pro grams. In 1924, WJZ participated in the first at tempt at international broadcasting by relay A dance music program from the Savoy Hote was radiated from England and intercepted a Houlton, Maine, and from there sent by wire t WJZ, in New York. The fading experienced o the 1600-meter wavelength, (187 kc.) upon whic the program was relayed, was sufficient to dis courage further attempts along these lines a that time. With the development of short-wav transmitters, however, more reliable results ma be expected. ❦❦❦ IN A statement of its polic on international broadcasting, the British Broad casting Company lays considerable stress upo the failures of previous attempts along thes

HOW VISITORS SEE THE ATWATER KENT FACTORY lines. It describes an experimental relay of programs for Sidney as barely recognizable; a parallel attempt to relay Melbourne a few days later as a complete silence. It regrets that so much emphasis has been laid upon the possibilities of international broadcasting and points out that considerable development work is necessary before we can hope for regular and reliable international broadcasting. ❦ ❦ ❦ E. T. SOMERSET writes us from Sussex, England, that he enjoys WGY, WJZ, WLW, WEAF and KDKA on their regular broadcasting channels, but American programs come in with much greater regularity on the high frequencies. 2XAZ, WGY's short-wave twin is the star performer, with KDKA on twenty-six meters and 2XAF following. He has also heard with great clarity, 2XAH, WRNY and WLW on its short wave, and ANH, Radio Malabar, Bendosng, Java, on 17.4 meters and last, but not least, 2ME, Sidney, Australia. It gave him a particular thrill, he writes, to hear the clock striking four A. M. in Sidney, when it was still seven P. M., British summer time, of the previous night. Mr. Somerset advises American fans to listen for 5 GB, Daventry, England, on a frequency of 610 kc. with 30 kw. output, and Langenberg, Germany, with a 25 kw. output on a frequency of 640 kc. ❦ ❦ ❦ SAM PICKARD, who first gained fame in radio circles as director of the Department of Agriculture Radio Service, has been made Federal Radio Commissioner to succeed Henry A. Bellows, recently resigned to resume the management of WCCO. The Commission loses Mr. Bellows because the gentlemen of the Congress failed to confirm his appointment. He was a useful and hardworking Commissioner. Mr. Pickard is qualified to serve on the Commission because of his familiarity with its problems as its former secretary. Carl H. Butman now becomes Secretary of the Commission. He is well known to the newspaper fraternity and may be helpful to the Commission, not only as an efficient secretary, but in advising it how to handle its relations with the press and the public. ❦ ❦ ❦ "I HAVE come to the conclusion that it is not a practical or even a theoretical advantage to a broadcaster to sponsor a program through any small station. The companies that are marketing national products can use radio advertising to excellent advantage but for local companies to broadcast through a small local station is not good advertising, in my opinion. Their efforts are so mediocre in comparison with the programs sponsored by the big companies and transmitted through the high power of a well equipped, well operated station, that a bad impression is made and no benefit is derived." That is the statement, not of a newspaper publisher, but of Mr. Robert A. Fox, of Ashland, Ohio, who owned and operated station WLPC. Realizing that the small station serves little useful purpose, WLPC requested the Federal Radio Commission to cancel its license and its owner now states that he wishes "about two hundred more stations, now operating, would do the same." ❦ ❦ ❦ THE DEPARTMENT OF AGRICULTURE Farm Radio Service is being broadcast by eighty-nine radio stations in thirty-four states. Each of these stations will broadcast one or more of the eleven regular farm and household radio services prepared and released by the U. S. Department of Agriculture. Such services as these help to sell radio to the farmer.

NEWS OF THE PATENT FIELD

LEE DEFOREST won a victory over Edwin Armstrong in the United States Circuit Court of Appeals at Philadelphia, which decided that he is the inventor of the regenerative or feed-back circuit and the oscillating audion. Since the right to use both DeForest and Armstrong patents is included in the R. C. A. license, the decision does not affect the R. C. A's licensees particularly. Certain companies, however, operated under licenses granted by Armstrong before his patent was acquired by the Westinghouse Company, appear, through this decision, to be liable for royalties under the DeForest patent. There is a possibility that this case may now reach the Supreme Court, although that body has the power to refuse to consider the matter. ❦ ❦ ❦ THE MACKAY interests announce that the DeForest victory places them on an equal footing with the Radio Corporation of America in the field of wireless communication. They will undertake immediate steps to establish short-wave wireless systems across the Pacific Ocean and throughout the United States. ❦ ❦ ❦ PATENT No. 1,639,042, recently issued to Wilford MacFadden of Philadelphia and assigned to the Atwater Kent Manufacturing Company, describes the use of a potentiometer for the stabilization of radio-frequency amplifiers. This system was used extensively before the neutrodyne system of stabilization was developed. ❦ ❦ ❦ THE DUBILIER Condenser Company has notified a number of manufacturers of the scope of patents 1,635,117, 1,606,212, and 1,455,141, describing plate-current supply devices and power amplifiers. Included among prospective defendants under these patents are various Radio Corporation licensees. One of these patents describes a power system comprising rectifiers, filter and choke circuits, using a. c. on the filaments; another, a two-stage power amplifier with alternating current on the filaments and a C battery used to obtain grid bias; plate potential is obtained from a thermionic rectifier.

AMONG THE MANUFACTURERS

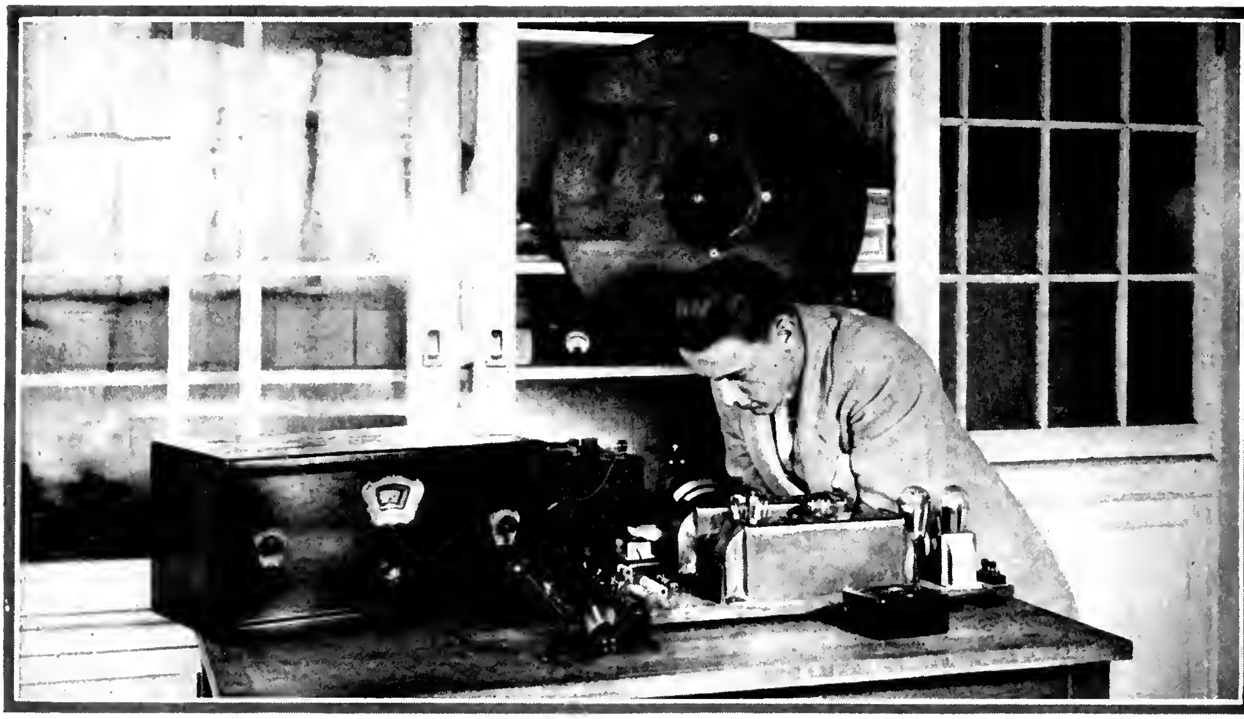
THE Sonora Phonograph Company, manufacturers and distributors of phonographs and radio sets, the Bidhamson Company, a patent holding corporation, organized by John Hays Hammond, Jr., Lewis Kausman and others, and the Premier Laboratories, headed by Miller Reese Hutchinson, have recently merged to form a corporation devoted to the manufacture of acoustic devices. ❦ ❦ ❦ ARTHUR D. LORD, receiver in equity of the DeForest Radio Company, has filed a complaint with the Federal Trade Commission on Clause IX of the R. C. A. license contract. This clause specifically forbids R. C. A. licensees to equip and sell licensed radio sets without equipping them with R. C. A. or Cunningham tubes to make them initially operative. In his complaint, Mr. Lord claims that the consumer is penalized because he is forced to take a tube which otherwise might not be his choice. The clause is obviously aimed at independent tube manufacturers. He expresses the belief that this is an attempt at monopoly and restraint of trade, a direct violation of the Federal Trade Commission Act, the Clayton Act and the Sherman Anti Trust Law. ❦ ❦ ❦ IN FULL page newspaper advertisements in the principal newspapers of the country, Mr. A. Atwater Kent announced a price reduction of twenty per cent. in his receiving sets. This reduction, says the announcement, is made possible by tremendous increase in production facilities. Particularly in the lower price classes, we may expect an era of intensive price competition with consequent advantages to the consumer. ❦ ❦ ❦ POWEL CROSLEY, JR., has announced that his Bandbox model will probably not be changed for several years. This is the first time that a manufacturer has ventured such a prediction. ❦ ❦ ❦ THE STEWART WARNER Speedometer Corporation, which has long defied the R. C. A. in patent matters, is the most recent addition to the ranks of those committed to a $7\frac{1}{2}$ per cent. royalty.

A STATEMENT by Dr. J. H. Dellinger, calls attention to a general current misunderstanding regarding short-wave beam communication. The international short-wave beam links confine the radiated energy to a thirty-degree arc which is indeed not concentration in a single narrow path. It represents merely, Doctor Dellinger points out, an economic advantage and not a secrecy system.

Science has been unable to affect a concentration of radiated wave energy, either light, sound, or heat, in a perfect single beam by the aid of any form of reflector, and there seems little ground for hope that we shall soon achieve it with radio telegraphy or telephony. The concept that we may reduce beam transmission to a concentration comparable to that obtainable by wire communication is now untenable.

THE NEW COAST GUARD SHORT-WAVE TRANSMITTER

B. J. Fadden, chief radioman aboard the U. S. C. G. *Modoc* in ice patrol duty is shown standing beside the 35.5-meter (8500-kc.) transmitter. The transmitter on this wave is used for direct communication between the *Modoc* while in the North Atlantic ice fields and headquarters in Washington



Radio Broadcast Photograph

MAKING FINAL ADJUSTMENTS ON THE PUSH-PULL AMPLIFIER DESCRIBED IN THIS ARTICLE

Measurements of the grid bias voltage are being made. Note the electro-dynamic Magnavox loud speaker in the background. A circular baffle-board has been attached to it in the laboratory

PUSH-PULL AMPLIFICATION—WHY?

By HOWARD E. RHODES

THE essential prerequisites for faithful reproduction from a radio set are, first, a properly designed receiver capable of giving reasonably distortionless amplification and, secondly, a good loud speaker fed with power from a source able to supply the necessary energy without overloading. Much of the distortion in receivers is due to tube overloading, which usually occurs to the greatest extent in the last audio tube. The cure for this condition, obviously, is to use a tube, or combination of tubes, in the output circuit that has a high enough power rating so that overloading will not take place. As will be brought out in the following discussion, this requires that "power" tubes be used in the output circuit of the receiver, and at the end of the article some constructional details will be given regarding a push-pull amplifier employing 210 type tubes. Such an amplifier will deliver a large amount of power to a loud speaker without overloading.

Let us first determine approximately what requirements are necessary in the output of a receiver to prevent serious overloading. By the term "overloading," in this discussion, we mean that the input voltage on the grid of the tube is so great as to cause the grid to become positive at times so that current begins to flow in the grid circuit. In the operation of any ordinary amplifier, care must be taken that the signal input voltage is never great enough to cause grid current to flow for, when this does occur, the input signal will be badly distorted. In determining the characteristics of an amplifier to prevent overloading, we must assume certain values, with the result that the final answer will not be exact, but should nevertheless give a good idea of what conditions must be met. Suppose, to take an average case, that an orchestra is broadcasting and that the ratio of power between the fortissimo and pianissimo passages as played by the orchestra, is a million to one, corresponding to a power ratio of 60 TU. Because of the characteristics of the amplifier used to pick up this music, it is necessary to cut down this power ratio somewhat so as to keep the pianissimo passages above the noise level and to prevent the fortissimo passages from overloading the amplifier. In practice, this ratio is cut down in the control room at the broadcasting station by an operator in charge of the gain control. The power ratio is, after being cut down, generally about 40 TU into the amplifier system. This corresponds to a ratio of ten thousand to one. Let us assume that this ratio is maintained throughout the entire broadcasting and receiving system, a condition which will be true if there is no overloading at any point. Suppose that the energy in the pianissimo passages as they are reproduced by the loud speaker is 3 microwatts (0.000003 watts).

Radio Broadcast Photograph

A CLOSEUP

Showing the plug which provides for variations in line voltage

To get an idea of what this amount of energy represents, it may be compared to the average speech power delivered by a person speaking, which is about 10 microwatts. The energy associated with the fortissimo passages will be 10,000 times as great, or 0.03 watt. It is now necessary to assume a figure for the average efficiency of the loud speaker, but because the efficiency of a loud speaker varies considerably over the range of audio frequencies, it is hardly accurate to assume an average efficiency and have it mean very much. We will do so in this case, however, merely to get some idea of how much power is required. The efficiency of a loud speaker is very low, we will assume it to be 3 per cent., which means that, in order to obtain a given amount of sound energy, we must supply the loud speaker with many times as much electrical energy. The amount of electrical energy required is found by dividing the sound energy output by the efficiency of the loud speaker; in this case we must divide 0.03 watt by 0.03 (3 per cent.) and the quotient, one watt, is the amount of energy the power tube in the receiver must be capable of delivering to the loud speaker during the fortissimo passages. Now let us see what tube or combination of tubes is capable of supplying this power.

The maximum amount of undistorted power that can be obtained from various tubes is given below.

TABLE NO. 1

Tube Type	Plate Voltage	Grid Voltage	Undistorted Output Watts
199	90	− 4.5	0.007
120	135	−22.5	0.110
201-A	90	−9.0	0.055
112	157	−10.5	0.195
171	180	−40.5	0.700
210	450	−38	1.700

When two tubes are used in a push-pull arrangement the maximum power output of the combination is twice that of a single tube.

It is evident from the table that the only tubes delivering, in push-pull arrangement, more than 1 watt of power are the 171 and 210 combinations, and, therefore, these combinations are most satisfactory for supplying a loud speaker with the necessary amount of undistorted power. In practice it will be found that a push-pull amplifier can be overloaded, but this amount of overload is so small as to be negligible.

This treatment of the problem is not exact. It was necessary to assume an average value for the power associated with the pianissimo passages and this first assumption determines how much power will be required for the fortissimo passages. It is also true that a considerable amount of distortion can be present in the output of a loud speaker without being evident to most of us. The figures do, nevertheless, give an idea of why power tubes must be used, and show that present-day loud speakers cannot be supplied with sufficient undistorted power from tubes other than the 171 or 210 type. Marked improvement in the efficiency of loud speakers will some day make other tubes with a lower power output suitable for use in the last stage of a receiver, but until such an improvement is made, we must make certain that we have plenty of power handling capacity available in the receiver's output.

PUSH-PULL OR PARALLEL TUBES?

AT THIS point there might be some question regarding the relative merits of a push-pull amplifier with two 210 tubes and a parallel arrangement of the same tubes. Let us list the advantages and disadvantages of the two arrangements.

The italics indicate with which arrangement the advantage lies. Although point No. 4 was indicated as an advantage for the parallel arrangement, it is possible, by the use of a special push-pull output transformer, to compensate the higher plate impedance of the push-pull circuit, and the two arrangements will then be equal in this respect. Point No. 5 has not, as yet, been explained, but it is the most important reason for the existence of the push-pull arrangement:

Parallel Arrangement	Push-Pull Arrangement
(1.) *Requires only half as much input voltage from receiver to give same output as push-pull arrangement.*	Requires twice as much input voltage from receiver to give same output power as parallel arrangement.
(2.) Distortion due to overload quite noticeable.	*Slight overload (about 25 per cent.) possible without noticeable distortion.*
(3.) *Voltage gain somewhat higher.*	Voltage gain is somewhat lower.
(4.) *Plate Impedance four times smaller than push-pull arrangement.*	Plate impedance four times greater than parallel arrangement.
(5.) Distortion due to curvature of tube characteristic not eliminated.	*Distortion due to curvature of tube characteristic eliminated.*
(6.) Some hum may result if filaments are operated on a. c.	*Any a. c. hum from filaments eliminated due to push-pull arrangement*

We shall endeavor to explain now how the push-pull amplifier eliminates a certain type of distortion which exists in a simple single-tube amplifier. It is necessary to start the discussion by examining in some detail the characteristics of a CX-310 (UX-210) type tube (or, for that matter, any tube).

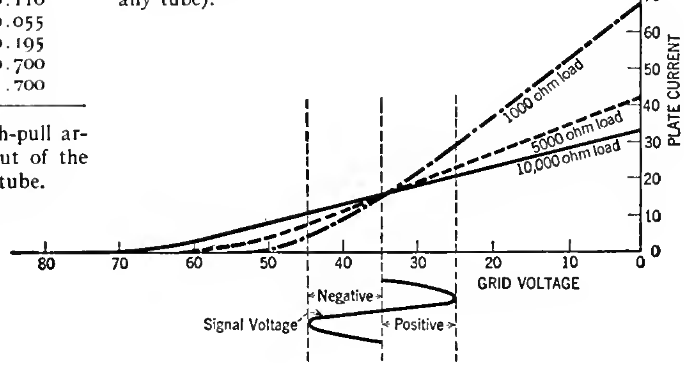


FIG. 1

Grid voltage-plate current curves of a 210 type tube

In Fig. 1 we have drawn several curves for a single tube of the 210 type with a plate voltage of 400 and a grid bias of −35 volts, and these curves show the relation between the plate current and the grid voltage with various load resistances in the plate circuit. The curve marked 1000 was made with a 1000-ohm resistance in the plate circuit and the curves marked 5000 and 10,000 were made with resistances of 5000 and 10,000 ohms respectively in the plate circuits. These curves are dynamic characteristics in the sense that they indicate how the plate current will vary with different loads in the plate circuit. If a signal having a value of, for example, 10 volts, is impressed on the grid of this tube, it will cause the grid voltage to vary 10 volts either side of its average value of 35 volts. Such a signal voltage is represented in Fig. 1 by the curve, marked "signal voltage," drawn below the grid voltage axis. If the change in plate current due to this voltage is determined on the 10,000-ohm curve by reading the values of plate current at each extremity, we find that, when the voltage is positive, the current rises to 21 milliamperes and that, when the voltage is negative, the current decreases to 11 milliamperes, a drop of 10 milliamperes.

The signal voltage of 10 volts has, therefore, caused the plate current to increase and decrease an equal amount with respect to the average value, the increase and decrease being 5-milliamperes in this case. If the same measurements are made on the 5000-ohm curve we find that the plate current increases 7 milliamperes above the average value but only decreases 6 milliamperes. On the 1000-ohm curve the increase is 14 milliamperes and the decrease is only 11 milliamperes. These values have been arranged in the form of a table:

TABLE NO. 2

Output Resistance	Increase in Current	Decrease in Current
10,000	5	5
5,000	7	6
1,000	14	11

This table indicates clearly that, as the resistance in the output circuit of the tube decreases, the increase and decrease in plate current due to a given signal become unequal. This represents distortion because it indicates that the positive side of the input voltage produces a relatively greater change in the plate current than does the negative side.

LOUD SPEAKER CONSIDERATIONS

AND now let us consider the loud speaker. The impedance of a loud speaker is a function of frequency and increases with increase in frequency. At low frequencies, therefore, the loud speaker will have a comparatively low impedance and the tube feeding the loud speaker will then operate on the characteristic corresponding to a low-resistance load in the plate circuit. This characteristic is indicated by the 1000-ohm curve in Fig. 1. At medium frequencies, where the loud speaker's impedance is higher, the tube will operate on a characteristic similar to the 5000-ohm curve, and at high frequencies the tube will operate on a characteristic similar to the 10,000-ohm curve. As indicated by the figures in table No. 2, the 10,000-ohm curve is quite straight and therefore produces little distortion. A small amount of distortion is produced by the 5000-ohm curve, but much greater distortion occurs when the tube operates along the 5000-ohm curve. When a loud speaker is operated from a single 210 type tube, this distortion occurs and, if possible, it would evidently be of advantage to arrange the circuit so that no distortion of this type is produced. This leads us to consider push-pull amplification.

The circuit diagram of a push-pull amplifier is given in Fig. 2. In some push-pull arrangements the output choke, L, is replaced by a transformer, but the circuit will function with a simple choke coil as indicated. When a signal is induced in the secondary of the input transformer, T, the voltage relations are as indicated by the plus and minus signs on the diagram. It will be noted that the voltage at one end of the transformer is positive relative to the voltage at the other end, which is negative. The signal voltage impressed on either grid is one half the total voltage across the transformer. Since the two grids are at relatively opposite potential the plate current changes will also be opposite

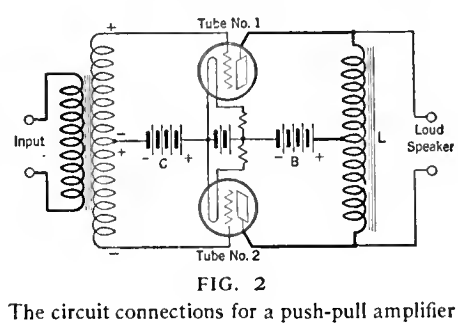


FIG. 2

The circuit connections for a push-pull amplifier in nature. Referring to Fig. 1, this means that, during the time that the grid of tube No. 2 goes positive, the plate current will increase, and that the plate current of No. 2, as the grid goes negative, will decrease. In Fig. 3, we have represented at A the signal induced in the secondary of the input transformer, T, curve A-1 indicating how the voltage on the grid of tube No. 1 varies and curve A-2 indicating the variation of voltage on the grid of tube No. 2. It should be noted that the voltages are similar, that there is no distortion, and that the voltages are in opposite phase relation to each other (when one is positive the other is negative). Now these voltages cause changes in plate current in accordance with the curves given in Fig. 1, and if the particular signal being amplified is low in frequency, the loud speaker's impedance will be low and the tube's characteristic will have a form similar to the 1000-ohm curve. This curve will produce unequal changes in plate current (see table No. 2) and the curves at B-1 and B-2 in Fig. 3 indicate the change in plate current due to the voltages impressed on the grid. It should be noted that these two curves are distorted (the positive halves are larger than the negative halves) although the distortion of the two curves is similar in nature. These curves at B can be split into two parts, as indicated at C, C-1 and C-2 represent plate current variations exactly similar in form to the grid voltage variations and C-3 and C-4 represent additional plate current variations due to the curvature of the tube characteristic. The point of interest here is that, although the variations in plate current indicated by C-1 and C-2 are out of phase (as they should be) the distorted parts represented by C-3 and C-4 are in phase; that is, they are both positive or negative at the same time. In order to have current flow through the loud speaker, the a. c. voltage at one plate must be opposite in sign relative to the voltage at the other plate. We might consider that the plate whose voltage is negative tries to "pull" some current through the loud speaker while the plate whose voltage is positive tries to "push" some current through the loud speaker, and this gives us an idea of why such an amplifier is termed "push-pull." C-3 and C-4, indicating the distorted part of the plate current variation produced by the curvature of the tube characteristic, are such that both plates are relatively positive at the same time. These currents, therefore, cannot force any energy through the loud speaker. The only current flowing through the loud speaker is indicated by C-1 and C-2, and it is undistorted. In this way two tubes in a push-pull arrangement eliminate a form of distortion present in a simple circuit using a single tube.

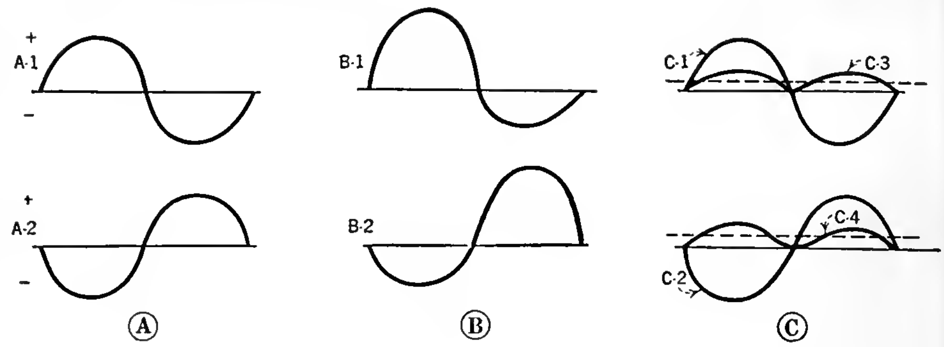


FIG. 3
These curves are used to explain how a push-pull amplifier operates

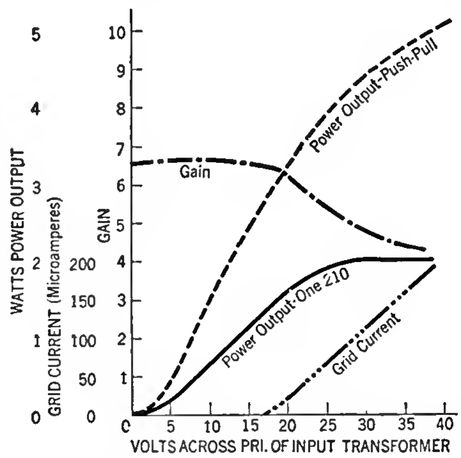
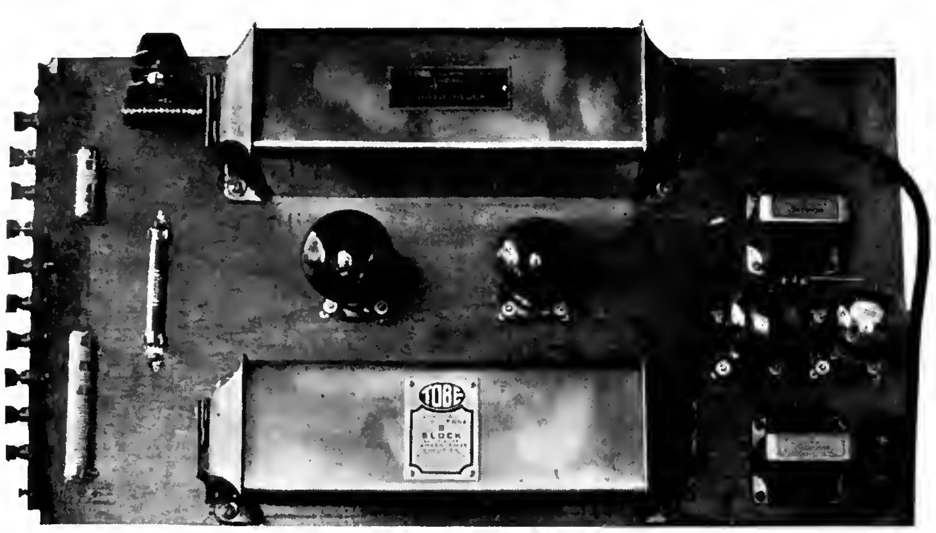


FIG. 4
What happens when an amplifier is overloaded can be determined from these curves. They are explained in the text, col. 3, page 204

In Fig. 4 are given a group of curves obtained from some data on the Samson push-pull amplifier illustrated in this article. The three curves shown in solid lines were made using a single 210 type tube. Note how the gain begins to fall off when the voltage on the grid reaches about 18 volts and this point also corresponds approximately to the point at which grid current begins to flow. The power output also begins to flatten out after more than 18 volts is placed across the input. These three effects, a decrease in the gain, the presence of grid current, and a falling off in power output, are all definite indications of overloading. The dotted curve indicates the power output obtained from two 210's in a push-pull amplifier. This curve also begins to fall off slightly after about 18 volts has been placed on the input, but the change is not as rapid as in the case of a single tube. The power output of the push-pull amplifier at the point where grid current begins to flow is twice as great as that of a single tube.

The Samson push-pull amplifier illustrated in this article is an excellent example of a well-designed unit. The major characteristics of this amplifier are as follows:

(1.) The unit consists of two 210 type tubes in a push-pull arrangement fed from an input push-pull transformer. The unit is designed to connect to the output of the first audio stage in a receiver, and thereby makes possible the attainment of better quality than can be obtained from the smaller tubes ordinarily used in a receiver.
(2.) The power transformer and choke coils have been enclosed in a nicely finished metal case with the various leads brought out through a small terminal box at one end. At the other end of the transformer is a special plug, a Samson feature, which can be turned to different points to compensate differences in line voltage. The condenser bank is also enclosed in a metal case.
(3.) The device will supply B power to a receiver. The circuit incorporates a glow tube which maintains the output voltages from the various terminals practically constant independent of load, and this makes it possible to use the device with almost any receiver with assurance that the voltages marked on the terminals will be equal to the actual voltages delivered by the device. The following voltages are available; 180, 135, 90, $67\frac{1}{2}$, and a variable tap so that accurate adjustment of the detector voltage can be made. The 210 type tubes receive about 500 volts and the C bias is about 40 volts. The device also supplies C potentials as follows: −4.5, −9, and −43.



Radio Broadcast Photograph
THE LAYOUT OF THE PUSH-PULL AMPLIFIER FROM ABOVE
No d. c. plate current can flow through the loud speaker, and blocking condensers are therefore not necessary in this amplifier for this purpose. However, in the arrangement shown the loud speaker itself is at a potential of 500 volts above ground and a serious shock will be had if the loud speaker and a grounded object are touched at the same time. In order to make the installation entirely safe it is a good idea to connect a 4-mfd. high-voltage condenser in series with each lead to the loud speaker terminals

The circuit diagram of this power amplifier is given in Fig. 5. The following parts were used in the amplifier illustrated in this article.

LISTS OF PARTS

TL—Samson Power Block, Type 210, Containing Power Transformer and Two Filter Choke Coils	$ 37.00
Tobe Condenser Block, for Samson Power Amplifier, Containing the Eleven Necessary Condensers	38.00
R₁—Electrad 7200-Ohm Type C "Tru-Volt" Resistance, 50 Watts	2.25
R₂—Electrad 420-Ohm Type C "Tru-Volt" Resistance, 25 Watts	1.50
R₃—Electrad 50,000-Ohm Variable Resistance, Type T-500	3.50
R₄—Tobe 10,000-Ohm Veritas Resistance	1.10
T—Samson Input Push-Pull Transformer, Type Y; L₂—Samson Output Push-Pull Choke, Type Z	19.50
12—Eby Binding Posts	1.80
4—Benjamin Sockets	3.00
2—RCA UX-210 (Cunningham CX-310) Tubes	18.00
1—RCA UX-874 (Cunningham CX-376) Tube	5.50
1—RCA UX-281 (Cunningham CX-381) Tube	7.50
TOTAL	$138.65

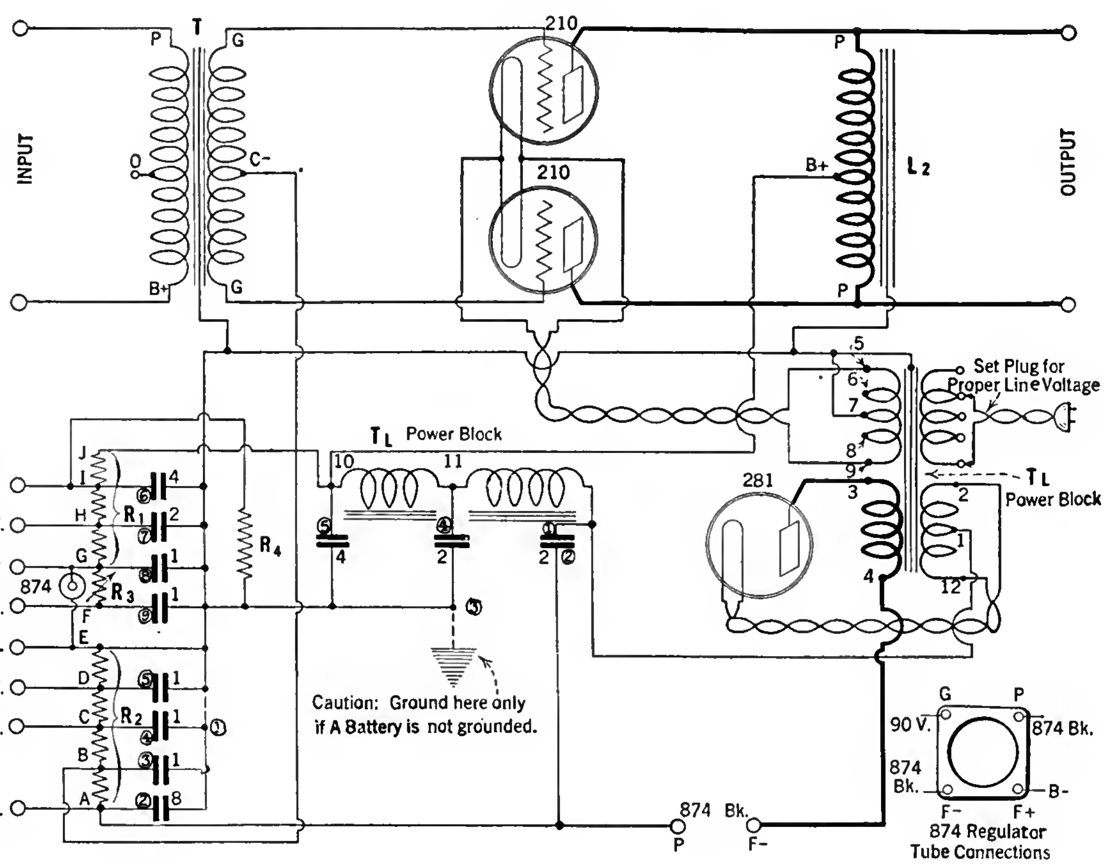
The circuit diagram has been marked with figures corresponding to the terminal markings on the power block and the condenser block. The arrangement of the apparatus on a single large baseboard makes it a simple matter to construct it and the circuit diagrams and photographs given herewith should supply all the necessary information.

All of the transformer cases, and also the case of the condenser block, should be connected to the negative B, as indicated in the schematic diagram, to prevent hum. This grounding can generally be most readily accomplished by running a lead from the negative B to the mounting screws of the various units. The wire can be fastened under these mounting screws. Remember that the voltages delivered by the transformer are very high and therefore care is necessary in making all of the connections. The 50,000-ohm resistance is the only variable control in the entire unit, and it is used to obtain accurate adjustment of the detector voltages.

When the construction has been completed, the special plug on the power input side of the Samson transformer may be inserted in the correct manner and connected to the a.c. light socket. When this is done, the tubes should light and the regulator tube should glow with a pinkish light.

In operation, the transformer block may become somewhat warm, but if it becomes so hot that the hand cannot be comfortably held on it, it indicates some error in the wiring. The input terminals of the device should be connected to the output of the first stage of the receiver and the loud speaker then be connected to the output of the amplifier.

If carefully constructed and properly operated, the unit will be found capable of giving excellent reproduction.



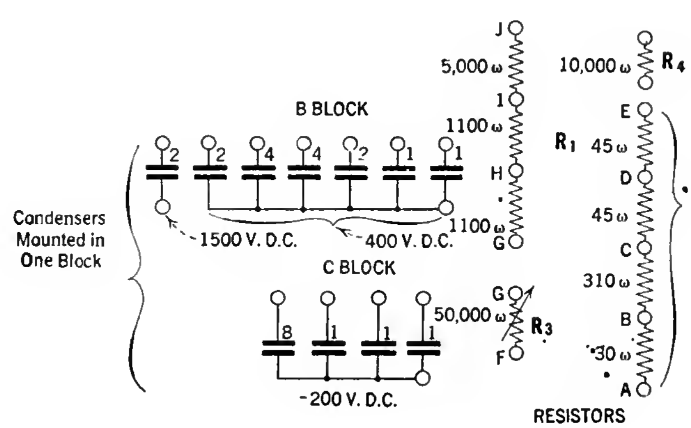


FIG. 5

This is a complete circuit diagram of the Samson push-pull power amplifier. The various numerals on the units correspond with the markings on the terminal blocks on the various parts; numbers in circles indicate terminals on the condenser block. This amplifier employs two 210 type tubes in the push-pull circuit, a type 281 tube as the rectifier, and an 874 type regulator tube. The connections to the socket holding the latter tube are indicated in the diagram. The P and F minus terminals on the socket are connected in the filter circuit as shown at the point marked "874 BK." on the diagram. The two corresponding contacts on the tube are short-circuited inside of the tube base during the process of manufacture and, therefore, if the regulator tube is removed from its socket while the power is on, the circuit is automatically opened and damage to the filter condensers thus prevented. The G post on the socket connects to the + 90 voltage tap and the F + terminal connects to B minus

TO JUDGE by the sale of radio-phonograph combination instruments and the popularity of the various electromagnetic pick-up units, the phonograph and the radio set in combination are climbing to high favor among radio users. If you have a good radio receiver and loud speaker, the purchase of a magnetic pick-up makes your old phonograph up to date and all the fine new electrical recordings then pour out of your loud speaker sounding as well as the best radio program. This magazine and others have contained descriptions on how to bring the old phonograph up to date using the electromagnetic pick-up. These pages on the entertainment that the radio-phonograph offers to the user are a regular feature of RADIO BROADCAST. *It is not enough to know that the combination of the radio and phonograph provides a flexibility of home entertainment that is astounding—we feel our readers would also like to know what the disks actually offer. These columns discuss only the records made by artists well known to broadcasting.*

—THE EDITOR.

The PHONOGRAPH

A New Use for Records

IN THE days when life was simpler, we thought of the phonograph merely as an instrument for the diversion of the multitude of home-loving folk, who were enabled by it to listen to jazz or classical music without budging an inch from their Franklin stoves. Then someone realized that by preserving on its records the speeches, music and other audible accompaniments of events of national importance the phonograph could be made to have a definite historical importance. And now the phonograph has had another burden laid upon it, that of delivering speeches for important individuals at gatherings at which they cannot themselves be present. This was actually done at the opening of the fifth annual convention of the American Institute of Steel Construction in Pinehurst, North Carolina, on October 25. Secretary of Commerce Herbert Hoover was asked to deliver the speech of welcome at this convention, but he could not take the time to make the trip there and back. The Institute, determined to have the speech, enlisted the services of the Victor Company, who made a record of a speech which Mr. Hoover delivered in his own office in Washington, and on October 25 this record was reproduced in Pinehurst before the convention. As Mr. Hoover himself remarked, one of the advantages of this method is that it puts a definite time limit on speeches. What a unique device for curtailing long-winded recitations! And what a splendid way to eliminate superfluous oratory, for as the Secretary also noted, and as all who have broadcast well know, a microphone is about as inspiring an audience as a bathroom door knob! We foresee a great future for this branch of phonograph service.

A CLOSE-UP OF VICTOR'S NO. 955 "ELECTROLA"

This illustration shows the radio panel of this elaborate combination radio phonograph model. The radio panel can be tipped for convenience in operation as shown here, or it can be tilted upright. Pilot lights make tuning easy. This instrument, completely electrically operated will play 12 records without stopping, contains built-in loop, power loud speaker (shown behind the grille above) and power supply. Price complete, $1550

A Review of Recent Records

BUT though the phonograph now has a Mission it still continues to provide amusement and entertainment for those who want it. And, as far as we can see, the recent output of records is much the same as ever; there are many good records, a few poor ones, and a goodly supply of in-betweens. Of the latter the majority seem to be instrumental dance records. The orchestras which play for these are admirable and the recording of their playing is in most cases all it should be, but the selections on which they waste their talent are just about zero in musical worth. The result is like apple pie without the apple. Alas for more Gershwins and Berlins!

On the Victor, Columbia and Brunswick lists are many names familiar to those who sat at home turning the dials of their radio sets through the long winter evenings of 1926–27. They will recognize numerous regular performers and others who have made only a limited number of ethereal bows on such programs as Atwater Kent, Eveready, and Victor. New names are being added daily to this register of recording-broadcasters and now that Columbia has its aërial chain, we can expect even more.

Of the recent dance records, *Who Do You Love?* and *I'll Always Remember You* played by Paul Whiteman and His Orchestra (Victor) head the list. This famed outfit have taken two of the best songs now extant and by decorating them with a trick orchestration in the inimitable Whiteman manner have made an unusually good record out of them.

Is It Possible? and *Just Call On Me* played by Leo Reisman and his Orchestra (Columbia) is another grand record. If we hadn't always lived in the belief that Whiteman had no equal, we would say this was as good as the first record on our list. We will say it. Anyway, it is pretty smooth music and we defy you to keep your feet still when you listen to either number.

Gorgeous by Johnny Hamp's Kentucky Serenaders would be an asset to any collection of dance records and its companion on the opposite side, *There's a Trick in Pickin' a Chick-Chick-Chicken* by Nat Shilkret and His Vic-Vic-Victor Orchestra is just as full of pep. (Victor).

Habitual listeners-in on Harold Leonard and his Waldorf Astoria Orchestra will want his latest Columbia product, *Just A Memory* and *Joy Bells.* You don't have to be told it is good.

Once Again and *No Wonder I'm Happy* as played by Ernie Golden and his Hotel McAlpin Orchestra will have the ring of familiarity to those who tune-in on station WMCA. They are good snappy numbers. (Brunswick.)

Having heard excellent reports of the new Broadway show "Good News" we were disappointed in the three numbers from it which have found their way onto the rubber discs. The title number, *Good News*, and *Lucky in Love* have been recorded for Columbia by Fred Rich and his Hotel Astor Orchestra. and Cass Hagan and his Park Central Hotel Orchestra have done *The Varsity Drag* (also Columbia). If you are one of those who raved over the show you may enjoy the records. You may also like *Dancing Tambourine* by the Radiolites on the reverse side of *The Varsity Drag*, though we can't enthuse over it.

If you stuff cotton in your ears during the seconds devoted to the vocal chorus in *Baby Feet Go Pitter Patter* you may agree with us that this record by Abe Lyman's California Orchestra (Brunswick) is one of the best that have appeared in many moons. In addition to an aversion to vocal choruses in general we detest the words to this particular song. It was an error on someone's part to attach such a silly lyric to such an excellent tune. However, it's short and the few seconds one sacrifices to get through it are a drop in the bucket and the rest of the record is fine. The other side carries *There's One Little Girl Who Loves Me*, also played by Abe Lyman, and also good.

Another of the better records slightly marred by a vocal chorus is *No Wonder I'm Happy* and *Sing Me a Baby Song* by the George H. Green Trio with Vaughn De Leath doing the vocalizing. (Columbia.)

The Ipana Troubadours, smile vendors under the direction of S. C. Lanin, have done a fine job with *Are You Happy?* and *A Night in June*, of which Frank Harris carols the chorus. (Columbia.)

Inhabitants of Mayor Thompson's Strictly American City will welcome a Columbia disk made by one of Chicago's Municipal Heroes, Paul Ash, and his Orchestra. *Just Once Again* is excellent and its vocal chorus by Franklin Baur makes us eat some of our words just uttered; we must admit it is an addition to the

THE UTICA JUBILEE SINGERS

There are those who are not especially impressed by negro spirituals. But if you like these interesting melodies and want to hear them sung as they should be sung, listen to this group on WJZ and associated stations at 9:45 eastern time Sunday evenings. They have made one double-faced recording for Victor, one of the finest recordings of the kind we have heard

Joins the RADIO *Set*

record. In self-justification we insist that Franklin Baur is an exception. The reverse of the record *Love and Kisses*, is not quite up to the Paul Ash standard but that doesn't mean it is bad.

Several other records get only half a vote due to the fact that one face of record is good and the other not. *Stop, Go!* executed by Nat Shilkret and the Victor Orchestra has a unique rhythm, better than any other number on the list but *Something To Tell* is only moderate. *Me and My Shadow* by Phil Ohman and Victor Arden and their Orchestra is good; *Broken Hearted* is not. Even Paul Whiteman could not do much better with that last number but *Collette* on the reverse makes the record decidedly worth buying. (Victor). Don Voorhees tried something tricky with *Soliloquy* (which we are told belongs to the new school of music ushered in by the *Rhapsody in Blue*) and was not very successful, but his more orthodox *My Blue Heaven* is exceedingly good. *Just a Little Cuter* falls rather flat but *Marianette* is excellent dance music. Both come from the orchestra under the baton of Ben Selvin and are recorded by Brunswick.

We dont care much for *Cheerie Beerie Be* or *Waters of the Perkiomen* even though played by Leo Reisman and his Orchestra. *Roodles* and *I Ain't Got Nobody* are not as good as they ought to be coming as they do from Coon-Sanders Orchestra. And we were very much disappointed in *Who's That Pretty Baby?* and *Barbara* by Paul Specht and his Orchestra. The fault lies in each case not with the orchestras but with the stupid selections they play.

AND NOW FOR COMEDY

OF THE good humorous records recently issued by far the best is *Two Black Crows*, Parts 3 and 4. (Columbia). Of course we don't need to describe it. Everyone knows Moran and Mack and their riotously funny dialogues. What, you dont? Well, go right down to the corner music store and buy this record and their first one, *Two Black Crows, Parts 1 and 2*. You will remember us in your prayers.

Next in order of importance comes that grand song perpetrated by the Happiness Boys, Billy Jones and Ernest Hare, *Since Henry Ford Apologized To Me*. (Victor.) It is worth seventy-five cents just to hear this record once, which is fortunate, for we wouldn't give a nickel for the song on the reverse side, *I Walked Back From The Buggy Ride*, by Vaughn De Leath and Frank Harris.

Then the famous Sam and Henry combination (Correll and Gosden of WGN) offer two dialogues called *Sam's Big Night* and *The Morning After*. (Victor.) They are both labelled comic dialogues but oh! the pathos of Sam's refrain, "Henry, Henry, I'se sick! My head's bout to kill me! . . . I b'lieve I'se gonna die!" It almost makes you want to sign the pledge.

Of the many popular vocal records we nominate for first place, a work of art by the Happiness Boys, *You Dont Like It—Not Much* and *Oh Ja Ja*. (Victor.) This is typical of what they offer to the audience of WEAF every Friday night and it's good! Personally we like them best of all the regular aërial performers, It's personality that does it—plus good voices.

Van and Schenck sing *Magnolia* and *Pastafazoola* for you on a Columbia record. The Radio Franks present *No Wonder I'm Happy* and *When Day Is Done*. (Brunswick). And Johnny Marvin and Ed Smalle do a little duet with *Just Another Day Wasted Away* on a Victor. All of these are good. But on the back of the last mentioned disk is *Just Like a Butterfly* sung by Franklyn Baur. Personally, as little Alice said in *Peggy Ann*, we'd rather have a baked apple. No matter how good the voice, the song is terrible! We feel just as strongly about *Baby Feet Go Pitter Patter* as we have hinted before, and when it is sung by Vaughn De Leath we see spots before our eyes. She could make *Turkey in the Straw* sound like a sentimental ditty and when she has something as mawkish as this to start with . . . words fail us. In case you are still interested in the record the opposite side bears another song by the same lady, *Sometimes I'm Happy* (Brunswick).

The Sunflower Girl of WBAP vocalizes *You Went Away Too Far* and *I Hold The World in The Palm of My Hand* on a Columbia disk. We cannot say she sings them because she has one of those rough and tumble shouts so often heard on the vaudeville stage. It is about as far from being musical as anything could be, but for that sort of thing, she will do.

We don't feel strongly one way or another about *Charmaine!* and *The Far-Away Bells* sung by Franklyn Baur (Columbia), *Ain't That a Grand and Glorious Feeling?* and *Magnolia*, sung by Harry Richman (Brunswick), or *Flutter By, Butterfly* and *I'd Walk a Million Miles* by Art Gillham and his Southland Syncopators (Columbia).

RED SEAL RECORDS AND SUCH

TURNING now to the sublime we find several red seal records made by operatic stars from the Metropolitan firmament, who twinkled before microphones upon occasion last winter. Lucrezia Bori, the beautiful Spanish soprano who is as lovely to look upon as she is to listen to (though you couldn't tell that when you heard her sing in the Victor radio concerts or in the Atwater Kent hour) presents us with the lovely old waltz song by Pestalozza, *Ciribiribin*, and *Il Bacio* by Ardit. (Victor).

Another soprano who was presented to the radio audience by Atwater Kent is Hulda Lashanska In company with Paul Reimers, tenor, she records for Victor two simple but extremely lovely old German folk songs, *Du, Du Liegst Mir Im Herzen* and *Ach, Wie Ist's Möglich Dann*. The harmony of the first selection is particularly notable.

It was a Victor hour that launched Emilio De Gogorza's baritone voice on the ether waves and it is a Victor record which presents his voice again for your permanent enjoyment. He sings two favorites, *O Sole Mio*, and *Santa Lucia*. We think it would be a grand idea for everybody to have this record in his home, if for no other reason than just so that whenever he hears the song murdered by a would-be artist he can play the record on the phonograph and reassure himself that the song is all right after all.

We presume it is rank heresy to say that we prefer to hear the Utica Jubilee Singers sing *Old Black Joe* than to hear Lawrence Tibbett. Tibbett's voice is marvelous, of course, and it is perfectly trained, but he cannot manage this negro melody as expressively as the Utica Jubilee Singers do. If this be treason. . . . The reverse of the record is *Uncle Ned*. We have never heard the Jubileers sing this but we will wager our two cents that they could do it more to our satisfaction than the Metropolitan star has done. Both these songs are so worn out that they need all the expression that can be put into them.

The Utica Jubilee Singers *have* done a record for Victor, *Angels Watching Over Me* and *Climbin' Up the Mountain*. It's perfect! We can say no more. Incidentally it is interesting to note that these singers have just returned from a concert tour of Europe where they were greeted with great acclaim, so their popularity is no longer limited to this continent. They are now heard from WJZ and others on that chain Sunday nights at 9:45, eastern time.

Virginia Rea, staff artist for Eveready, has recorded a popular number which Victor thought good enough for a red seal record, *Indian Love Call* from Rose-Marie; and Lambert Murphy, whom you undoubtedly heard in an Atwater Kent hour, has recorded the title number from the same musical play on the reverse of the record. Though we saw this show at regular intervals through the winter of 1924–25 and heard these numbers on hand organs for the next two winters, we *still* like them.

ERNIE GOLDEN OF WMCA

He leads the Hotel McAlpin Orchestra, regularly heard through WMCA of New York. The Hotel McAlpin Orchestra has recorded many good dance numbers for Brunswick

AN ELECTRIC RADIO-PHONOGRAPH FROM FRESHMAN

This instrument, completely a. c. operated provides the usual Freshman receiver, electric turntable, electric pick-up, record space and loud speaker which serves for radio or phonograph music. Complete with a. c. tubes, $350

UX-222 TUBES

Some idea of the construction of the new R. C. A. screened grid tube may be obtained from this illustration The extra connection is made to the metal cap atop the tube. Eby new type sockets are shown

THE SCREENED GRID TUBE

By KEITH HENNEY

Director of the Laboratory

STUDENTS of the characteristics and applications of the vacuum tube, and of circuits to do with it, may find themselves somewhat bewildered by the apparent complexity of the screened grid tube when they begin their researches into its idiosyncrasies. They will be impressed at once with the thought that this tube is no ordinary structure, and will appreciate more such names as Schottky of Germany and Hull of the United States—names actively associated in its development. Experimenters here have yet to become familiar with the new tube, which has already taken its share of space in English, French, and German radio periodicals, and it is certain that, with the Radio Corporation's announcement of the UX-222, not a great length of time will elapse before it will be possible for anyone to obtain these interesting and useful screened grid tubes.

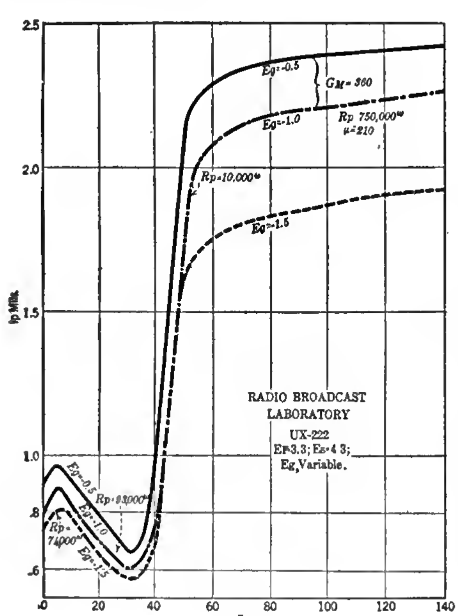


FIG. 1

The plate current of a screened grid tube varies in strange fashion, as these curves show. In these data the effect upon the plate current of changing the plate voltage, with several values of bias voltage, is given. The normal bias is about 1.5 volts, with 45 volts positive on the screen, and about 135 on the plate

American writers, too, will have considerable to say about the double-grid tube, of which the screened grid tube is a type, as they become more familiar with its operation, and as its possibilities become more apparent.

Imagine a tube with an amplification factor of about 250, and such a small grid-to-plate capacity that it has little tendency to oscillate even though the plate circuit be made highly inductive in reactance. The nearest approach is the standard "high mu" tube with an amplification factor of about 30, but, unfortunately, with sufficient capacity to make oscillation inevitable if sufficient inductance is included in its plate circuit to transfer energy efficiently to a subsequent circuit. The screened grid tube, of which the UX-222 (CX-322) is the precursor, is a most unusual tube. What are its characteristics, its possibilities, its weak points?

Physically it is complicated by having a fourth element within the glass bulb. Picture a cylindrical construction with a 3.3-volt filament in the center, surrounded by a rather coarse grid, then, at some distance, another fine mesh grid, then a cylindrical plate, and the whole surrounded by another very fine grid of about forty spiral turns. The latter two grids, connected in parallel, form one electrode, thus constituting the extra element in the tube. It would be more accurate, for geometrical reasons, to call this tube a screened plate tube, but electrically, as we shall see, it is really the grid which is protected from alternating voltages impressed upon the plate.

The inner coarse grid is connected to a small metal cap which sits on top of the bulb, where the tip used to be, making the overall height about three quarters of an inch higher than standard tipless tubes. The screening grid connects to the usual grid terminal in the base so that the tube fits into the standard UX or UV socket.

As pointed out in the December, 1927, RADIO BROADCAST by Mr. T. H. Nakken, there are two types of double-grid tubes, those in which the inner grid is positive, known as the space-charge tube, and those in which the outer or protective grid is positive. The UX-222 may be used either way. Let us consider first its action as a shielded-grid device. In this case the outer grid is positive.

We shall place 3.3 volts on the filament, make the inner grid negative, place about 45 volts on the shield, and read the plate current as the plate voltage is changed. The result is shown in Figs. 1 and 2.

When this is done there are unusual results: First, the plate current rises, as is customary with increase in plate voltage. Then the plate current begins to decrease, giving the tube a characteristic like that of the electric arc, *i.e.*, decreasing current with increased voltage; next, after a sharp minimum, the current rises almost per-

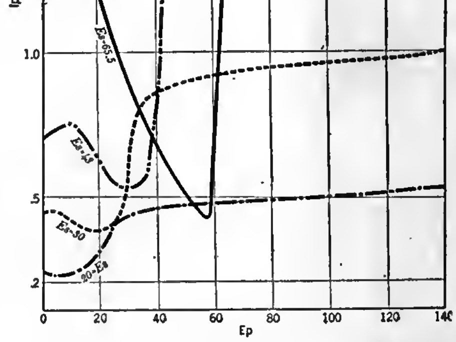


FIG. 2

If any reader of RADIO BROADCAST feels that he knows all there is to know about tubes, let him explain the sudden and extensive changes in plate current with change in plate voltage indicated in these graphs. With even greater screen voltages than are shown here, the plate current may be reduced to zero or even go negative (reverse its direction of flow) at some positive plate voltage pendicularly and finally flattens out to become practically horizontal. All of this is contrary to what happens in standard tube practice and, to the student of physical phenomena, is extremely interesting.

The slope of this plate voltage-plate current curve represents the plate impedance and, if plotted, an extraordinarily large scale graph would be required owing to the extent to which it changes. For example, in Fig. 1 it is 74,000 ohms near the origin, then it suddenly goes negative to the extent of 100,000 ohms, then positive about 10,000 ohms, and finally becomes about three-quarters of a megohm in value! The tube has a negative resistance, or a dynatron effect, at low plate voltages.

These rapid and extensive changes in internal resistance are due to the varying proportions of current taken by the shield and the plate, both of which attract negative electrons, and to a certain amount of secondary emission which takes place within the tube. At the present moment, however, the detailed explanation of these effects must give way to the more practical information regarding the tube. We are more interested in this article in how the tube works than in "why." It is sufficient to state that the sum of the currents taken by the shield and the plate is constant, the plate current increasing when the shield takes fewer electrons, and vice versa. Under usual operating conditions, *i.e.*, high plate voltages, the shield takes very little current indeed.

Grid voltage-plate current curves appeared on page 111 of RADIO BROADCAST for December, 1927, and will not be repeated here. They conform to what one secures from other tubes of the general-purpose type. They indicate a mutual conductance of about 300 to 400 under average conditions, and an amplification factor of about 250 to 300, values which should be compared to those of standard tubes in Table 1. It is difficult to measure these factors on the ordinary bridge because of the extraordinarily high values of mu and plate impedance involved, and the better plan is to pick them from characteristic curves as we have done here.

MATHEMATICS OF THE TUBE

THE screened grid tube is designed primarily for radio-frequency amplification and, to understand its possibilities in amplifier circuits, we must examine somewhat more critically than usual the processes involved in the ordinary amplifier. Naturally we must have an input and output circuit, and for general analytical purposes we shall consider Fig. 3.

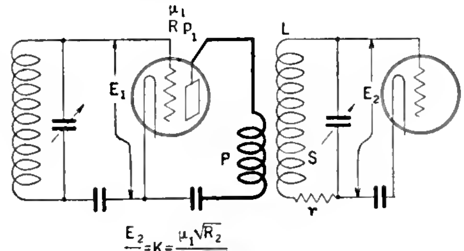
The purpose of the transformer in such circuits is not, as many would have us believe, to increase the voltage step-up from tube to tube, but to obtain a proper impedance for the amplifier plate circuit to look into. Mathematics will show that the maximum voltage amplification will be obtained when the effective primary impedance of the transformer is equal to the internal resistance of the tube, and that under these conditions this amplification is:

$$K_{max} = \frac{L\omega}{2\sqrt{Rp\,Rs}}$$

where R_p= tube impedance, L = secondary inductance, R_s = secondary resistance, and ω = 6.28 x frequency.

If the effective resistance of the tuned circuit at resonance is higher than that of the preceding tube impedance, a step-down transformer must be used. This effective resistance may be found mathematically by substituting the proper values in the following expression:

$$Ro = \frac{L^2\omega^2}{Rs}$$



$$\frac{E_2}{E_1} = K = \frac{\mu_1\sqrt{R_2}}{2\sqrt{Rp_1}}$$

$$R_2 = \frac{L^2\omega^2}{r}$$

FIG. 3

A diagrammatic representation of the ordinary interstage radio-frequency amplifier, consisting of a transformer, tuned to the frequency desired, connecting two tubes. The voltage gain at resonance is given in the form of two equations

where L = inductance, R_s = high-frequency resistance, W = 6.28 x frequency.

If we use an inductance of 250 microhenries having a resistance of 15 ohms at 1000 kc., this effective resistance will be:

$$Ro = \frac{(250 \times 10^{-6})^2 \times (6.28 \times 10^6)^2}{15} = 177{,}000 \text{ Ohms}$$

and if the previous tube is a 201-A with an impedance of 12,000 ohms we shall be compelled to use a step-down transformer to secure maximum amplification and to prevent short circuiting the secondary, to the impairment of the selectivity. Using a tube and coil of these characteristics, and with the proper primary, the maximum amplication will be:

$$K_{max} = \frac{8}{2} \times \frac{250 \times 10^{-6} \times 6.28 \times 10^6}{\sqrt{12{,}000 \times 15}} = 15.0 \text{ (Approx.)}$$

When any receiver designer states that he gets a uniform amplification per stage of much over this, he has neither used his mathematics nor his vacuum-tube voltmeter to substantiate his statement.

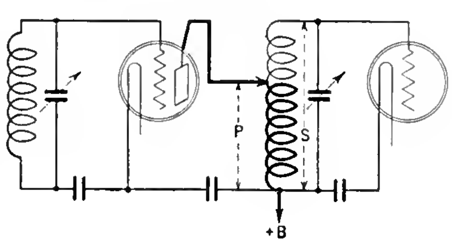


FIG. 4

For analytical purposes the two-winding transformer of Fig. 3 may be replaced by this auto transformer. The same conditions for maximum voltage amplification obtain

This transformer, with its two windings, can be replaced by an auto transformer for all practical purposes, as shown in Fig. 4. An auto transformer, it will be remembered, is used in the "Universal" receiver previously described in this magazine and in the R. B. "Lab." Circuit, when the plate or primary coil is reversed. The impedance of the circuit, looked at from the preceding tube, must equal the impedance of that tube, and the position of the tap regulates the effective transformation ratio, so that this condition is realized, since the ratio of impedances across secondary and primary is equal to the square of the turns ratio.

If we use a special radio-frequency tube with a higher amplication factor and higher impedance, such as the Ceco Type K, we must move the tap higher toward the grid end, or use more primary turns if we use a transformer, while if a 112 type tube is used with its lower impedance, the tap can be brought further down. Table 1 gives essential data on existing tubes. The approximate turns ratio, in the auto transformer case, can be found by substituting the value of plate impedance in the following equation:

$$\text{Turns Ratio} = \frac{60000}{\sqrt{Rp}}$$

TABLE 1

TUBE	μ	R_p	G_m	TURNS RATIO
199	6.25	16,600	380	1.90
201-A	8.00	12,000	675	2.25
112	8.00	5,000	1,600	3.5
210	7.70	5,000	1,540	3.5
171	3.00	2,000	1,500	5.5
222	250.00	700,000	400	1.0
"K"	13.00	16,800	780	1.9

Now all of this sounds simple to carry out but, practically, there are difficulties ahead—most of them due to the fact that the tube does not act like a one-way street. Some traffic always goes in the opposite direction, because of the grid-plate capacity. As soon as we get the tap on our auto transformer moved high enough toward the grid end to secure maximum amplification, we include sufficient inductance in the plate circuit of the amplifier to make it oscillate, and trouble begins. Therefore we must do one of two things: we must either move the tap down, and lose amplification because our equal impedance condition is no longer satisfied, or we must play neutralization tricks on the amplifier to keep it from oscillating, with perhaps slight loss in amplification as the price of stability.

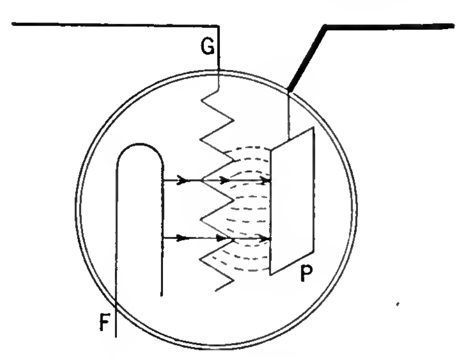


FIG. 5

In the ordinary tube, some electrostatic lines of force connect the plate and grid because they are at different potential. This means, simply, that some capacity exists between them and it is this capacity that causes trouble in the usual high-frequency amplifier

Here is where the screened grid comes in. Suppose, as in Fig. 5, we have the plate receiving electrons from the filament after passing through the grid in straight lines. Because of the fact that the grid and plate are at different potential there will be electrostatic lines between them, represented by the curved lines. In other words, there is some connection between the plate and the grid, other than that produced by the passage of negative electrons. Now if we surround the plate by a fine grid which is grounded, as shown in Fig. 6, these electrostatic lines do not reach the grid, and the latter is free to function only as a control on the flow of electrons. If, in addition, we make this shield positive with respect to the filament and grid, we neutralize some of the space charge which, in turn, boosts the amplification factor to a very high degree.

If the plate is completely screened, the tube will be a one-way repeater, there will be no tendency to oscillate in the familiar tuned grid-tuned plate circuit, and a little mathematics will show that the amplification is a factor of the mutual conductance of the tube and the external impedance. This external impedance is the effective resistance of the tuned circuit, as already mentioned, and varies as shown below for average coils at usual frequencies. The possible voltage amplification may be easily calculated, with an assumed mutual conductance of 400 micromhos and an infinite plate impedance.

Frequency, Kilocycles	$Ro = \frac{L^2\omega^2}{Rs}$ ohms	Amplification Gm x Ro
100	400,000	200
1,000	100,000	40
10,000	10,000	4

These values of amplification are considerably greater than is possible with standard tubes such as we all use at the present time. At 1000 kc. (300 meters) the average gain in modern receivers may be as high as 10, and not many sets can do as well without some loss of stability.

Actually, however, these values in the table with the 222 tube will not be attained, since the assumptions on which they were calculated, infinite plate impedance, no grid-plate capacity, and an effective resistance in the plate circuit of 100,000 ohms, are not realized. Since the tube's internal impedance is of the order of a half megohm, or greater, which is considerably more than can be attained by average coils or by coils which will not cut side bands, there is no use in

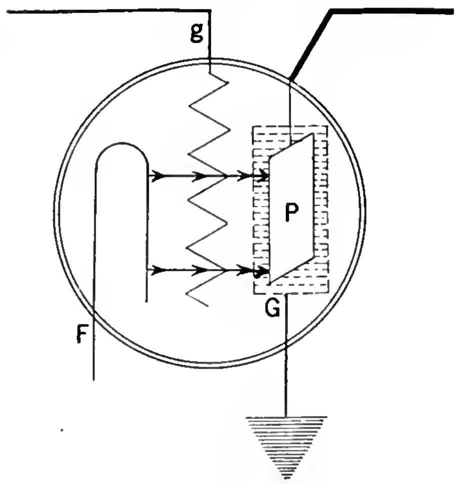


FIG. 6

If a grounded shield is placed around the plate, the lines of force from grid to plate will be interrupted, and fewer changes of plate voltage will affect the grid—in other words, the grid is shielded from the plate

above. If this resistance is equal to that of the tube, approximately one-half the mu of the tube may be realized. With 100,000 ohms in the plate circuit approximately one seventh of the amplification factor, or about 35 may be expected. For maximum voltage gain the effective resist-

amplifier, which had attached to its input a single wire antenna about 35 feet long, and a ground.

With the brass box containing a Rice neutralized amplifier, using a 201-A tube, and with the best position of the plate tap on the detector coil (see Fig. 8), the voltage upon the input to the detector was measured. Then the screened grid tube was used, the whole coil being used in its plate circuit, and the neutralization apparatus was done away with. The voltage was again measured with exactly the same input, and at the same frequency—500 kc. In this case the output voltage was a little over three times the best that could be obtained with the 201-A circuit. Resonance curves showed that the two circuits were about equally selective.

If the 201-A tube gave an amplification of ten, which is reasonable, the new tube had an indicated voltage gain of over 30, which seems to fit in with our calculations explained previously. Two stages would give a gain of 900 compared with 100 for two 201-A amplifiers, or approximately 20 TU, which has about the same effect as adding one stage of audio to existing receivers.

With the antenna described, and with but two tuning circuits, there was no difficulty in separating WEAF and WJZ, 50 kc. apart, when the former was 8 miles away with 50 kilowatts of power in the antenna and the latter was roughly 30 miles distant with somewhat less power. Measurements showed that, with the screened grid tube, WEAF delivered over 4.5 volts to the detector, sadly overloading it.

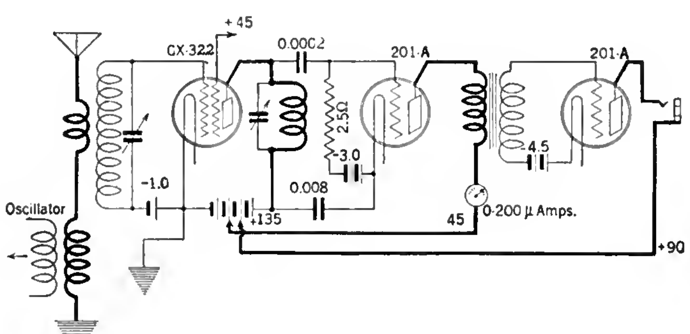


FIG. 7

In the Laboratory this arrangement of apparatus was used to discover the voltage delivered to a detector when the screened grid tube was used as an amplifier. The meter in the detector plate circuit read the change in plate current when a. c. voltages were applied to its grid. It was a calibrated detector, or vacuum-tube, voltmeter

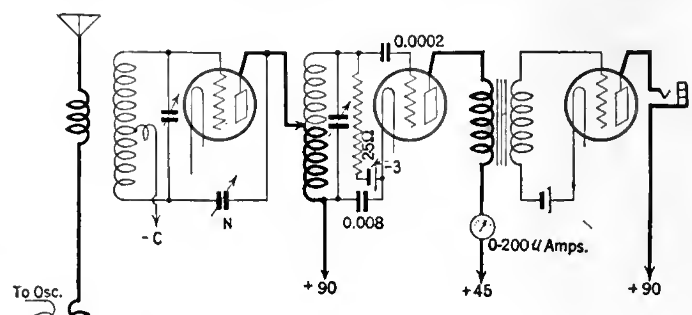


FIG. 8

Here the vacuum-tube voltmeter was applied to the output of a standard Rice neutralized amplifier. The difference between the input voltage in this case and that in Fig. 7 determines the gain in using the screened tube. The meter used in the calibrated detector was a Westinghouse 200-microampere meter, type PX

using a step-down transformer to couple the output of the tube to a succeeding stage, and the whole coil may be used without danger from oscillation.

With the entire coil in the plate circuit, as shown in Fig. 7, the amplification per stage may be figured by somewhat simpler mathematics. In this case we have a simple tuned impedance in the plate circuit of the tube, which at resonance has an effective resistance, as explained

ance must be high, that is, we must use exceptionally good coils of high inductance and low resistance with the probability that fidelity will suffer.

In the Laboratory a simple set-up was employed to examine the tube's behavior. The circuit is shown in Fig. 7 and, as may be seen, consisted of a single amplifier tube followed by a non-regenerative C bias detector which could be calibrated in volts input against change in d. c. plate current.

The shielded tube and its accessory input apparatus was carefully enclosed in a tight brass box which was grounded. The audio amplifier was useful as a kind of monitoring stage to follow what was happening in the preceding circuits. It made it possible to insure against the amplifier oscillating, etc. A 1000-cycle modulated signal was induced into the

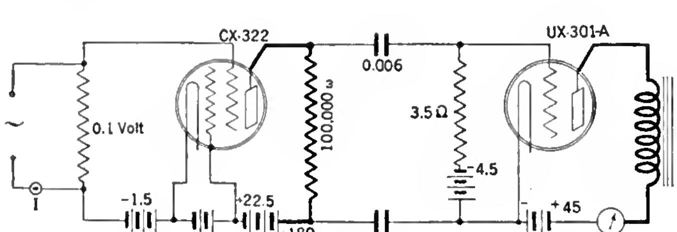


FIG. 9

When the grids of the UX-222 (CX-322) are reversed, *i.e.*, the inner grid is made positive, the amplification factor and plate impedance fall to more usual values, and the tube can be used as an audio- or intermediate-frequency amplifier.

The tube may also be used as a space charge grid affair, where the inner grid is positive with respect to the filament and the fine structure which ordinarily screens the plate is used as the signal grid. To test its capabilities the circuit shown in Fig. 9 was used. With an input voltage of 0.1, the gain was about 30, from 60 to 30,000 cycles, and then fell slowly. At the higher frequencies the tube capacities (in the space charge grid tube the capacities are much greater than in the screened grid connection) shunt the output resistance, with consequent loss of amplication.

Here, then, is a tube which must henceforth be carefully considered by all designers of radio equipment, for amplification of the very high frequencies, those of intermediate range such as are used in super-heterodyne receivers and broadcast frequencies, and again at the low audible tones. In all of these ranges it seems probable that greater amplification will be secured than has been possible with ordinary or high-mu tubes. In subsequent articles, we shall discuss the design problems at greater detail and have something to say about the problem of selectivity and fidelity of reproduction.

WHAT SET SHALL I BUY?

By
EDGAR H. FELIX

WITHOUT repeating the old arguments which earn for radio the title "the ideal Christmas gift," we are certain that more people select a new radio at this season than at any other. The fundamentals of good selection do not change from year to year, but the improvements which come with each new season always bring with them new factors to consider when purchasing. Indeed, the constant improvement of the radio receiver leads some to await new developments, expecting some sort of radio millennium.

Improvement will always continue in the radio art, and he who awaits perfection will neither purchase nor enjoy radio. Were the same policy followed with respect to the purchase of motor cars, some forty million people would still be walking because the ultimate automobile, after a quarter of a century has been devoted to development in this field, is not yet here.

The radio receiver of to-day is a product which, both from the musical and technical standpoint, is capable of many years of service. It will not be greatly outclassed in the musical quality of its output for a long time. In sensitiveness, selectivity, fidelity of reproduction, simplicity of control, and convenience of maintenance, it has reached high standards. In appearance, efficiency, compactness, simplicity of installation, and automatic operation, considerable progress may still be looked forward to, but none of these factors mean great changes in the fundamental output of the radio receiver, that is, reproduced musical programs. We have passed through the period of revolution and have come to the era of refinement in this radio world of ours. There is no longer any excuse for delay in purchasing a high-grade manufactured receiver.

Maintenance convenience is the keynote of 1927's advances. The last word in installation instructions now is: "Plug the cord in the light socket, turn the set switch, and tune." This is indeed a contrast to the requirements of former years. There were antennas to install, batteries to connect with multi-colored cables, chargers to wire, power amplifiers to plug in, and loud speakers to attach. Between these two extremes, there are several stages of convenience, each of which is still represented in this year's products. The term "light socket operation," for example, is applied to power systems varying considerably in convenience, and is a very flexible term. It is advisable, therefore, to ascertain exactly what type of receiver and what degree of convenience you buy.

There are several ways of powering a receiving set "directly from the light mains." Filament power might be supplied from a storage battery-trickle charger unit and plate power from a rectifier unit operating directly from the power mains; or both filament and plate power may come directly from the mains through a rectifier unit; in another case the filament power may be delivered directly from the line to a set using alternating-current tubes, through a step-down transformer, and plate power obtained through a rectifier unit.

The field of usefulness for the storage battery receiver is far from exhausted. Its lower manufacturing costs give it a price advantage, at no sacrifice in attainable performance, over the alternating-current powered receiver. Because of lower cost, it is destined to remain in the radio market for a long time to come. Magnetically controlled trickle chargers, which turn on automatically when the set switch is turned off, reduce the maintenance responsibility placed on the user of a storage battery to a minimum. Precautions against overcharging, and occasional filling of the cells with distilled water, are the only attentions required. Indeed, this type of storage battery receiver is often sold to the uninitiated buyer as the last word in socket power operation.

Large storage batteries, used almost exclusively with receiving sets four and five years ago, are likely to require replacement after two to five seasons, the period of service depending upon the care taken of the storage battery by its owner, and the quality of the battery itself. Bear in mind, when such replacement becomes necessary, that the reliability of many an old receiver would be greatly improved by the purchase of a trickle charger outfit, a suggestion which may be of value to many persons desiring to give a Christmas gift costing twenty to thirty dollars.

A device of interest to every storage-battery set owner is the "Abox," which may be substituted for the storage battery or trickle charger-storage battery combination. The "Abox" requires no maintenance attention and operates on an entirely different principle from the storage battery-trickle charger combination. Other manufacturers are marketing devices similar in principle to the "Abox." Balkite might be cited as an example.

A comprehensive article on A-power units, in which twenty or so A units were listed, and their characteristics noted, appeared in the November, 1927, Radio Broadcast, beginning on page 30 of that issue.

TUBE POWER UNITS

RECEIVING sets having A, B, and C power supplied from vacuum- or gas-tube rectifier units incorporated in the set, require no maintenance other than renewal of rectifier tubes. There is no periodic adding of distilled water to battery or chemical charger, nor is there any other maintenance problem in connection with these sets. There are a large number of receivers of this type on the market. With skillful engineering and high-grade components, they offer carefree and high-quality reception. If carelessly designed, they may give a marred output because of excessive hum, and unreliability of service due to failures in vital parts. It should not be thought, however, that a set is necessarily good because it does not hum. If poor audio transformers are incorporated they may not be capable of amplifying the low-frequency hum produced by alternating current. The problem of the uninitiated in distinguishing between the inferior and the superior type is perplexing. The name and reputation of the manufacturer, the endorsement of men technically qualified to judge radio products, and the pages of high-grade publications, which censor and check the statements made in their advertising columns, are helpful sources of information and guidance.

Practical tests can be made by the technically untutored buyer, when a set is being demonstrated, which will protect him against the purchase of a power set of inferior design. The principal characteristic of a poorly designed receiver, deriving its A, B, and C potentials directly from the light mains, including both those employing rectifier systems and those using a. c. tubes, is the excessive hum experienced when the set is adjusted to sensitive reception.

A dealer, selling a radio set subject to hum, is likely to concentrate his demonstration upon the reception of strong, near-by stations. Ask him to tune-in a weak station, preferably one fifty or a hundred miles away, during the daytime, or one several hundred miles away at night, requiring that the sensitivity or volume control be turned up all the way to get the station comfortably. Then slightly detune the set. Without the covering effect of the music, you should then get a direct indication of how much the receiver hums under unfavorable conditions provided, of course, that a loud speaker is used which reproduces the very low notes. To be entirely satisfactory, the hum should be so weak that it cannot be heard in a quiet room ten feet from the loud speaker which the prospective purchaser will use.

It is quite possible to attain this standard but it costs money. A great discrepancy in price between two sets having the same sensitiveness, tone quality, and appearance, is often accounted for by the complete absence of hum in the more expensive receiver. The hum test is a simple one and should be made by every purchaser, regardless of his technical qualifications.

MEETING MODERN STANDARDS OF FIDELITY

IF THERE is one quality in radio receiving sets which has been appreciated by manufacturers, it is the ability to produce good tone. The judgment of a receiver's tone quality has already been fully discussed by the author in three recent issues of RADIO BROADCAST and hence it is unnecessary to repeat in great detail the factors applying to this most important requirement. Briefly, to obtain good tone quality requires that the set have: (1) Adequate power supplied the loud speaker by the use of a UX-171 (CX-371) type output tube, or even by the still more powerful UX-210 (CX-310) type tube; (2) an audio amplifying system which covers the tonal scale and (3) a loud speaker adequate to handle the volume and tonal range supplied it. To the non-technical reader, these requirements may seem difficult to appraise. But a simple test reveals a great deal about the tonal capacity of a receiver. Ask the dealer to tune-in a strong, near-by signal and bring it to full volume. Although the music is uncomfortably loud, using the output tubes mentioned, it should not, even with very strong signals, be scratchy, stringy, or drummy. Music should be simply loud with tonal quality unaffected.

The second test is to listen critically with the set at moderate volume for the instruments producing low tones, like the 'cello, drums, or the organ. If these appear to be in their proper proportion, without being overshadowed by the treble, the receiver is capable of handling low tones.

There is much danger of selecting a set which exaggerates the low tones, a characteristic easily demonstrated in speech. A low, throaty, ringing effect, which makes words difficult to understand, is an indication of over amplification of low notes. A receiver omitting low notes, usually gives harsh, unsympathetic, but clear speech. Speech over the telephone is quite easily understood, but the rich, sympathetic quality of a good voice is lost because of absence of low tones in telephone transmission.

TESTING FOR SELECTIVITY

SELECTIVITY is necessary under modern receiving conditions, particularly in congested areas. Generally speaking, the more tubes a set has, the more likely it is to be selective, because each stage of radio-frequency amplification adds another filter circuit. It does not necessarily follow, however, that a great number of tubes means great selectivity any more than a great number of cylinders means great power in an automobile.

The pick-up system used is a valuable guide in determining the selectivity. Given an equal number of stages of radio-frequency amplification, an antenna set is likely to be less selective than one with a loop. A receiver lacking in selectivity, can often be improved by shortening the antenna.

Selectivity is simply tested but it is hardly possible to set down any definite procedure since local conditions play an important part; while a receiver may be perfectly satisfactory in one district, it might fail badly elsewhere, where the conditions and requirements are different.

There are some receiving sets so lacking in selectivity that the nearest station (we do *not* mean a so-called "super-power" station) can be heard over one-fourth to one-eighth of the entire dials' scales, while a few, high-grade receivers pick up the same station over only two or three degrees of the dial. The signal should tune-in fairly sharply without long fringes over which it is heard weakly above and below the point where it is heard at full volume. The selectivity with a weak and distant station is no indication of the receiver's performance under ordinary conditions.

EVALUATING SIMPLICITY OF CONTROL

THE third factor, and one of great importance, if the entire family is to use the receiver, is its simplicity. Only three controls are essential to the operation of the receiver: (1.) An "on-off" switch; (2.) a volume control and (3.) station selector. The "on-off" switch should take care of all power supply connections, such as those of the chargers and power supply units, as well as the filaments of the tubes themselves.

The volume control should enable you to bring the loudest, near-by station down to a whisper, without impairing its quality, while the station selector should give you the complete parade of broadcasting stations, up and down the scale, without requiring any other adjustment. Set the volume control to a weak station and turn the dial from top to bottom and the stations should come in in the order of their frequency, this depending, of course, on their power and distance.

If, at the low end of the dial, the tone quality of the station cannot be cleared up without cutting down the volume control, the receiver is not properly balanced and probably radiates, and thus interferes with other receivers on the short wavelengths. The functioning of volume control and station selector should not be interdependent.

When two station selectors are used, which is frequently the case, one may be calibrated in frequencies, so that the dial may be set to a desired station accurately, and the other arbitrarily calibrated from 1 to 100, suiting it to antennas of different length. It is not inconvenient to operate a receiver with two station selectors, although the ideal arrangement provides but one.

Receivers having a single station selector and designed for antenna (as opposed to loop) operation, generally require an extra stage of radio-frequency amplification generally untuned. This extra stage only contributes little amplification and does not materially affect the selectivity. Because of this consideration, the fallacy of rating a receiver's capabilities by the number of tubes it possesses is obvious. Its sensitiveness and selectivity are dependent upon the number of stages of *tuned* radio-frequency amplification.

The buyer is often perplexed by the great number of receivers, apparently similar, but possessing a wide range of price. The factors of tone quality, selectivity, and volume capacity may be roughly tested upon demonstration, but unreliability develops only in service. Beware of the receiver that is too cheap, particularly one having power supply incorporated in it, because filter condensers may break down and mechanical difficulties may arise in service. It is true that very large quantity production decreases costs but, as with everything else, you do not get something for nothing. The extra cost of purchasing a set having back of it the name of a well-known manufacturer, is a protection against the hidden factor of unreliability. There is no reason for tolerating an unreliable receiver because the instrument which the buyer has at his command nowadays requires virtually no attention other than the periodic renewal of tubes.

The question is often asked, "How much does a good radio cost?" or "What is the best radio set for the money?" There are so many different requirements which must be met, dependent upon receiving conditions where the set is to be installed, and so wide a variation in the skill and temperament of the users, that such general questions cannot be answered.

The qualities every discriminating listener looks for are good tone, reliability, selectivity, convenience, and simplicity.

The prospective purchaser of a radio receiver should be fully cognizant of his requirements before setting forth to the radio store. He may also decide how far he will go in cost to secure the degree of maintenance convenience he desires, as already considered. He will confirm the quality of design of the power supply by listening for hum with the receiver set at maximum sensitiveness with no station tuned-in; its volume capacity and selectivity by tuning in the loudest near-by station to maximum volume; its tonal range by listening for low and high tones; and its simplicity by checking the exact number of operations required to tune-in a desired station. With the aid of these precautions, he will know just what he is buying and be able to compare intelligently one receiver with another.

"Our Readers Suggest—"

OUR Readers Suggest. . ." is a regular feature of Radio Broadcast, *made up of contributions from our readers dealing with their experiences in the use of manufactured radio apparatus. Little "kinks," the result of experience, which give improved operation, will be described here. Regular space rates will be paid for contributions accepted, and these should be addressed to "The Complete Set Editor,"* Radio Broadcast, *Garden City, New York. A special award of $10 will be paid each month for the best contribution published. The award for the December prize contribution "Antenna Compensation in a Single-Control Receiver" goes to Harold Boyd of Winchester, Virginia.*

—The Editor.

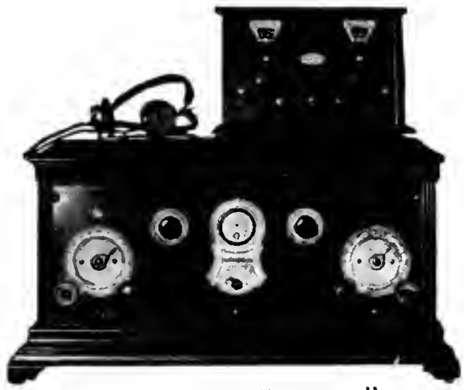
Eliminating the Loop

A FREQUENTLY suggested method of increasing the sensitivity of loop receivers is that of coupling the loop to a short antenna. This, of course, is a feasible proposition, but when coupling to any sort of an open antenna, why not eliminate the loop altogether?

The system generally advocated when a loop is used in conjunction with some kind of antenna is that of winding several extra turns of wire on the loop-frame and connecting the short antenna span and a ground lead to the two ends of these extra turns of wire. The combination of the loop with an extra winding thus constitutes a simple coupler, but one of rather extravagant dimensions. There is no reason why the size of the coupler cannot be reduced to more conventional dimensions, and an ordinary antenna coupler, such as an Aero or Bruno-Coil, substituted for it. The loop-antenna combination will be no more sensitive than the antenna-small coupler arrangement.

It requires no technical skill to effect the change. The coupler consists of two windings, a primary winding having relatively few turns—from six to twenty—and the secondary, having about fifty turns of wire. The primary should be connected between antenna and ground while the secondary should be substituted for the loop, as shown in Fig. 1.

It is desirable to obtain a coupler of the correct size for the tuning condenser. If the connections from the loop are traced, they will be found to lead to a variable condenser. In the majority of cases this condenser will have a capacity of 0.00035 mfd. The capacity of the condenser can almost always be determined by counting the plates. A condenser having approximately thirteen plates has a capacity of 0.0003 mfd.; one having about 17 plates is probably 0.00035 mfd.; with 23 plates, the capacity will be near 0.0005 mfd. In purchasing a coupler, specify the size condenser it is to be used with. In the few instances where it is difficult to determine the exact



THE CROSLEY "LOWAVE"

Used with a Stromberg Carlson "Treasure Chest." See descriptive matter in the box below

capacity, obtain a coupler for a 0.0003-mfd. condenser. If you find that the receiver no longer responds to the shorter wavelengths, or that the longest desirable wave is attained with a considerable portion of the tuning condenser unused, a few turns can be taken from the secondary.

It is a simple matter to wind your own coupler. The following tables give the correct number of turns of wire:

Condenser	Tubing Diameter	Wire D.C.C.	Turns Pri.	Turns Sec.
13 Plates 0.0003 Mfd.	3-½"	No. 24	14	55
	3"	No. 24	16	64
	2-½"	No. 28	18	70
This Coil Has an Inductance of 282 Microhenries				
17 Plates 0.00035 Mfd.	3-½"	No. 24	12	49
	3"	No. 24	14	58
	2-½"	No. 28	16	64
This Coil Has an Inductance of 245 Microhenries				
23 Plates 0.0005 Mfd.	3-½"	No. 24	11	40
	3"	No. 24	12	40
	2-½"	No. 28	13	50
This Coil Has an Inductance of 175.6 Microhenries				

Are You Interested in Short Waves?

LAST month in this department we published the description of a simple home-made short-wave converter, an auxiliary attachment which makes it possible to receive wavelengths as short as 18 meters (16,700 kc.) on any receiver. Radio Broadcast Laboratory has recently received a commerical instrument, the Crosley "Lowave," of somewhat similar design. Its adaptation to a Stromberg Carlson "Treasure Chest" receiver is shown in an accompanying photograph.

The Crosley "Lowave" is an especially designed circuit employing three tubes, and so arranged that the radio-frequency amplifier of the broadcast receiver is also utilized. The "Lowave" is connected to batteries according to directions, and one wire is led from it to the antenna post of the broadcast receiver. A small switch on the front of the panel throws the short wave attachment in or out of the circuit.

In tuning over the very high frequencies with such a converter, many broadcasting stations will be heard, but a great majority of them carry a badly distorted signal, which no amount of tuning will clear up. These are the harmonics of standard broadcasting stations, the frequency characteristics of which are invariably badly garbled. True short-wave broadcasting will be received as clearly as long-wave reception.

The Laboratory Staff

. I am using a simple electric light plug antenna made by Dubilier. The substitution for the loop was effected in this case not because of poor sensitivity, but merely for esthetic reasons—to do away with the unsightly loop. The successful use of this system is by no means confined to super-heterodynes and may be applied to any loop receiver.

A. J. Howard
New York City.

Combining Horn and Cone

CERTAIN of the cone type loud speakers now on the market are designed to compensate the failure of the usual two-stage transformer-coupled amplifier to satisfactorily amplify the very low audio frequencies. The customary audio amplifier feeding into such a loud speaker gives a very satisfactory overall characteristic. If, however, the audio amplifier itself is designed to give a slightly rising low-frequency characteristic, or even "straight-line" amplification, and it be used to feed into a cone of the type described, the bass is emphasized to such an extent that a sense of frequency distortion is introduced.

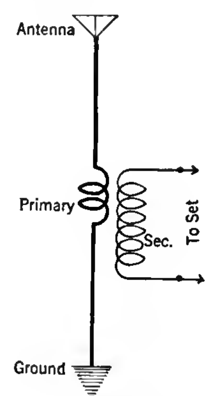


FIG. 1

A three-stage audio amplifier was hooked up in conjunction with a Radio Corporation of America cone loud speaker, model 100 A. The resultant reproduction gave the effect of exaggerated bass. A very great improvement in the quality was accomplished in the following manner: A Radiola horn type loud speaker was obtained and connected in series with the model 100A cone. The horn was shunted by a Centralab Modulator, variable from 0 to 50,000 ohms, as suggested in Fig. 2. Without this shunt, the proportion of the total load taken by the horn would have been excessive, on account of the higher impedance of its windings. With the shunt resistance set at about 25,000 ohms, the load seemed to be about equalized between the two loud speakers. Between 25,000 ohms and 50,000 ohms the effect of the horn was more pronounced, while from 25,000 down to zero, the cone predominated. At a setting of zero the horn was completely shunted from the circuit.

The particular cone used in this circuit gave excellent reproduction of the bass, while the horn brought out the treble clear and distinct. The reproduction resulting from this combination of about 20,000 ohms was the most pleasing the writer has ever listened to. By the turn of a single knob it was possible to bring out the bass or treble to any relative degree to suit the particular ear of the listener.

D. C. Redgrave
Norfolk, Virginia.

Another Cone and Horn Combination

Like many other radio fans I recently discarded my horn loud speaker for a cone. When listening attentively, I decided that the cone slighted the higher frequencies somewhat so I dug out the old horn, which rather favors the high notes, with the idea of using the two loud speakers in combination. But the impedance of the loud speakers were so poorly matched that some balancing arrangement had to be devised.

I evolved the scheme illustrated in Fig. 3, employing a half-megohm potentiometer, such as is often used for a volume control. As the slider is moved, one loud speaker is cut in and one eliminated.

I soon found, however, that I needed a better criterion than my ears to place the slider where it belonged, so I plugged a pair of good phones in the detector plate circuit and adjusted the potentiometer until the loud speakers duplicated the pitch of the telephone receivers.

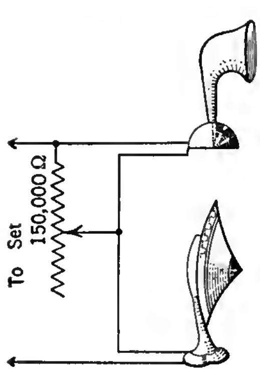


FIG. 2

H. D. Hatch
Boston, Massachusetts

STAFF COMMENT

The choice of the systems outlined above by our two readers rests pretty much on the convenience of what you have in the way of a variable resistor. Fig. 3 provides a greater variation in loud speaker selection than Fig. 2 but sufficient variation can be secured with the latter for the purpose of correct balance. In the arrangement shown in Fig. 2 the variable resistor should always be connected across the loud speaker having the higher impedance, *i. e.*, the loud speaker that seems to produce the most sound when the resistor is disconnected.

Mr. Hatch's system for adjusting the relative intensities of the two loud speakers is worthy of special note. While a preference may exist for an emphasis of high or low notes (adjusting to suit individual tastes), this is not necessarily natural reproduction. The phone test method probably provides as correct a balance as can be achieved without elaborate equipment.

C Bias from B Socket Power Units

In this department for November, 1927, an interesting item was published showing how a B socket power device could be changed to supply grid bias voltages as well as plate potentials. In effecting this change, it was necessary to "get inside" the device, break a connection, and make several additions. This method is quite practicable, but there is always a general disinclination to "monkey" with a commercial set-up.

It is possible to obtain the C bias potentials by application of external resistors—no change whatever being necessary in the device itself. In so doing, several possible faults in the device can be corrected, such as break down of resistors, as may be evident in noisy reception and poor voltage regulation. It is also possible with the external arrangement to secure voltages other than those supplied by the original device for special sets or purposes.

The additional device takes the form of an entirely separate set of resistors, which is connected between the high-voltage and negative posts on the old power unit. The resistors are tapped to supply the desired B and C potentials and are mounted on a base-board.

The number of resistors required is determined by the number of voltage outlets. We shall need one Amsco "Duostat" to supply two variable "C" biases, while one resistor will be required between the negative tap and the lowest positive plate tap, and another resistor for each additional plate tap. The Amsco "Duostat" is equipped with two variable arms, making it possible to secure two variable C bias potentials with the one resistance unit.

The average arrangement is shown in Fig. 4, which requires three fixed resistors in addition to the "Duostat." The fixed resistors may be any satisfactory power resistor, such as those of Electrad, Amsco, Metaloid, Ward Leonard, Durham, Carter, etc.

The method of calculating the values of the resistors takes into consideration the probable plate current drain through each resistor, and is best illustrated by the example of Fig. 4.

An arbitrary value of ten milliamperes is chosen as the loss current—the current through the resistors over and above that drawn by the receiver. The presence of this loss current reduces the variations in voltage with slight differences in load. The higher the loss current the better the voltage regulation.

The output from the average power device receiver combination under load is about 200 volts. By an application of Ohm's Law, which tells us that the resistance is always equal to the voltage drop divided by the current in amperes, or one thousand times the voltage drop divided by the current in milliamperes, it is a simple matter to determine the total resistance necessary. The equation in this case is:

$$R = \frac{200 \times 1000}{10} = 20{,}000 \text{ Ohms}$$

So the total resistance of the "bridge" will be 20,000 ohms, 2000 of which is already apportioned to the "Duostat," R_4. It remains to calculate the values of R_1, R_2, and R_3. To do this, we must consider the probable plate currents through these resistors. A 201-A type tube, properly biased, draws the following currents: r. f. amplifier, 90 volts, 4 milliamperes; detector, 45 volts, 1.5 milliamperes; a. f. amplifier, 90 volts, 2 milliamperes.

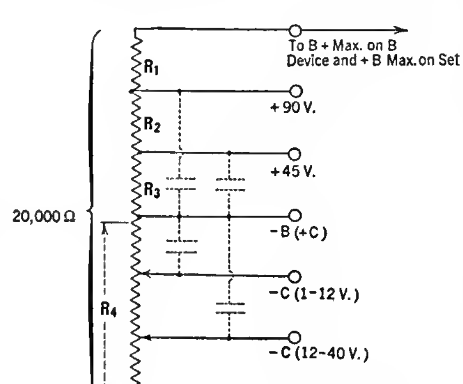


FIG. 4

We shall consider a receiver which comprises three r. f. tubes, detector, and two audio tubes, the last of which should be a power tube functioning directly from the highest voltage. So the first five tubes are all we have to consider now in designing the resistor bank.

Refer once more to Fig. 4. The current through R_1 is 10 milliamperes loss current, plus 12 milliamperes r. f. current, plus 1.5 milliamperes detector current, plus 2 milliamperes 1st audio current, or a total current of approximately 26 milliamperes. The voltage drop is 200 volts less 90 volts, or 110 volts. By Ohm's Law, the value of the resistor will be:

$$R_1 = \frac{110 \times 1000}{26} = 4200 \text{ Ohms}$$

R_2 carries a loss current of 10 milliamperes plus the detector plate current of 1.5 milliamperes. The voltage drop is from 90 volts to 45 volts. The calculation here is:

$$R_2 = \frac{45 \times 1000}{11.5} = 3900 \text{ Ohms}$$

Only the value of R_3 remains to be calculated. As the sum total of all the other resistors is 10,100 ohms, R_3 obviously should have a value of 9900 ohms—or, say, 10,000 ohms.

The resistors should always be capable of dissipating sufficient wattage. The wattage is equal to the voltage drop across any particular resistor times the current in milliamperes divided by 1000. The wattage in R_1 therefore is:

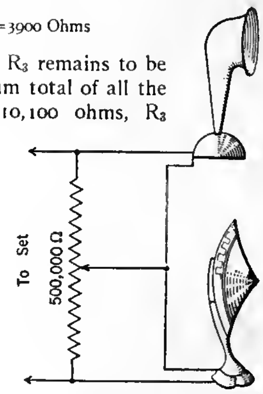


FIG. 3

$$W_1 = \frac{110 \times 26}{1000} = 2.86$$

A five-watt resistor should be used, thus insuring perfect safety.

Similarly R_2 should be a 1- or 2-watt resistor, and R_3 the same.

In the majority of cases the reader will not have to make the calculations outlined above, for the resistor bank shown in Fig. 5 is well adaptable to the average B power device and receiver.

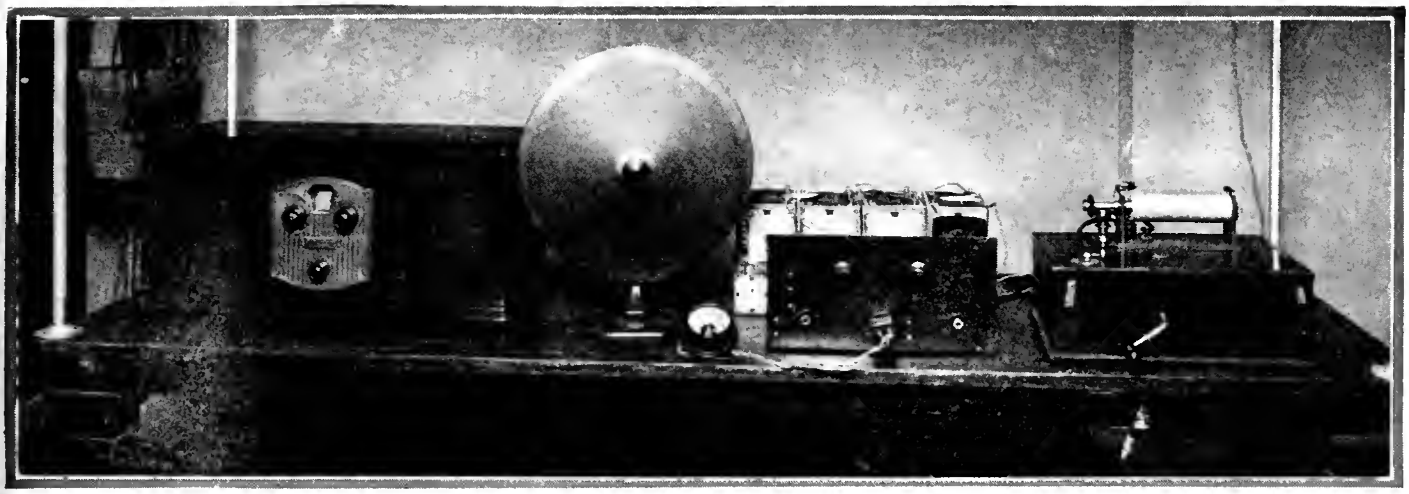
The resistor bank is merely connected to the old B power unit at the high-voltage and negative posts. No other posts on the B device are connected, the various voltages now being drawn from the new resistors.

John J. Willis
Batavia, Illinois.

STAFF COMMENT

Mr. Willis suggests a simple way of obtaining various B and C voltages from B power device other than those for which the device was originally designed. No changes whatever are made in the B unit itself. This arrangement, however, is practical only in the case of B device supplying voltages of 220 or more with a drain of 35 milliamperes, since the obtainment of C bias will reduce the voltage of the maximum B tap by an amount equal to that of C voltage. Thus, a device ordinarily capable of delivering 220 volts will still deliver sufficient voltage (180 v.) for best operation of a 171 type tube after a reduction of 40 volts is made to provide for C bias. The output of your present B device can be determined from the manufacturer's specifications accompanying it.

The resistor unit should be bypassed with 1-mfd. condensers, as indicated by the dotted lines in Fig. 4.



L. Bamberger & Co. Photograph

A COMPLETE COOLEY RAYFOTO RECEIVING INSTALLATION

The incoming radio signals from a standard broadcasting station are received on a standard Freed-Eisemann broadcast receiver the audio output of which is connected to the printer unit and thence to the recorder at the extreme right. Station WOR, on November 5, 1927, transmitted the first series of radio pictures ever to be sent from a broadcasting station which were successfully received by an installation similar to this. This complete Cooley receiver was demonstrated early in November at a special radio show held at the Bamberger store in Newark. There are only two essential units to the Cooley Rayfoto receiving apparatus and they are shown on the table at the right of the loud speaker. Any good broadcast receiver can be used to pick up the Rayfoto signals. The recorder at the extreme right is not the type usually supplied, which is furnished without the spring phonograph motor. The commercial recorder may be attached to the turntable of any standard phonograph, thus decreasing the expense

WHY I INSTALLED A COOLEY PICTURE RECEIVER

By Edgar H. Felix

BEFORE me, as I write, is a photograph of a lady. I treasure it highly. Her face is rather indistinct; in fact, I doubt if I could recognize her from the photograph. Although the circumstances surrounding the acquisition of this photograph are highly romantic and thrilling, I neither hope, seek, nor expect to make her acquaintance. Yet her picture will always remain a treasured memento. It is the beginning of a beautiful friendship, a new addiction which will make my charming wife still more thoroughly a radio widow. My new absorbing interest is the radio reception of photographs and the valued curio is the first photograph ever received on a home-assembled radio picture receiver from any broadcasting station.

Not many months will pass before picture transmission will be a regular feature of broadcasting programs. I do not say this because I have inside information, but because picture reception is an inevitable step in the progress of broadcasting. The only hindrance so far has been the fact that no simple and inexpensive apparatus has been available, a problem which has been solved by the appearance of the Cooley Rayfoto System.

It is easy to speculate on the possibilities of picture reception. Most people think of it as a means of seeing broadcasting artists performing in the studio. Although such a use of picture transmission is quite feasible, it is only a minor application. Imagine a ringside description of a champion prize-fight coming through the loud speaker, while near-by your Rayfoto recorder is grinding out one picture after another of the high lights of each round. Or, imagine the ceremonies at the take-off of the first transatlantic air liner, accompanied by pictures of the immense bird taking on its cargo, taking off with its load, and finally disappearing in the distance.

The new medium has all the diverse possibilities of tonal broadcasting and it will add a new lure to radio reception. Perhaps my imagination runs away with me because I have just made my first radio picture, but I firmly believe that it is only the first of hundreds, each of improved quality, which I shall pick out of the air.

On November 5, 1927, WOR, the broadcasting station of L. Bamberger & Co., Newark, New Jersey, put the first picture on the air from a public broadcasting station. It was only a preliminary test, to precede a public demonstration. So far as I know, my picture receiver was the only one, not installed at an experimental laboratory, capable of receiving the picture. But so great has been the interest manifested by set builders in picture reception that I am sure thousands of picture receivers will be in operation within a few weeks.

Picture transmission by wire and radio is not a new art. Pictures flash across the Atlantic by the Ranger system almost daily. The Jenkins system has been available to amateurs for years. The A. T. & T. has been transmitting high-quality pictures over wire lines to all parts of the country for some time. But most of these systems require either expensive receiving apparatus or more than one broadcasting channel, so that they are hardly suited to widespread use without considerable development.

© Bachrach

AUSTIN G. COOLEY

THE COOLEY SYSTEM IS SIMPLE

THE Cooley Rayfoto system is rugged and inexpensive. It uses but a single radio telephone channel for transmission. The parts for a picture recorder cost no more than those required for a good six-tube home built receiver. The quality—and quality in picture reception means detail and accuracy in shading—is not below the standard of tonal reception quality which we had in 1921 and 1922, a quality sufficient to set the world on fire with a broadcasting boom. There is no reason to doubt that picture reception will improve as rapidly as did tone quality in a like period. In fact, all of the experience gained with tone broadcasting is directly applicable to the broadcasting of pictures.

The constructional details of the Cooley system have been given completely in this magazine. The radio element of the Cooley apparatus is no more difficult to assemble than a two-tube radio set. Essentially, it is a stage of audio-frequency amplification, coupled so as to modulate the output of an oscillator. It can be assembled and wired in two hours. The rest of the work is connecting power supply, setting the mechanical unit on the phonograph, and adjusting the relay, corona discharge, and phonograph motor speed. Mr. Cooley, in his articles, has described these matters in some detail; my only purpose in mentioning them here is to give you an idea of how easy it is to get the Cooley receiver in working order.

To receive this treasured picture of mine, we adjusted the Rayfoto relay by tuning-in a musical program. A few moments of tinkering with a screwdriver and the relay tripped at each loud modulation peak. Mr. J. L. Whittaker, who did most of the hard work while I looked on, had the relay working in two minutes.

Adjusting the corona offered no special difficulties. By tuning the variable condenser across the oscillator coil, the corona starts as soon as the oscillator starts going. There really isn't anything to it. To get the modulation current right, you plug in the meter to set the input at the correct value. It's only a matter of juggling the input volume control.

Synchronizing the phonograph motor when everything else is working properly is simple when you know how. The phonograph motor should revolve just rapidly enough so that the synchronizing signal releases the drum at each revolution. When it does so, the drum stops with a firm click and then resumes turning with hardly a perceptible stop. When it is working just right, the drum stop makes its click with perfect regularity, about as loud as that of a typewriter key against the platen. If the speed is decreased below this point, there is a drop in the intensity of the clicks and a few may skip entirely. That is the critical speed, when the drum is at "zero beat" with the transmitting drum. At that speed, the synchronizing signal is not utilized in releasing the drum; at a slightly faster speed, when the clicks are regular, it is in proper adjustment.

These three adjustments made, and you are ready to receive the picture. We got the first one quite well, but we did not get the second one. First the grid leak went wrong, dimming the corona. Then the phonograph needle slipped off the bushing. Then the relay stuck. And, finally, the A battery went down. Of course, we didn't get the second picture!

So, you see, there is plenty that may happen when you get your first picture with a Cooley receiver. You have reason to be proud of a successful result. Of course, when there are plenty of pictures on the air, you won't have to meet all of your troubles in two short minutes. And, more important, is the advantage to be gained if you have a phonograph record of a Cooley picture transmission. I recorded the Cooley transmissions from WOR on a high-quality Dictaphone. By reproducing these records with an electric pick-up, every element of the picture receiver can be put in working order before transmission begins. Such records can probably be used for transmission purposes so that all the broadcasting station needs to put Cooley pictures on the air is a phonograph record and a phonograph.

The author receiving pictures by means of a Cooley Rayfoto receiver

THE GATEWAY TO TELEVISION

PICTURE transmission is the gateway to television and every red-blooded experimenter longs for the opportunity to become familiar with its problems by actual experience. The Cooley system sends the picture in one minute and to increase this speed of transmission sufficiently to get motion pictures requires a thousandfolding of this speed. Considering the magnitude of the improvement required, it seems impossible that the Cooley system can ever be the basis for television. A fundamental and startling invention is necessary before so great an increase of speed can be hoped for. There have been demonstrations of television already, but all use electrical machinery so complex and expensive that the tests really proved that television is not yet a practical possibility with our present knowledge.

Someone will some day accomplish the essential invention to make television practical. Very probably the discoverer will be someone who has worked with picture transmission. And the man who does make television possible will go down as one of the world's greatest inventors.

Thousandfolding the speed of any process is a large order. But remember that only twenty-five years ago, when radio telegraphy made its appearance, the detector used was a glass tube filled with iron filings. Electromagnetic waves caused these iron filings to congeal or cohere so that the current from a local battery flowed through them. This operated a sounder. The iron filings were agitated by the clapper of a bell so that they would de-cohere or interrupt the battery current as soon as the radio wave ceased flowing through it. With this crude apparatus, transmission of two, three, four, and five words a minute was the maximum possible. Ranges were matters of a few miles.

Then came the invention of Marconi's magnetic detector. This greatly increased both speed and range. And then the really revolutionary vacuum tube. Now, with high-speed radio telegraphy, we send thousands of characters a minute. From many of the long-wave, transoceanic stations, you can hear the myriad of dots and dashes, so rapid that you cannot distinguish between them. The step from the coherer to radio telephone transmission and reception is no greater than that necessary from telephotography to television. Undoubtedly, someone will make that essential invention to make television possible and I hope it will be an American amateur experimenter, who has enough vision to see in the crude, simple, telephotographic apparatus available to him to-day the possibilities of the great new science and art of the future.

TWO PICTURES RECEIVED ON A RAYFOTO RECEIVER

The picture on the right shows the effect of improper adjustment of the oscillator in the Rayfoto printer unit. The white streaks are produced when the oscillator suddenly stops oscillating. The left-hand picture indicates the improvement in results after the oscillator has been adjusted. For best results the oscillator should not be tuned exactly to the point at which the maximum corona discharge is obtained since, when so adjusted, it is rather critical and easily stops oscillating. The variable condenser controlling the oscillator circuit should always be slightly detuned from that point at which maximum corona discharge is obtained

Suppressing Radio Interference

Every Conceivable Source of Radio Interference Is Considered, Remedial Suggestions Being Offered—Farm Lighting Plants, Railway Signals, Telegraph Lines, Stock Tickers, Street Railways, and Interference Originating in the Receiver Itself, Are Taken up in This Chapter

By A. T. LAWTON

THE studies made by the author in the elimination of interference have been so extensive that it would be hardly possible to combine the various chapters in one issue. An endeavor has been made, however, to eliminate cross references so that each article in the series may be complete in itself. The forms of interference covered in the two previous chapters, printed in the September and November, 1927, issues of RADIO BROADCAST, dealt with interference originating at the following sources: Oil-burning furnaces, X-ray equipment, dental motors, motion-picture theatres, telephone exchanges, arc lamps, incandescent street lamps, flour mills, factory belts, electric warming pads, and precipitators. The information printed results from a two-and-a-half-year study by the author in more than 132 cities. The first form of interference considered in the present chapter, is that originating in farm lighting plants.

FARM LIGHTING PLANTS

INTERFERENCE from this source is confined to rural districts. The characteristic click, click, corresponding to the ignition spark, reveals the source at once; rarely do we get trouble from the commutator.

This continuous clicking is very loud on nearby radio receivers and because of the large number of plants in operation in communities not served by electric power companies, the total interference is very annoying.

Complete elimination of the disturbance created is a relatively simple matter. Nearly all these plants, being bolted down to a wooden platform, are insulated from the ground and two 2-microfarad condensers in series, midpoint connected to the engine frame, and bridged across the outgoing d.c. feeders, will clear up the clicking. Ground connection of the series wire should not be made to a water pipe or earth rod in this case. Even 1-microfarad condensers will be found suitable for small plants.

If the engine bed is of concrete or the plant is grounded in some other way, complete elimination is not obtained by the above method although the reduction (about 80 per cent.) is material. The remaining interference is not likely to be serious. However, where it is desired to clear this out also, choke coils should prove effective.

It is not uncommon to find the exhaust pipe of such plants carried to a muffler drum in the ground; such a connection to earth offsets the effect of the condensers and more satisfactory results will be obtained if this pipe is cut and a section of asbestos or other suitable piping inserted.

Further experimental work is required in the cases where Electrical Inspections call for the grounding of small lighting plants. Possibly a fine wire choke coil, say, of No. 26 wire, bridged by a standard lightning arrester, would be satisfactory, the coil preventing the accumulation of any static charge and the arrester taking care of any abnormal surge superimposed on the system from outside sources.

As a precaution, all leads around the plant proper, either high- or low-tension, should be cut as short as possible.

Where one or two of the storage cells are used to operate a radio set as well as light the residence, complete elimination of the trouble for that particular set becomes difficult.

Prior to arriving at suitable preventive measures in the various plants investigated, experiments were carried out directly on the ignition system but all methods tried proved of no avail. In the case of "make and break" type ignition, condensers applied directly to the ignition system stalled the engine, apparently neutralizing the effect of the inductance coil, but were quite effective on the outgoing lines and, of course, did not interfere with normal operation.

In all cases attachment of the condensers is made at the switchboard, under the same terminals to which the two lighting mains are connected.

RAILWAY SIGNALS

RAILWAY "wig-wag" signs and crossing bells give rise to heavy clicking radio interference. Fortunately, their periods of operation are limited, but where the trouble is material it can be cleared up by shunting the operating contacts with a resistance of about 350 ohms. This applies to low-voltage d.c. operated bells and signals.

For types operating on 400–600 volts it is necessary to bridge each individual set of contacts with a resistance of the above order.

The vibrating reed type battery charger used in conjunction with these signals is a real offender. Interference from this source has given rise to a large number of complaints but, generally speaking, railway companies are averse to tacking on any surge traps to this equipment and in the dozen or so cases cleared up, the operating company took the chargers out bodily and substituted a type which is silent so far as radio interference is concerned.

LAND LINE TELEGRAPH AND STOCK TICKERS

RAPID clicking interference from the above equipment is a serious matter in towns and smaller cities. Not that there is less telegraph activity in the larger centres, but in the places referred to a comparatively greater number of residences and radio dealers are located in the vicinity of the telegraph offices.

Normal operation of the keys and repeaters set up a vigorous highly damped wave which breaks in on practically any setting of the dials of the average radio set. The clicking from stock tickers is severe even where the wires are enclosed in lead-sheathed cable.

Since it is necessary to apply suppressive measures to each individual line, the factor of cost looms large when we consider the number of lines entering the average city office. Where only a few lines are concerned it is usual to place a 1-microfarad condenser across the key contacts inserting in each condenser lead a resistance of about 20 or 30 ohms.

Strictly speaking, only one resistance unit is required but it makes a very great difference which contact of the key this resistance lead is connected to. If the condenser alone is used, reduction of the interference may be noted but the resultant arcing at the contacts is prohibitive. It is ordinarily supposed that the condenser in this case should absorb the spark; rather, it turns the spark into an arc and resistance is required to overcome this.

We must remember that many variables enter here; at a given time, one leg of the key may be to ground and the other leg to line, positive or

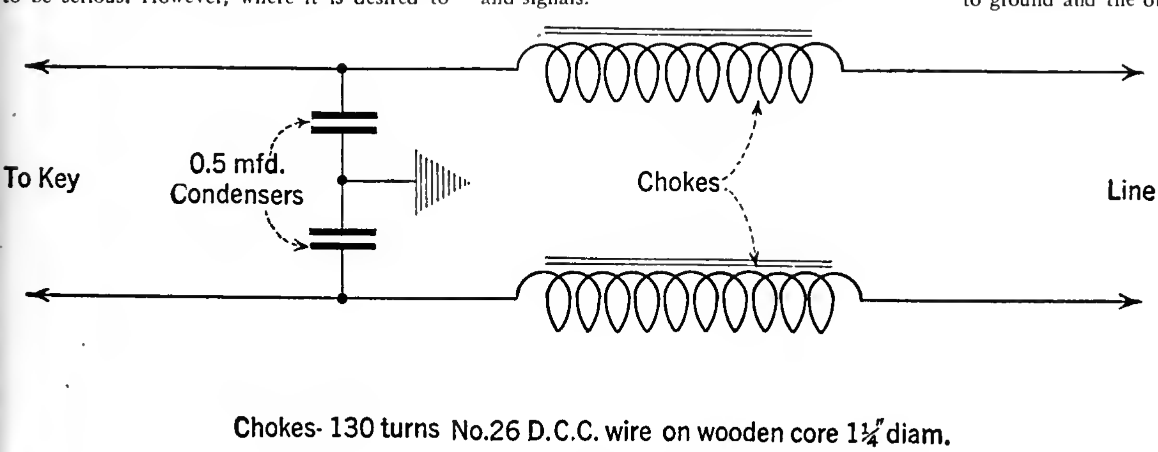


FIG. 1 The circuit employed to eliminate interference caused by key clicking. An obstinate case was eliminated by application of a surge trap, as shown in this diagram

negative. Again, the key may be cut in on a through line, positive or negative either way, and these conditions are likely to be reversed many times in the course of a day through jack plugging operations at the switchboard.

In most cases these clicks are unreadable; they occur at the break of the key, not on the closing of the circuit, but in the immediate vicinity of a telegraph office, radio interference may be noted from the local or sounder circuit. This is readable and can usually be eliminated by bridging the relay contacts of the local circuit with a one-half microfarad condenser without any series resistance.

Occasionally, complications enter into the situation, making necessary the use of full surge traps. An obstinate case of key clicking was cleared up only after applying the surge trap described in Fig. 1.

Another difficult case, in connection with a set of repeaters, required choke coils as described in Fig. 2 in each line and 0.5-mfd. condensers, series arrangement midpoint grounded, across the repeater contacts.

Duplex and quad circuits require individual treatment; much experimental work is required before standard eliminators can be recommended for these and the various types of stock tickers in daily operation.

RADIO RECEIVERS

MUCH of the so-called inductive interference has its origin in the broadcast listener's own set. It might be due to any one of the following causes:

(1.) Loose antenna or ground connections will give rise to serious clicking noises when shaken by wind or other agency.

(2.) Loose or corroded connections at the A battery will cause flickering of the tubes and consequent clicking.

(3.) Internal defects in any one cell will cause harsh grating noises. This can be checked with a telephone transformer and pair of headphones, the secondary of the transformer being connected to the battery and primary to the phones.

(4.) Defective B batteries cause a "chirping" or clicking interference. It doesn't follow that because a B battery registers full voltage, 22½ or 45, that it is in good condition. One high-resistance cell of the many incorporated in this battery can render the battery unfit for use although on open circuit it reads up to full strength.

(5.) Oxidized contacts of the tube prongs or spring contacts of the sockets are fruitful sources of trouble. These should be scraped occasionally and the spring strips pulled up gently to insure that good contact is being made.

(6.) Broken lead-in wires cause poor reception and clicking noises. Naturally, a lead-in wire must be insulated where it enters the building but the practice of using covered wire all the way down from the horizontal portion of the antenna is not to be recommended. From swinging in the wind, this wire often breaks inside the insulation but is held up by the fabric so it appears to be continuous whereas the wire itself is separated an eighth of an inch or more.

(7.) Concealed house light wiring in the walls will cause humming noises if the radio set is installed close up to such partitions. This is especially noticeable in the case of single-circuit receivers.

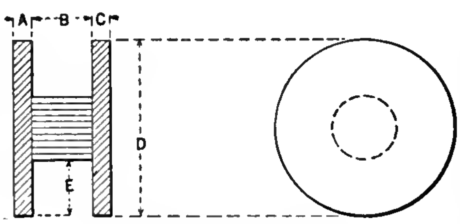
In the case of abnormal humming it is probable that the main supply line (three-wire system) is badly out of balance or the wrong side of the house lighting system is grounded. This latter will not necessarily blow the fuses.

A and B supply devices designed for sixty-cycle supply will also give some similar trouble when used on twenty-five cycle lines.

Various stray noises will, of course, result from defective tubes, shaky splices, poor construction, connections soldered with acid flux, etc. Before assuming that any given interference comes from the outside, broadcast listeners should disconnect the antenna and ground wires and note if the interference weakens or disappears. If it does, the source of the trouble is outside. If it remains the same and is not responsive to tuning, the trouble, nine times out of ten, is in the set itself.

Unshielded sets may pick up outside interference without the antenna or ground being attached, but a decided weakening will be observed when these are disconnected and this is sufficient proof that the disturbance is not internal.

As a test, the house lighting supply switch should be opened for a moment. If the interference disappears coincident with this, all lights and electrical apparatus in the residence should be checked over for possible faults. A lamp loose in its socket can cause quite a lot of trouble. Partial shorts in the interior wiring will cause trouble over a fairly wide area; such a case occurred recently where a long nail driven in an attic floor brought a concealed power wire in contact with the grounded plumbing.



A-¼" B-¾" C-¼" D-2½" E-¾"
Hardwood Bobbin, approx. 300 turns No.22 (about 125 ft.)

FIG. 2

ELECTRIC STREET RAILWAYS

INTERFERENCE from this source presents a problem for which no really satisfactory solution has been found. Without question, many radio sets are unnecessarily interfered with by this agency and in such cases relief is possible.

The steady interference under a street-car line is violent; fifty feet either side of this it is almost negligible. Only when cars go by or some very abrupt alteration of the line energy values occurs do we get trouble at this distance.

The following actual test is interesting: On a radio set, the antenna of which ran parallel to a car line, broadcast programs were rendered valueless as mediums of entertainment but when this antenna was changed to run at right angles to the line, good reception became possible. The effect was decided.

If your antenna is at present installed at the front of the building, facing the car line, shift it to the rear as far as possible. If conditions permit, run it at right angles to the line of interference. It is surprising what a difference one or two feet variation in the plane will make here and we suggest when installing, permanently fixing one end of the horizontal portion and temporarily attaching the other end of the horizontal part to a pole which may be carried backward and forward on the roof to test out the exact position of minimum interference.

Relative intensity of the interference is noted at each setting and a permanent pole fixed at the proper point. We must remember that lighting and power circuits nearer the residence than the trolley feeder are concerned in transferring this disturbance to the antenna, and distortion of direction is pretty sure to occur.

Sparks at the trolley wheel cause clicking interference; large arcs cause none. The bigger the flash, the less the interference. Cars going up grade on full power cause decidedly less interference than cars coasting with practically all power off, only the lights or heaters being in operation. Trolley shoes are no improvement over wheels. Catenary suspension makes no difference.

If the positive lead of the station generator goes direct to the trolley wire, interference will probably result. If this lead goes to the series field winding first, the free end of the series field going to the line, the choking effect of the coils tends to suppress any commutator interference.

In addition to checks on the usual 600-volt d. c. systems, observations were carried out on:

(a.) Pantograph System, 6600 volts a.c. copper trolley wire.

(b.) 1500-volt d.c. system using shoes. Copper trolley.

(c.) 2400-volt d.c. pantograph. Copper trolley.

(d.) 1500-volt system d.c. shoe contact. Entire system steel trolley wire.

A great many variable factors entered into the results and for scientific purposes the data obtained are not considered satisfactory. Much time and effort and expense have been devoted to the whole problem of interference from electric railways but, so far, results have not been very encouraging.

It must not be concluded, however, that the proposition is hopeless; greater efforts are being made in every city to keep the rail bonding in good shape and it is probable that more careful attention to car motors and equipment generally will tend to alleviate the situation.

Peculiar effects are often observed on radio sets installed in the vicinity of a car line. It is not uncommon to find that a passing car, even when causing little or no radio interference, will "take away," temporarily, the program being received. As soon as the car moves away a few hundred feet the program comes back, without any alteration of the set tuning whatever.

Again, in two widely separated instances, and some distance away from the car lines, the disturbance on residence radio receivers amounts to a continuous loud roar. Immediately outside both residences no interference can be picked up on a standard six-tube super-heterodyne receiver. Evidently this was a case of electrolysis since an exploring coil on the water piping indicates fluctuating current in the plumbing system. Concealed pipes and wiring in these residences carry the surge also and loop reception is practically no better although the ground wire to the water pipe is cut off.

One of the most curious and perplexing cases of radio interference that we know of had its origin in an electric street railway system. This particular noise affected only three residences, all fairly close together. All efforts to locate the trouble failed but the plumber solved the problem. It so happened that the drain pipe of the centre house became blocked; on digging this up it was found to be full of a fibrous growth and at a crack in the pipe a mass of roots had come through and grown out in the direction of the railway tracks, close up to the rails, in fact.

This offshoot evidently served as a conductor to electrify the plumbing fixtures of the three houses concerned and as the radio set grounds were attached to this, every variation in the railway line voltage set up a disturbance on the radio receivers. When the drain pipe was cleaned and replaced, all interference disappeared.

The Listeners' Point of View

ARE PROGRAMS GOING IN THE WRONG DIRECTION?

By JOHN WALLACE

SOMETIMES when we sit ourself down to pound out this monthly manifesto concerning matters radio, we attack the job with great gusto and enthusiasm. We are filled with a vast faith in radio's achievements and possibilities and garner a certain amount of personal satisfaction in making our small critical contribution to radio's great ends.

There are other times when we entertain grave misgivings as to whether the subject is actually worth the fifteen clean sheets of typewriter paper we employ to comment on it. Such doubts assail us this very minute. Probably when we are effusing enthusiastic utterances about radio entertainment we are writing romance, and to admit that it is pretty punk is simply to be realistic. Though if you be of the other turn of mind you may claim that it is the former that is realism and that the latter is rank pessimism—which suggests an appropriate variation of Cabell's ingenious epigram: The *optimist* thinks that radio has now reached the greatest heights of achievement. The *pessimist*, alas, is afraid that he's right!

Whatever roseate promises radio may have seemed to have held in the past we are at present thoroughly convinced that things have reached a sorry pass and that radio is standing still—smug, self-satisfied, and inutterably banal. One robin does not make a summer and the indubitably good program to which you may point here and there (only too infrequently!) isn't enough to raise radio to the standard it ought to be maintaining.

If two years ago someone had told us that by the end of 1927 programs would have only attained the level they now actually occupy we would have pooh-poohed him as a person incapable of reading the signs and portents. At the rate things were progressing in 1925 there was every indication that another two years would find us surfeited with high-class program material, of such high standard that we would be loath to absent ourselves from our receiving sets for two nights in a row.

As we look back several years, the greatest hope for improved programs then seemed to lie in the ever increasing number of sponsored programs. Great industries were going to start pouring their gold into the radio stations in payment for indirect advertising—more properly, radio publicity—and great things were going to result. Herein was the solution of all our difficulties: without government operation; without levying of taxes; without philanthropic financing, we were going to lead the world in program standards by utilizing our great American asset—Big Business.

Well the dismal fact of the matter is that none of these things has come about. And the ironical conclusion to which we are forced is that the rise of the sponsored program is responsible for the stand-still that radio has reached at the dawn of this year of grace 1928. In fact, stand-still is putting it mildly; the state of affairs is more exactly a retrogression. All the money, all the ingenuity, and all the labor that is being devoted to the designing of programs is being diligently devoted to efforts *in the wrong direction*—with the result that radio is going to the dogs at a breakneck speed, so rapidly in fact, that to check it will require no little effort.

LET US LOOK AT THE GUIDE POSTS

WHAT is the right direction? It would seem that program makers are too embroiled in their business to glance at the guide posts, too pressed by the strenuous and unceasing job of making programs to take a moment or two off for a little rational reflection on what their job is all about. They persist in refusing to take account of the fact that radio is a new medium, a unique medium and, like any other medium, endowed with its peculiar limitations and peculiar possibilities. Pig-headedly they persist in attempting to reconcile with their duties the traditions of the drama, the opera, the music hall, and the vaudeville stage. This observation has been made often before. We are a trifle abashed at shouting the same tune again. But probably it will have to be stated many times more—and certainly by others than ourselves—before it sinks in.

Radio Times, London

IGOR STRAVINSKY

The British Broadcasting Company, on a recent Sunday afternoon symphony program, presented the modernist composer, Igor Stravinsky, conducting a program of his own works. This is an event in radio annals. True, Stravinsky has been "outmoderned" by a group of still younger composers but his compositions are still quite far in advance of the popular taste. It's likely that no American station would have, nor will have for many years, the temerity to present a program of such dubious popular appeal. This does not indicate that the Britisher is any more sophisticated in his tastes than the American; it is our guess that the B. B. C. is enabled to essay such a high-brow program simply because it is non-competitive. On Mr. Stravinsky's program appeared the Overture to Mavra, the Suite from the Fire Bird and a Concerto for Pianoforte with Accompaniment of Wind Instruments. The latter was a premier English performance. The above portrait is from a drawing by the famous French artist, Picasso.

Without annoying you by enumerating radios' limitations, which you know as well as we (unless you happen to be a program designer, in which case you probably don't), we will proceed to the proposition that the one species of entertainment that radio is by its intrinsic nature best fitted to put across is instrumental music.

Music is the only existing mode of entertainment that can be assimilated solely by the unaided ear. The radio (together with the phonograph) is the only existing entertainment device which can reach nothing but the ear. Obviously they were made for each other! They should be joined in holy wedlock and wander hand in hand through the new mown hills, happily ever after.

Instrumental music should be the backbone of the radio program; it should predominate every program; it should be the *piece de resistance* with all the other little absurdities of broadcasting arranged around it like the potatoes around a roast beef. Plays, where you can't see the players, speeches where you can't see the speakers, comedy, where you can't see the comedians—all such like stuff is mere piccalilli and sauce.

So the business of broadcasting is music. And by music we mean music at its fullest realization, which is that of the instrumental ensemble—the symphony, the little symphony, or the chamber group.

In the field of the representative arts are many different mediums—water color, etching, caricature, wood cut, lithograph, miniature, pen drawing, fresco, and countless other specializations. But it is finally in the oil painting that graphic art finds its complete expression. Beside it all other artistic endeavors fall into comparative insignificance. It contains within itself the whole total of their qualities and infinite other ones of its own.

A perfect analogy exists in music. Vocal music is all right in its way, as are also organ recitals, piano gymnastics, jazz bands, and marimbaphones. But they are all dwarfed by the symphony orchestra. The orchestra not only can do all the things that they can do, but can do them better—and with its great musical resources can secure added effects that they can't possibly aspire to.

Of course it is always necessary to get back to the cold fact that, in America at least, the station manager's only business is to give the listeners what they want. But don't they want orchestral music? There has been much talk about how the taste of the listening public has been elevated by radio and much proclaiming that Mr. Average Citizen has reached a stage of enlightenment where he can actually enjoy serious musical compositions. We are inclined to believe that this is true. Moreover, there are thousands of people in the country who needed no "educating" but who already liked such music. It seems fair enough to deduce that genuine music is the "what-they-want" of a sizable section of listeners and potential listeners.

In view of the fact that orchestral music is the best thing that a station can put across, and the best thing that a listener could listen to, it seems fair enough further to deduce that there ought to be a certain amount of it in the air of an evening, available for such persons as wish to seek it out. But is it there?

THE HORRIBLE EVIDENCE

BY WAY of confirming our suspicion that there isn't, we sat ourself down at our receiver the other night and proceeded systematically to get a cross section of what was on the air. At 8:15 P. M. (Central time) we started at the top of the dial and worked our way patiently to the bottom, recording everything that was going on within our receiver's range. The stations encountered extended from Colorado to Texas to New England. At 9:35 P. M. (Central time) the chore was concluded, and if you entertain any delusions that there are a lot of fine things on the air awaiting the turn of a dial, gaze at the cold and cruel statistics we found on our tablet:

1 Jazz Piano, playing "Ain't She Sweet."
2 Jazz Orchestra, dance music.
3 Couple at a Piano, wise cracks, request numbers, ballads.
4 Sentimental Songs, "Sweetheart of Sigma Chi," etc.
5 Soprano, singing the Brindisi from "Lucrezia Borgia."
6 Baritone, singing unidentifiable ballad.
7 Sermon, of the vocal-cord-splitting variety.
8 Tenor, popular ballad, "I'll Forget You."
9 Dance Orchestra, playing "Rio Rita."
10 Old Time Fiddling, with "swing your partners," etc., interpolations.
11 String Trio, playing semi-popular airs.
12 Choral Group, in the finale of a light opera.
13 Soprano, singing the Shadow Song from "Dinorah."
14 Soprano, singing "Just a Wearyin' for You."
15 Churchill Sisters, singing "Say Au Revoir but Not Good-bye."
16 Soprano, singing some light ditties in French.
17 Dramatization, of Rip Van Winkle.
18 Tenor, solo.
19 String Trio, playing Saint-Saëns' "Swan."
20 Weather Report.
21 Dance Orchestra.
22 Novelty Song, with banjo.
23 Hawaiian Guitar and Mandolin, duet.
24 Travel, talk on Starved Rock, Illinois.
25 Female, reciting poetry.
26 Male Quartet, singing "Bye and Bye."
27 Prize Fight.
28 Brass Band, playing "Moonlight Wonderings."
29 Jazz Orceshtra.
30 Tenor, singing Welsh folk songs.
31 Tenor, singing popular ballad, "Lonesome."
32 Pianologue.
33 Tenor, singing sentimental ballad.
34 Violinist, playing Beethoven—Opus 12 Number 1.
35 Tenor. "A Robin Sings in the Apple Tree."
36 Trio, playing semi-classics.
37 Organ, "Pale Hands I Loved," etc.
38 Bass, soloist.
39 Dance orchestra, "On a Dew Dew Dewy Day."
40 Female duet, sloppy ballad.
41 Male Chorus, college songs.

And there you are! Nowhere was the orchestral program we had set out in search of. Twenty of the forty-one programs were vocal, practically fifty per cent.! And this in spite of the fact that vocal transmission is one of the lesser effective things broadcasting is capable of. Only three of the programs encountered seemed to hold any promise of suiting our mood of the moment, numbers 5, 13, and 34. But a return to these dial positions found the stations already shifted to something trifling.

But perhaps, we reflected magnanimously, we had picked out the wrong hour of the evening. So the following night we repeated the procedure, commencing at 7:15 P. M. Central time, and running through to 8:20. Behold our second log:

1 Soprano, singing Nevin's "Rosary."
2 Dance Orchestra, jazz.
3 Baritone, solo "Young Tom o'Devon."
4 Jazz Orchestra.
5 Dance Orchestra.
6 Dance Orchestra.
7 Dance Orchestra—(what, another!).
8 Organ, Mendelssohn's A Major Organ Sonata.
9 Male Quartet, "Back Home Again in Indiana."
10 Banjo, solo with piano accompaniment.
11 Talk, on something or other.
12 Piano, solo.
13 Negro Spiritual, "I Heard From Heaven To-day."
14 Play, Julius Caesar.
15 Small Orchestra, playing "Gypsy Sweetheart."
16 Band, playing march tune.
17 Violin, Schubert's "Ave Maria."
18 Vocal Duet, semi-popular songs.
19 Bible Readings.
20 Tenor, singing sloppy ballad.
21 Trio, playing light stand-bys.
22 Couple, singing novelty songs about sweet mammas.
23 Dance Orchestra.
24 Speech, by some labor leader.
25 String Quintet playing Handel's Water Music Suite—but, alas, even as we listened, this changed into a soprano solo!

Such was our clinic—sixty-six cases examined over a period of two hours and twenty minutes of the most favorable broadcasting time of the evening. It may be objected that we didn't examine all the programs of all the stations during that time period, but we see no argument to show that the cross section we observed was other than representative. Representative, for the most part, of a lot of inanities that only the veriest imbecile, with the meagerest amusement resources conceivable, could dignify with the name of worthwhile entertainment.

Of these sixty-six programs not a single one was orchestral. The few trios we ran across were simply doing their five or ten minutes' turn on a well scrambled variety hour.

WE DON'T NEED SO MUCH VARIETY

THIS frantic search for variety is one of the silliest things in the whole radio broadcasting business. Variety has been set up on a pedestal as the one goal to be achieved. The means used to secure it are devious and dull. Variety is necessary, of course, but there are other sorts of variety than that of the vaudeville show. Program directors do not realize that music, real music, contains within itself all the variety that is necessary. If program arrangers only realized it, their job has already been done for them by the great composers.

Practically every hour of program furnished by the broadcasters to-day is a variety program. And where every program is a variety program would it not be a variety to introduce a program that is *not* a variety program?

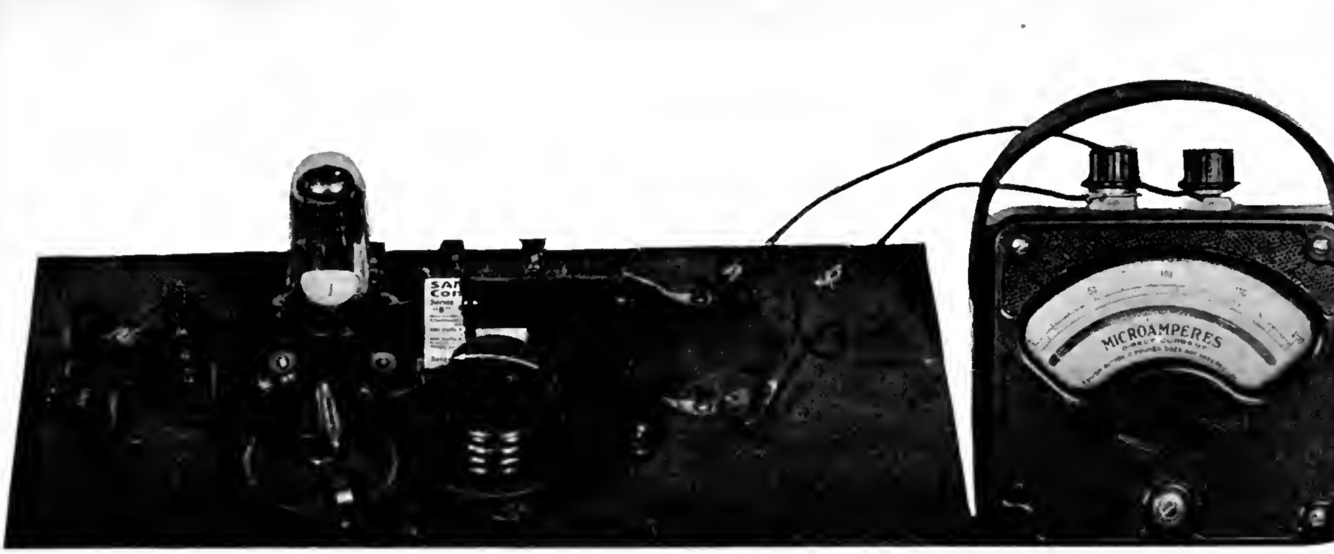
We throw out the foregoing sound suggestion to whomsoever chooses to make use of it (fearing the while that no one will).

To the rising tide of sponsored programs is due the blame for the overwhelming number of variety programs which is rapidly reducing radio to the level of a gigantic and worthless vaudeville show. In any schedule of entertainment it is the light frivolous item, introduced to break the monotony, that is the brightest thing on the program. This principle is borne in mind by the advertiser when he decides to produce a broadcast program of his own. He will make his program snappy and ever changing, he reasons, and thus make it stand out in high relief against all the others. Unfortunately every other advertiser goes through precisely the same sort of reasoning. The result is that sponsored programs are all as alike as peas in a pod, and no pea is any more novel or attention compelling than its neighbor on the left or on the right. All are dealing in olives and chilli sauce, nuts and caviar. None is willing to supply the meat of the repast. This meat must be orchestral music of solid musical worth.

If broadcasting, considering it as a whole, were maintaining a proper balance in its offerings—a thing it must eventually do or go out of business—it would be possible to find good music, played by competent orchestras, at at least ten places on the dial at any hour of the evening. Its present condition, that of having *no* respectable music to offer, is certainly not a healthy one.

Some stations used to maintain fair sized orchestras as a staff feature, but their number is rapidly diminishing—the very reverse of what should have happened. If radio had progressed in its proper channel we would now have some ten or twenty symphony orchestras throughout the country bearing as their titles the names of the stations which organized them, and being secondary in musical importance only to the old established symphonic societies. It is expensive, certainly, to maintain a large orchestra but when it comes to hiring dance bands or opera singers expense seems to be no important item to the broadcasting stations.

If expense is not the drawback it must be that there is still a lingering fear that not enough people will listen to a highbrow orchestral broadcast to make it worth while. This fear, as we have already stated thirteen different ways, is ungrounded. The Damrosch programs (an exception we advance in further proof of our point) seem successful enough. And witness the way the populace is clamoring for more sophisticated orchestration of its dance music. They go wild over Paul Whiteman's rendition of "When Day is Done." If they like this why wouldn't they enjoy the compositions of Stravinsky and others of the modern school. Katscher's piece is simply a shoddy and ineffectual mimicking of the works of these composers. There are tunes in the Beethoven symphonies as simply melodious as anything Victor Herbert ever wrote. No one who likes jazz effects could fail to be pleased by Casella, for instance, or Sowerby. We defy anyone but the stupidest moron to listen to the first movement of the César Franck symphony without craving to hear it repeated. Schelling's "Victory Ball" could sweep any Rotarian off his feet. The use of the human voice in Bloch's "Symphony Israel" is incomparable, but not incomprehensible. Ravel's "Waltz" makes those of the light operas tame indeed. Tschaikowsky's "Manfred" symphony, for those who would weep, is forty times more lugubrious than "Hearts and Flowers." The name of Bach could terrify no one who had heard Abert's arrangement of his Chorale and Fugue. Scriabin's Third Symphony is of such emotional ferocity that it could emotionally unstabilize a brass monkey. And as for soul satisfying harmony, better than any organ chords is the passacaglia that concludes Brahms' Fourth Symphony.



RADIO BROADCAST Photograph

USED IN THE LABORATORY

The photograph of the vacuum-tube voltmeter shown schematically in Fig. 2 indicates a simple breadboard layout. The equipment includes a Yaxley potentiometer, a Pacent rheostat, an Alden socket, Mountford and Crescent resistances, a Sangamo "Parvolt" condenser, and several Fahnestock clips

A VACUUM-TUBE VOLTMETER

By THE LABORATORY STAFF

IN THE study of radio-frequency phenomena, experimenters have always been more or less handicapped by their lack of accurate measuring instruments. It is a simple matter, comparatively, to build a meter that will cover a considerable range when one works at 60 cycles, or at fairly high values of current and voltage, but let the research student attempt to measure currents at a million cycles and of a few microamperes, or voltages of a few microvolts, and his problem has increased in difficulty many fold.

The advent of the vacuum tube has made material progress possible in the realm of radio-frequency measurements, so much progress, in fact, that it is now possible to buy a book that deals with nothing but measurements at frequencies far beyond those used for household purposes, and at values of current and voltage that are prefixed by the word "micro." Such a book, *Radio Frequency Measurements*, by E. B. Moullin, was reviewed in RADIO BROADCAST for October, 1926; no serious experimenter can afford to be without it.

In the present-day radio laboratory there will generally be found, on one hand, a vacuum tube generating currents and voltages of practically any frequency and any amplitude (the modulated oscillator described in the June, 1927, RADIO BROADCAST is an example), while on the other hand is another tube, perhaps exactly similar in type to the generator, the purpose of which is to measure the output of the first tube.

This latter tube, variously known as a "peak" voltmeter, or a vacuum-tube voltmeter, is the laboratory's most versatile and useful instrument. It can be used to measure voltages and currents of any amplitude and frequency, to measure the voltage or power amplification of audio- or radio-frequency amplifiers, the field strength of distant stations, the high-frequency resistance of a coil or condenser, as a level indicator in broadcasting stations or remote control stations—anywhere in fact where a meter is required which takes so little power from the circuit being measured that its presence causes no error in measurement. Briefly, the vacuum-tube voltmeter is a tube acting as a detector, or distorting device, so arranged that alternating potentials on the input may be read as direct current in the output. Unlike other translating mechanisms, the vacuum-tube voltmeter has no moving parts, there is little to wear out, it has nothing in its construction that is not easily replaceable and, best of all, it can be made to consume almost no power from the source to which it is attached.

Why is such an instrument necessary, and what are its particular qualifications compared to voltmeters with which we are all familiar? Let us suppose, for example, that we wish to measure the voltage delivered by a dynamo which will light a hundred 40-watt lamps, that is, will deliver 4000 watts, or 4.0 kilowatts. Suppose our ordinary moving-coil voltmeter has a resistance of 10,000 ohms and that when placed across the terminals of the dynamo it registers 100 volts, how much current and power does it take from the generator?

Ohm's law, which states that the number of amperes flowing in a circuit is equal to the voltage of the circuit divided by its resistance, tells us that 0.01 amperes will flow, and when we multiply this value of current by the voltage across the meter we find that the product, 1.0 watt, is the actual power required by the meter to give the proper deflection. Now this one watt is a very small part of the power that can be delivered by the dynamo, one four-thousandth as a matter of fact. It will readily be seen that the error of reading of the meter, due to the current it consumes itself, will be so small in this case as to be negligible.

But suppose our dynamo still had a terminal voltage of 100, but was so small that it could supply only one watt of power? How can we measure its output? It is at once obvious that

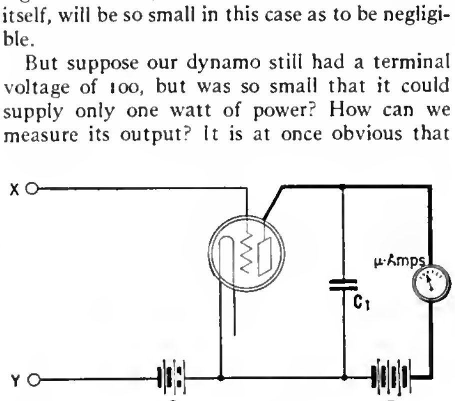


FIG. I

A C-battery detector and a direct-current meter are the principal parts of a vacuum-tube voltmeter

we cannot use the same voltmeter for it would consume all the power the dynamo is capable of supplying.

The answer lies in making the resistance of the meter so high compared to the resistance of the source of power, the dynamo, that very little current flows through it, and consequently, very little power is drawn from the source, which, in turn, means that applying the meter to the tiny one-watt dynamo will not short-circuit it, as would be the case with a low-resistance voltmeter. This problem has resulted in the design of high-resistance voltmeters useful in measuring the output voltage of plate-voltage supply units.

The problem is even more complicated when we wish to measure alternating currents or voltages of very small magnitude, or at very high frequencies. There is a very definite need for a voltmeter or an ammeter that will measure any values of current, or voltage, at any reasonable frequency, and without taking appreciable power to operate it.

The vacuum-tube voltmeter is such a device. Its input resistance can be made so high that it consumes practically no current from the source being measured, and aside from a small input capacity which may require slight retuning when working with tuned circuits, it has so little effect on the circuit that its presence may be neglected.

C-BATTERY METER

THERE are several types of vacuum-tube voltmeters, the C-battery detector type being the simplest and perhaps the most generally useful. The one described in this article has been designed for reading small values of a.c. voltage although it may be adapted for reading any desired maximum value.

The circuit diagram of a C-battery type of voltmeter is shown in Fig. 1. As can be seen, it is quite simple, consisting only of the tube and its necessary batteries, and a direct-current meter which, for all ordinary measurements, should read not over 500 microamperes.

The question, "how can a direct-current meter in the plate circuit of a detector be made to measure alternating voltages placed on the grid-filament circuit of the tube?" naturally arises.

Builders of plate-supply units, and owners of power amplifiers, who have placed a milliammeter in the plate circuit of the power tube, and watched its deflections under strong signals, have possessed the essential part of a vacuum-tube voltmeter—an overloaded tube. Whenever a signal came along which was greater than the C bias could handle, the average plate current changed and caused variations of the milliammeter needle.

But why does the needle wobble?

The normal plate current, as indicated by the milliammeter, is fixed with a fixed value of grid bias and a given plate voltage. When small a.c. voltages (the incoming signals) are placed on the grid circuit, the C bias is changed accordingly and in the plate circuit appears a magnified replica of these input voltages. In other words, the actual voltage on the plate of the tube varies with the input grid-filament voltage and naturally the plate current changes accordingly. If these changes are rapid and symmetrical, so that an increase in current is followed by an equal decrease, the average value of the plate current will remain the same and the milliammeter needle does not move. It is these a.c. plate currents which are amplified and which produce signals; the d.c. current is only a necessary and not directly useful part of the process.

If the changes in plate current are not symmetrical with respect to the value when no a.c. input is applied, the average value of plate current is different, and the plate milliammeter needle jumps about if this average value changes rapidly. The relative amount of plate current change, and whether it decreases or increases from the steady d.c. value with no input, depends upon the fixed C bias, so that we can make the complete unit, tube and meter, into a sensitive indicator of small a.c. voltages if we choose the plate and grid voltages correctly.

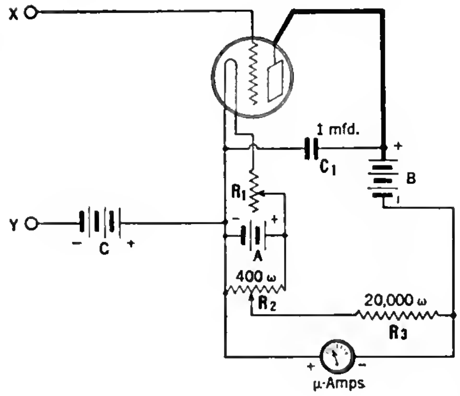


FIG. 2

Here is the circuit diagram of the vacuum-tube voltmeter described in this article. The additional apparatus not shown in Fig. 1 constitutes a bucking-voltage device to keep the normal plate current out of the microammeter and, of course, the filament battery and rheostat

The vacuum-tube voltmeter, then, consists of a tube so biased that input a.c. voltages cause large changes in average d.c. plate current. To make it into a calibrated meter, one merely places known a.c. voltages on the input, reads the plate current change, and plots a curve (typical curves are shown in Fig. 4). The purpose of the bypass condenser, C_1, shown in Fig. 1, is to improve the rectifying or distorting property of the tube.

To prevent the device taking power from the source being measured, the C bias must be great enough that input peak voltages do not make the grid go positive at any time. In practice the bias is such that the normal d.c. plate current is very near zero; this near-zero current is prevented from going through the microammeter by a "bucking" voltage secured from a battery or a potentiometer across the A battery, as shown in Fig. 2. The high resistance prevents shunting the meter with the potentiometer. The reason for preventing the normal d.c. plate current going through the meter is so that the latter's range will not be limited by having to register both the normal current and the current produced in the process of measurement.

Any type of tube may be used. For convenience, the small 199 type tubes are used in the Laboratory, and should be used with the voltages specified here.

One simple form of vacuum-tube voltmeter used in the Laboratory is shown in the photograph on page 221 and another type, housed in a Ware radio cabinet, on page 223. The microammeter in the first picture (that at the top of page 221) is a Westinghouse instrument Model PX and has a maximum range of 200 microamperes. It is also possible to obtain this model with a full-scale deflection of 500 microamperes. These are particularly good instruments for this work, since the scale length of four inches makes it easy to read accurately, and the little button at the left, when pushed, removes a shunt which protects the meter from overload. In other words, the meter is always protected until one pushes the button, and in a vacuum-tube voltmeter of the type described here, this is a very valuable feature.

The two Westinghouse meters list at about $35. Weston makes a model 301 meter in two ranges which are suitable for tube voltmeters, one with a full-scale deflection at 200 microamperes listing at $33 and another, a 1-milliampere (1000 microamperes) meter at $12. Jewell makes similar instruments at about the same prices. In the photograph on page 223 a Weston 1.5-milliampere (1500 microamperes) meter is shown.

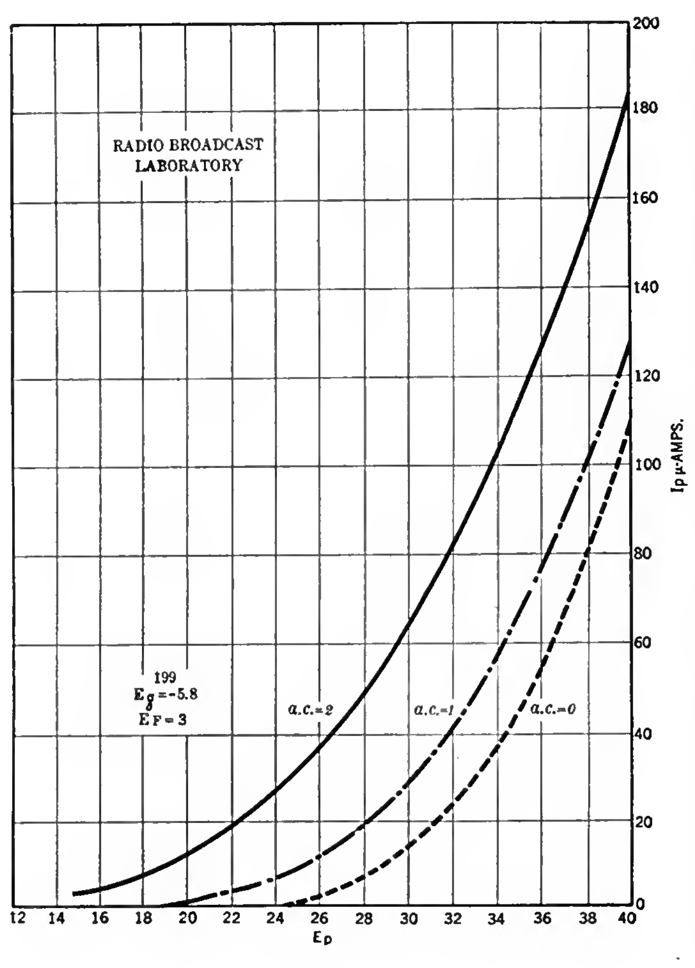


FIG. 3

Some calibration curves. Each curve was made with a different a. c. voltage input. Note how rapidly the plate current increases with small increases of plate voltage

CONSTRUCTION OF THE VOLTMETER

THE photograph on page 221 shows how simple the vacuum-tube voltmeter may be. The small single-pole double-throw switch at the left is used to short the input by connecting the grid directly to the negative post of the C battery when circuits to be measured are being set up. There is no need to place the apparatus in such a small space as shown in this photograph, although the grid lead between voltmeter and external apparatus under test must be as short as possible, and well protected from other leads carrying a.c. voltages.

A list of the apparatus used in the voltmeter shown in Fig. 2 follows. Any of these parts may be substituted by others that are well made, and none of the values of resistance, etc., are critical.

One Tube Socket.
R_1—30-Ohm Rheostat.
R_2—400-Ohm Potentiometer.
R_3—20,000-Ohm Resistance.
C_1—1-Mfd. Bypass Condenser.
One S.P.S.T. Switch.
7—Clips (or Binding Posts).
One Binding Post, Insulated from the Baseboard.
Microammeter.

The experimenter who builds such an a.c. voltmeter for the first time must remember that he has in the circuit a very sensitive and, therefore, expensive meter, namely, the plate current reading device If the grid circuit of the tube is left open, or if any one of several accidents happen, the meter will be blown up, and all experiments will terminate in an abrupt and disheartening manner. Every step in the construction, calibration, adjustment, and operation must be watched with great caution, and adjustments should be made only after due deliberation of what will happen once the proposed adjustment is carried out. After the experimenter becomes familiar with his apparatus, he will be able to proceed rapidly from calibration to operation, and to have such a feeling for his instrument that he can predict what each change in voltage, etc., will produce.

CALIBRATION

THE first job after the assembly of the vacuum-tube voltmeter is the calibration process. This is a fairly simple operation and need not be baulked at by the experimenter with average experience in handling measuring instruments. Before starting, bear in mind that too much current in the plate circuit of the tube will ruin the meter; so every step should be proceeded with gradually and with the utmost care.

But before the actual calibration is started, we must decide upon the voltage of the C and B batteries in the voltmeter circuit itself (the A voltage is, of course, that recommended by the manufacturer of the tube used). We are assuming in these experiments that a 199 type tube will be used. The microammeter should not be connected in circuit until the potentiometer switch arm is thrown as far as possible towards the negative end or, preferably, a small piece of paper should be slipped under the movable contact to insulate it from the wire beneath. This prevents any of the voltage across the potentiometer, due to the filament battery, flowing through the microammeter until needed. Since this current is backwards with respect to the meter, it may damage it until some plate current flows. Now adjust the filament rheostat until the voltage is normal.

Before proceeding further, we will test the circuit to see that everything is satisfactory (the actual calibration has not yet begun). We short-circuit the input to the tube by connecting together points X and Y, Fig. 2. Assuming that the microammeter has been connected in circuit and that the B and C batteries are of satisfactory value, a current will flow in the plate circuit and will be indicated by a deflection of the meter needle. The value of this current is dependent upon the voltages of the B and C batteries. Thus it will be seen that the value of these batteries is all important for if they are of such value as to give a larger plate voltage than the microammeter can indicate, it will be at this point that the abrupt and disheartening termination of experiments will occur. Do not, therefore, play about with different values of plate and grid voltages unless you know just what you are doing.

With a 199 type tube, we recommend that the B voltage be 45 and the C voltage be 9 to start with. Under these conditions a reading of 6 microamperes was obtained in experiments in the Laboratory. Fig. 3 shows some typical curves which were obtained in the Laboratory. They were obtained with a 199 type tube using a grid bias (Eg) of 5.8 volts and a filament voltage (E_f) of 3. Of the several curves shown, only that marked A.C.=O interests us at the moment. The term A.C.=O indicates that there is no alternating-current input to the vacuum-tube voltmeter (in other words, X and Y are shorted. See Fig. 2). We note in the curve A.C.=O how rapidly the plate current increases with small increases in plate voltage. At 40 volts plate potential (Fp), for example the plate current (Ip) is 110 microamperes (μ Amps.). If with, say, forty volts plate potential, we *increased* the grid voltage, the plate current would decrease. The other curves in Fig. 3, incidentally, show the effect of placing an a.c. input across the terminals X and Y; in other words, they represent microammeter deflections due to the sum of the normal plate current and the current caused by input a.c. voltage.

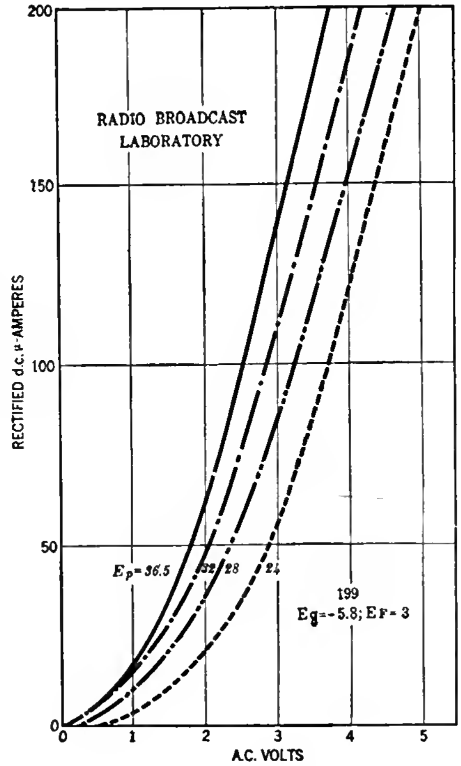


FIG. 4

Here are some typical calibration curves. The deflections of the microammeter needle caused by various a.c. input voltages are plotted, together with the effect of increasing the plate voltage (Ep) for a given value of C bias (Eg)

We have digressed a little to go into a brief explanation of the curves in Fig. 3. We had previously arrived at that point where it was recommended that the experimenter use 45 volts B battery and 9 volts C battery. Under these conditions, it was stated, a plate current of 6 microamperes was obtained in the Laboratory. Do not expect, however, to get a similar reading. Every tube will vary. It is quite possible that you will get no reading whatsoever. Perhaps the reading will be higher than 6 microamperes. Should there be no reading on the microammeter, slightly reduce the C voltage until a reading of a few microamperes is apparent. It is quite possible that a C battery quite a little smaller than a 9-volt one will ultimately be used, but the large value is recommended for safety's sake. The larger the C battery the smaller the plate current and, therefore, the greater the margin of safety.

Suppose that we have adjusted our batteries and have obtained a reading of 10 microamperes. We are satisfied that everything is working as it should, and take the next step, which is to balance out this 10-microampere reading. If we do not balance it out it will always be present when we are measuring a.c. voltages applied across X and Y and, therefore, the microammeter will not be used to its full advantage. That is to say, if the meter is always indicating 10 microamperes with no input across X and Y, its range will be reduced when an a.c. voltage *is* applied. True indeed, with a 200-microampere meter this 10 microamperes only represents one fiftieth of the whole scale, but possibly the combination of B and C voltages used will give a greater plate reading, perhaps 50 microamperes (such a high value would not be probable with a 199 tube and 45 volts B and 9 volts C), which certainly should be balanced out. The balancing out is accomplished by removing the piece of paper which we previously slipped underneath the potentiometer arm and adjusting the latter—slowly—until the needle on the meter reads zero. Some experimenters prefer their meters to indicate a few microamperes current when there is no a.c. input across X and Y so that any possible back deflection of the needle will not harm the meter.

The actual calibration of the instrument is our next job, and it is not an extremely difficult

Radio Broadcast Photograph

A VERY COMPLETE VACUUM-TUBE VOLTMETER

The complete instrument may be dressed up to look like this if you do not care for the breadboard layout shown in the photograph on page 221. Voltmeters to read the B and C potentials are included one. Fig. 4 shows four typical calibration curves made with different values of plate potential. After one has become familiar with the vacuum-tube voltmeter described here, the voltages may be adjusted and all kinds of different curves obtained.

For the process of calibration, some known source of a.c. is necessary.

A fairly accurate calibration may be made by using one of the many step-down transformers that are now being used to supply filament voltage to a.c. tubes. With the primary connected to the 110-volt a.c. house supply the secondary voltage from one of these units will give several points on a perfectly good calibration curve. For example, a transformer which supplies filament power to a receiver using 226, 227, and a power tube, has the following voltage taps available: 5, 2.5, 1.5, 0.75. These voltages can be added to or subtracted from each other by connecting the windings to aid or to buck each other. Fig. 5 shows the complete vacuum-tube voltmeter with the accessory equipment for calibrating it. If, during calibration, but before the maximum known voltage to be applied across X and Y has actually been applied, the microammeter needle is dangerously near the maximum deflection point, it will be necessary to increase the C bias and commence the calibration again.

Vacuum-tube voltmeters can be calibrated by any Laboratory at small cost and it is probable that the constructor can procure such a calibration near-by. The reader should remember that the tube which is to be used should be sent with the instrument and that the whole unit should be very well packed.

The calibration of the instrument is practically independent of frequency, so that the experimenter can compare voltages in circuits operating at audio, intermediate, or broadcast frequencies. He can measure the voltage step-up in an audio transformer or amplifier, or the output of two radio-frequency amplifiers, or plot the resonance curve of an intermediate frequency stage.

It will be noted that the input of the tube looks directly into the device whose terminal voltage is being measured. If d.c. flows through this device, it will be impressed across the input to the voltmeter and ruin either the calibration or the plate meter, or both. Some means, such as that shown in Fig. 6, must be provided for isolating the voltmeter from d.c. potentials existing in the circuit under measurement, when, for example, the output voltage of a resistance-coupled amplifier tube is being measured. With this arrangement the short-circuiting switch shown in the photograph on page 221 may be omitted, since the grid is always at a safe d.c. potential with respect to the filament. Frequencies in the same range, that is, all audio tones, or all frequencies in the broadcast band, will give similar calibration curves.

If the experimenter has no means of calibrating his instrument, he is not so unfortunate as might be supposed. He may make use of the fact that the deflections of the microammeter are roughly proportional to the input a.c. voltages squared. Thus he may get two deflections representing the gain, say, of two amplifiers. He need not know the actual voltages provided he knows roughly how much greater one is compared to the other. All he needs to do is to divide one deflection by the other and extract the square root. This will be the ratio of the voltages.

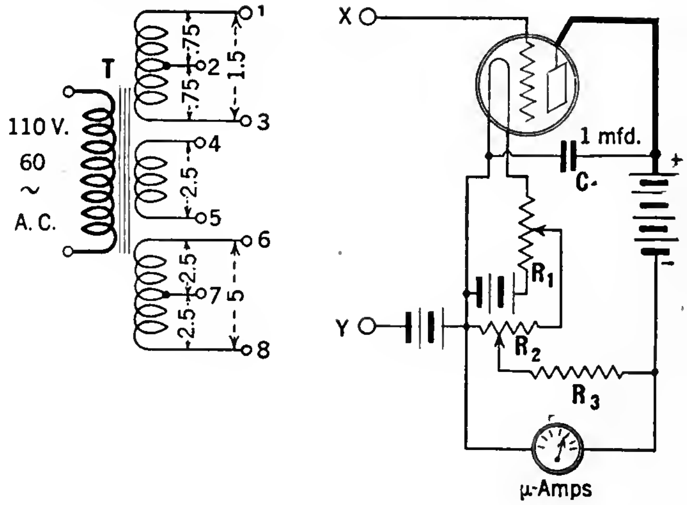


FIG. 5

A suitable set-up for calibrating the vacuum-tube voltmeter. T is a transformer which is used with a.c. tubes and, therefore, has several taps on the secondary. Thus several known voltages may be obtained, and these plotted as a graph, similar to Fig. 4

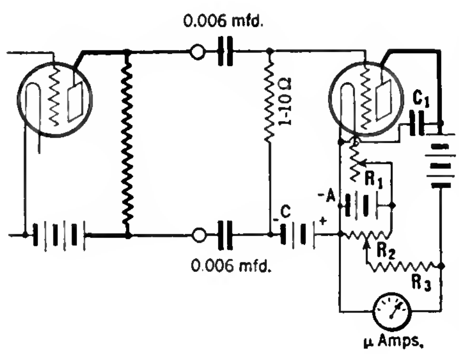
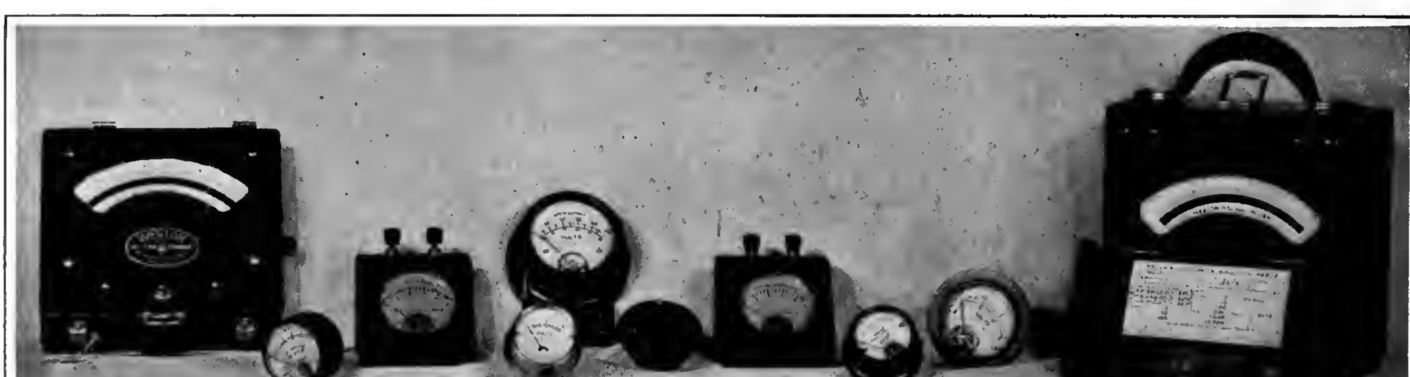


FIG. 6

When the vacuum-tube voltmeter is used to measure an a.c. voltage across the terminals of which is also a direct-current voltage, some means must be employed to prevent this d.c. from getting on the grid of the tube. Condensers as shown here will accomplish this. The diagram shows measurements being made on a resistance-coupled amplifier

The home constructor should be warned again to carefully watch every step when experimenting with the vacuum-tube meter and to be very careful of the microammeter. One mistake and the meter is gone. Always, at the conclusion of an experiment, remove the meter from the circuit first.

Those who wish to read further about the vacuum-tube voltmeter will find a most interesting and instructive series of articles in the English paper, *Wireless Experimenter and Wireless Engineer*, for October and November, 1926. Part of this material was republished in this country in *Lefax* leaflets in February, 1927, and forms the best background for the serious student of this instrument. It is possible to purchase from the Cambridge Instrument Company, of Ossining-on-Hudson, New York, a vacuum-tube voltmeter calibrated and "ready to go." It is a beautiful instrument, although somewhat expensive. The owner, however, may rest assured that he has the best possible apparatus for measuring small a.c. voltages, radio-frequency currents, the gain of his amplifiers, both audio and radio, and for the performance of a hundred valuable experiments.



Radio Broadcast Photograph

SOME METERS USED IN THE LABORATORY

The vacuum-tube voltmeter, although an invaluable asset to the Radio Broadcast Laboratory, by no means holds a monopoly in usefulness. Here are just a few of the dozens of meters always in use in the laboratory. Included are instruments by Weston, Sterling, Jewell, Dongan, and Hoyt

RADIO FOLK YOU SHOULD KNOW

I. RALPH H. LANGLEY

Drawing by Franklyn F. Stratford

RALPH H. LANGLEY, Assistant to the President of the Crosley Radio Corporation, and, in that capacity, manager of most of the operations carried on by the Crosley interests, was born in New York City on January 5, 1889. As this article goes into print he is, therefore, still two years short of the forty mark. By training, and probably by primary inclination, he is an engineer, but his vision has never been limited to screw-heads and tuning knobs; of late years he has become increasingly an executive figure. An administrator of thirty-eight would be considered very young in most lines of business, but in the radio industry there are a number of them. The fact is that no one can have more than thirty years or so of radio experience, and only a handful of men can point to anything like that. The twenty-year candidates, even, are few. In the case of all such veterans, the early years of experience have a value which is mostly sentimental, for the modern structure of the industry, with its complexities of mass production and public relations sprang up suddenly after the war. Mr. Langley's years of contact with the radio art amount to about nineteen, or half his age, which is quite enough in a field where the race is to the swift rather than the old.

Mr. Langley was born in New York City and lived there until 1916. His boyhood residence was near Morningside Park, under the hill on which the buildings of Columbia University were being erected. Young Langley, gazing at the newly created campus, formed an ambition to drink of knowledge at that fountain, but, as yet, he did not see how the project was to be financed. After finishing his elementary school course, however, he went to De Witt Clinton High School, 1904–1908, and towards the end of his secondary school course succeeded in winning a scholarship which enabled him to enter Columbia.

During the following winter, Mr. Langley's father died, and the son gave up college to take a position with the New York and Queens Electric Light and Power Company. But at Columbia, in the college "Wireless Club," the radio virus had already got into him, and in May, 1910, at the invitation of Emil J. Simon, he turned from electric power to work in Dr. Lee DeForest's laboratory at Park Avenue and 41st Street, where many strange wonders were being performed. Here he met Frederick A. Kolster and other men now prominent in the radio industry of to-day, which had its feeble and often abortive beginnings in just such laboratories. In those early days the courage of the workers made up for the scarcity of good milliammeters. A half year in DeForest's laboratory probably did Langley good, but a school teacher friend, James F. Berry, who had advised him before, now convinced the young man that he would be heavily handicapped in his later career if he did not complete his university course while there was still time. Mr. Langley took the advice and went back to college in the fall of 1910, repeating the sophomore year. But he did not give up radio. The summer of 1911 he spent working with E. J. Simon once more, this time for the International Wireless Telegraph Company (wasn't it the National Electric Signaling Company then?) at Bush Terminal in Brooklyn. Here he met S. M. Kintner, now in charge of the research activities of the Westinghouse Company. The summer of 1912 found him with the Wireless Improvement Company.

Mr. Langley graduated from Columbia University as an Electrical Engineer in 1913. Edwin H. Armstrong was one of his classmates, and

RALPH H. LANGLEY

Michael I. Pupin one of his professors. Professor Arendt, another of Langley's preceptors, had a poor opinion of the wireless game, and advised the young engineer to stay out of it, but Langley promptly joined the Wireless Improvement Company once more.

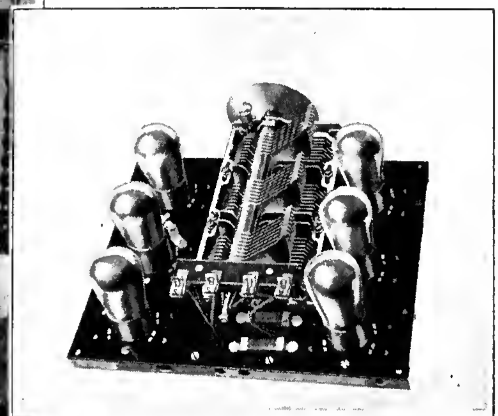
During the three years Mr. Langley put in with the Wireless Improvement Company, then under the guidance of Colonel John Firth, most of his work was with various types of 500-cycle quenched spark transmitters. The $\frac{1}{2}$ kw. submarine transmitter was one of his early design jobs. Mr. Langley's interests were not, however, confined to commercial matters. He had joined the Institute of Radio Engineers as an Associate in 1912, and in 1914 served as Assistant Secretary. In 1916 he was advanced to the grade of Member of the Institute. In that same year, at the invitation of David Sarnoff, he joined the engineering staff of the Marconi Company, and went to work at the Aldene factory, of which Adam Stein, Jr., was Works Manager. Roy A. Weagant was Chief Engineer of the Marconi Company during the period of Mr. Langley's connection with the firm. The Marconi Company was handling war-time orders, principally for the armed forces of the United States. In 1917 the plant was greatly enlarged, and, running on three shifts twenty-four hours a day, must have employed in the neighborhood of one thousand men. New types of quenched spark transmitters were designed for submarine and aircraft use. In the meantime the manufacture of the standard Marconi marine transmitters and receivers, with auxiliary apparatus, such as Leyden jar condensers, had to be continued, and in the shops one would see standing side by side models of Naval receivers of the SE Types, with their heavily-varnished bank-wound coils, the older Type 106 tuners in their black cases, and cheap little cargo receivers which looked as if they had just come out of the five-and-ten cent store. But Mr. Langley's concern at this time was with the transmitters, so much so that, in 1918, one of them almost ended his career. This distinction would have gone to the 250-watt aircraft transmitter, equipped with the General Electric pliotrons of the same rating. During one of the tests of the transmitter, Langley, having shut off the filaments of the tubes, reached in and grasped a plate terminal, forgetting that the 1500-volt supply was still on. "That particular set never worked again," states Mr. Langley laconically. "and it was some time before I did." There was evidently nothing wrong with his heart. After the completion of the development work on the sets, he made test flights with them from the air base at Norfolk, Virginia. "But none of these sets was ever used in France," the designer adds, somewhat sadly. The answer to that is that few of the airplanes ever got to France either.

In 1920, the Radio Corporation of America having been formed, the radio engineering and manufacturing activities of the Aldene factory were transferred to the General Electric Company's plant at Schenectady. Adam Stein Jr. became Managing Engineer of the Radio Department there, and Langley was assigned to the Receiver Section, later to become the Engineer-in-Charge thereof. Practically all the broadcast receivers turned out by the General Electric Company have contained one or several of Langley's inventions and design features. Working with Messrs. Carpenter and Carlson, Mr. Langley was responsible for the production of the first Radiola super-heterodyne models, incorporating the sealed "catacomb" construction and the divided cabinet. He spent seven years at Schenectady, leaving for his present executive position with the Crosley Company on February 1, 1927.

During the last three years, Mr. Langley has been much interested in the work of the radio manufacturers' associations. He was vice-chairman of the Radio Section of the Associated Manufacturers of Electrical Supplies, and later, when that body was merged with the National Electrical Manufacturers Association, became Chairman of the Committee on Section Activities in the Radio Division. He also served, in 1926, on the Standardization Committee of the Institute of Radio Engineers.

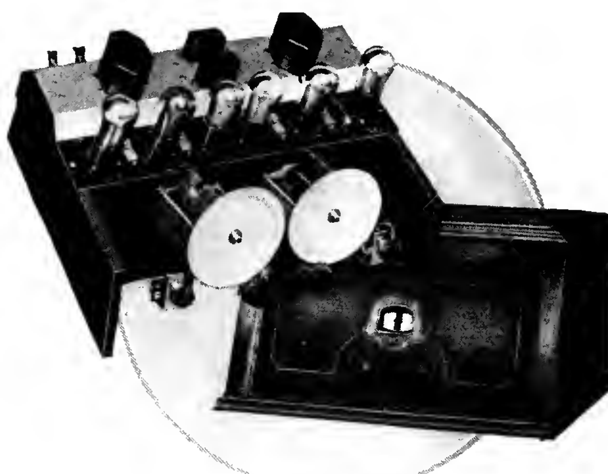
With his years of experience in radio manufacturing and organization, and his wide acquaintance among radio men, Mr. Langley believes that the next two years will witness remarkable progress in the industry. He points out that many lines of progress have been almost completely blocked until the present season. With patent difficulties largely resolved, notable progress in standardization, adequate Federal control of broadcasting, and the development of exact methods of measurement and quantity production, the economic stability of the industry should approach that of more settled branches of business. Mr. Langley has contributed more than his share in the progress of radio toward that goal.

Some Fine Receivers



THE "HIAWATHA"

An attractive six-tube receiver by Mohawk, Chicago. As the chassis picture shows, there are six tubes. The three tuned stages are adjusted by means of a single tuning knob. The chassis depicted is standard in several Mohawk receivers, which range in price from $67.50 to $275.00 for battery operation. For a. c. operation, add $110.00 to the above prices. The retail price of the "Hiawatha" is $165.00. It has a built-in pyramid form loud speaker, for which very excellent reproducing qualities are claimed



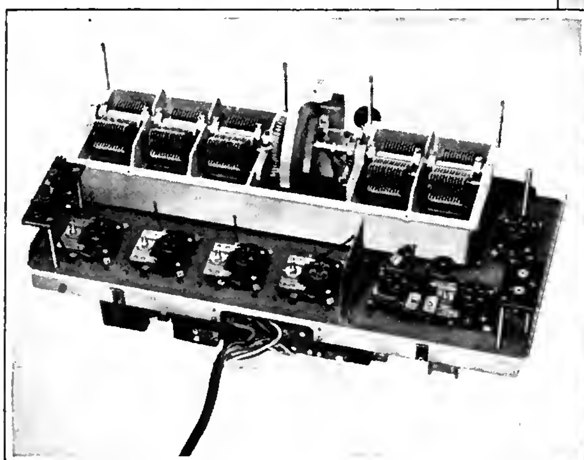
FOUR TUNED STAGES

Are incorporated in this six-tube receiver by Bremer-Tully. The "Counterphase" 6-35, to give the receiver its exact name, will delight the advocates of two-dial tuning, for the condensers are arranged in two units of two, and are, therefore, controlled by two knobs on the front panel. There are separate controls for sharp tuning and volume. This new "Counterphase" retails at $110.00. A console model sells for $165.00

'GRANADA" CONSOLE

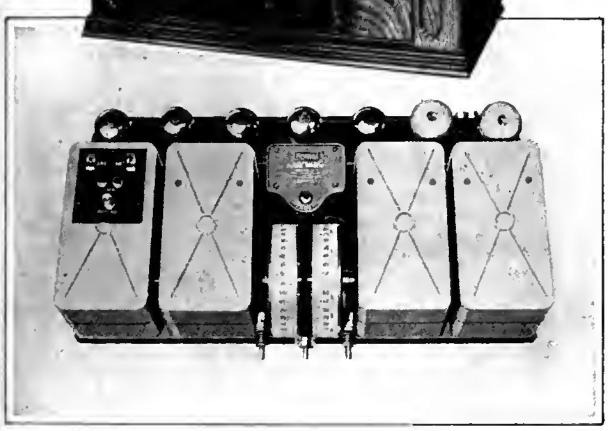
By Electrical Research Laboratories ("Erla"), of Chicago. The finish is of dark antique walnut combined with birdseye maple. The drawer front is of satinwood with maple overlay. The chassis comprises the equipment for four r.f. stages (three of which are tuned), detector, and two transformer-coupled audio stages. Tuning is accomplished by means of a single dial, and there is a built-in loud speaker. Price $295.00. Furnished with an a.c. converter system, all tubes, and an output filter, price $395.00

and Their CHASSIS



BOSCH, MODEL 57

Here is an interesting receiver typical of the progress of recent years—an example of the modern self-contained installation. The price, $440.00, is not excessive when we consider that the receiver is designed for socket-power operation, has a built-in loop, and also includes a loud speaker of advanced design. This price is reduced to $340.00 if the socket power feature is not desired. The single station selector, which adjusts five separate variable capacities, is graduated in kilocycles



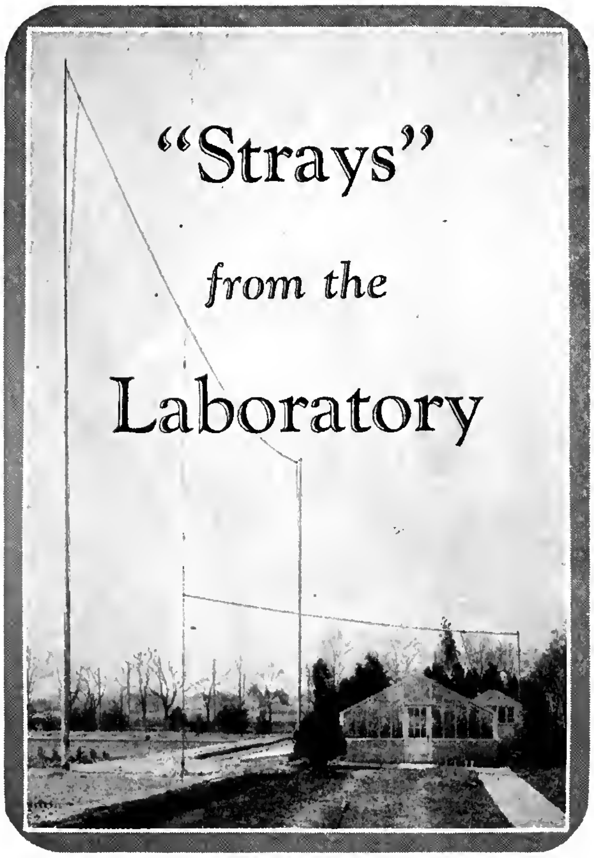
THE FADA 7

Another receiver employing four stages of r.f., but two tuning controls are used with this model. A loop is supplied with the Fada 7 although an outside antenna may be used successfully. The loop fits into a special clamp on the side of the cabinet. The two audio stages are transformer-coupled. A special arrangement in the detector circuit reduces the possibilities of overloading. Price, $185.00

AMRAD'S THE "BERWICK"

A popular six-tube neutrodyne type circuit, employing four tuned stages and single-control tuning. As the chassis illustration shows, complete shielding is featured. A cone loud speaker is built into the "Berwick," which, partly due to the special Amrad tone filter, gives remarkably good quality of reproduction. The price is $195.00

"Strays" from the Laboratory



How Reliable Are Short Waves?

Recent experiments of the General Electric Company, of engineers from other companies, and of those interested in private research, have resulted in an explanation of many of the mysteries that have surrounded the short waves. Everyone marvels at the ease with which amateurs communicate with fellow enthusiasts over great distances with small input powers. We have done it ourselves—communicated and marveled both—and great is the "kick" thereof. It is undeniably thrilling to take from one's lamp socket 60-cycle power of less than one fifth that required to heat the average electric iron, and to feed it into a comparatively simple system of apparatus from which it emerges as radio-frequency energy with which we actually ask a man in South Africa how the weather is there, all the time sitting quietly in our den surrounded by unimposing gear. When it is winter in New York it is summer in South Africa, when day here, it is night there, and so on. It is one of the marvels of our time that two people in the security of their homes but separated by 7000 miles can transfer their thoughts instantaneously and economically.

Just how good are these short waves? How reliable is communication? How many hours of the day, how many days of the year, can we send messages via short waves from New York to South Africa?

The results of several investigations point to the following facts which seem fairly well established. Ten meters (30,000 kc.) is probably the shortest useful wavelength. Below about 20 meters (15,000 kc.) the waves prefer to travel in the daylight, and above that wavelength, night time is the best. Below about 45 meters (6660 kc.) curious "skip distances" occur, resulting in regions beyond which signals are heard but within which they are inaudible. For example, on 15 meters (20,000 kc.) during daylight, transmission is not practicable within a distance of 900 miles, which increases to about 1000 miles at night, although it is possible to transmit signals for reception at points more distant than these figures indicate. At 27 meters (11,000 kc.) the daytime skip distance has been reported as 1000 miles and 450 miles at night, these distances being about the same at 33 meters (9086 kc.).

The General Electric experiments show that the 32.79-meter wave is no good at all for short distances. A power output of 500 watts on 65.16 meters (4500 kc.) will, however, transmit commercial daytime signals up to 100 miles.

Short waves seem necessary for extremely long-distance communication. During daytime, waves of the order of 20 meters should be used; waves below about 45 meters are not much good for short-distance work.

Night after night we have heard NAA on 37.5 meters pound away at a terrific rate, we have listened to the Marconi beam stations on 26 meters, AGA at Nauen, Germany, FW in Paris, and others, all bent on getting somewhere in a hurry, and we wonder how soon it will be before the band between 25 and 45 meters is as busy as the long-wave channels. Amateurs in this country who have a channel 1000 kilocycles wide around 40 meters have been blessed with an excellent assignment which at the time it was doled out was thought to be more or less worthless. More and more amateurs are going to 20 meters and with low powers are accomplishing unheard of records in broad daylight. They have not as yet the feeling for this band and for conditions existing there that they had for the 40-meter band, but it will come when they gain the wealth of experience they have amassed on the longer wavelength band.

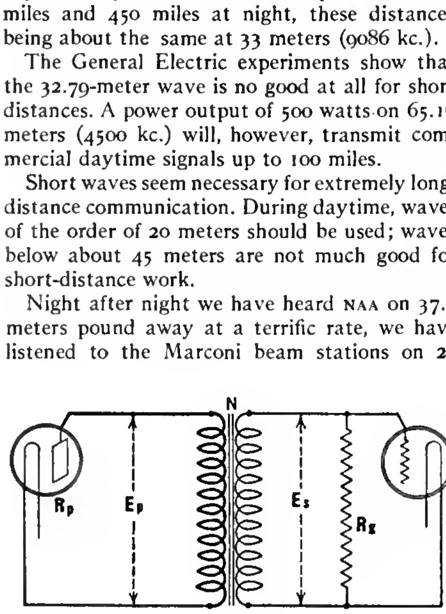


FIG. 1

Mathematics of the Audio Transformer

In most radio work the mathematics is fairly simple; the difficulty comes when it is necessary to put the mathematical theory into practice. For example, the following mathematics is that underlying the theory of the input transformer for audio-frequency amplifiers. The circuit about which this theory is built up is given in Fig. 1, and its equivalent is shown in Fig. 2. In this mathematics, N is the turn ratio of the transformer.

$$Es = NEp = Ig\ Rg$$
$$Ep = \mu Eg - Ip\ Rp$$
$$Es = N\ (\mu Eg - NIg\ Rp)$$
$$Ig\ Rg = N\ (\mu Eg - NIgRp)$$
$$Ig = \frac{N\mu Eg}{Rg + N^2Rp}$$
$$\text{Whence } Es = \frac{Rg\ N\mu Eg}{Rg + N^2Pp}$$
$$= \frac{N\mu Eg}{1 + N^2 = \frac{Rp}{Rg}}$$

Differentiating this equation with respect to N and solving for a maximum, it is found that:

$$N^2 = Rg/Rp$$

and substituting this into the equation above for Es:

$$Es = \frac{\mu Eg\ N}{2}$$

All of this assumes that the transformer is perfect, i.e., no d.c. resistance, no magnetic leakage, infinite primary and secondary reactance. It shows that under these conditions the voltage delivered to the input of the tube is one half that delivered to the previous tube multiplied by the turns ratio of the transformer and by the amplification factor of the previous tube.

If the input impedance is one megohm, 1,000,000 ohms, and the plate impedance of the previous tube is 12,000 ohms, the turn ratio will be equal to the square root of the ratio between these two quantities, viz:

$$N = \sqrt{\frac{1,000,000}{12,000}} = 3 \text{ approximately}$$

In order that a large percentage of the a.c. voltage developed in the plate circuit of the previous tube be available across the primary of the input transformer, the impedance of this transformer must be high. If we want to amplify well at 100 cycles, the input impedance should be not less than 30,000 ohms which means that the primary should have no less than 50 henries inductance—which in turn explains why transformers, good ones, cost money, and why a skinny little affair with a few sheets of iron in the core and a little wire on the primary makes radio music sound "something fierce."

Furthermore, if the turn ratio is three, and the inductance of a winding varies as the square of the turn ratio, the secondary inductance must be about 450 henries—and when anyone states that the secondary of an audio transformer makes a good output choke he neglects the fact that one cannot wind up an inductance of 450 henries without adding enough d.c. resistance to prevent the last tube from getting any plate voltage at all.

MATHEMATICS OF THE OUTPUT TRANSFORMER

The mathematics of an output transformer design is no more difficult than that of the input transformer—and the answer is the same, as the following rigamarole proves. The symbols used in this discussion are the same as for the input transformer. N is the turn ratio of the transformer, and instead of Rg we use Rs.

$$Is = \frac{Es}{Rs} = \frac{NEp}{Rs}$$
$$Ep = \mu Eg - IpRp$$
$$Ip = \frac{\mu Eg}{Rp + \frac{Rs}{N^2}}$$
$$\text{Whence } Is = \frac{N}{Rs}\left(\mu Eg - \frac{\mu\ Eg\ Rp\ N^2}{N2\ Rp + Rs}\right)$$
$$= \frac{N\mu Eg}{N^2Rp} + Rs = \frac{N\mu Eg}{\sqrt{2}\ (RpN^2+Rs)}$$

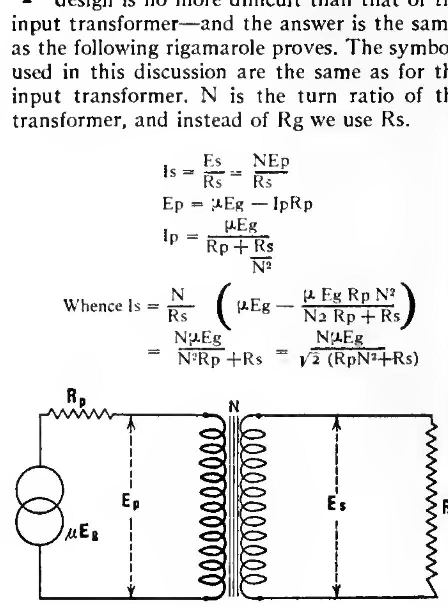


FIG. 2

Differentiating this expression with respect to N and solving for a maximum,

$$N^2 = \frac{Rs}{Rp}$$

$$\text{And } Is = \frac{\mu Eg}{2\sqrt{RpRs}}$$

$$\text{whence power in } Rs = I_s^2 \, Rs = \frac{\mu^2 Eg^2}{8\,Rp}$$

If the speaker Rs is in the plate circuit of the power tube without the output transformer, and if the impedance Rs equals Rp the power will be as indicated above, showing that the transformer is indeed an impedance adjusting device and that it is possible to secure maximum power in a load impedance which is not equal to the tube impedance provided the output transformer has the proper turn ratio.

A little consideration will show that if the primary impedance of this transformer is equal to the tube impedance and if the secondary impedance is equal to —"matches," is the usual word—the load impedance one half the voltage existing in the plate circuit will be expended in heating the plate. It is obvious, then, that the primary impedance again should be several times that of the tube impedance, but since the final tube has a low impedance, the UX-171 (CX-371) type for example has an impedance of 2000 ohms, a manufacturer of transformers needs to put nothing like the impedance in his output transformer primary that he puts into an input transformer. Likewise the secondary impedance must be high compared with the load, or speaker. As long as the turns ratio is proper, energy will be transferred from the tube to the speaker with a minimum loss, and for all practical purposes the output transformer may be neglected in calculations.

High-Powered Bunk

SOME OF RADIO BROADCAST'S readers are technically inclined, and must enjoy the monthly battle of wits among radio advertising writers whose "eulogies" appear in many radio publications. We saw recently a new loud speaker advertised which consisted of a "tone column of new design; by means of a scientifically designed tone distributing chamber a forced crossing of sound waves is accomplished, and a divisional tone chamber of unique design segregates high and low tones, reproducing both with equal facility." Bell Laboratories engineers should take notice of this new scheme for attaining perfect fidelity, and should forget all about loud speakers which will look like a pure resistance to a power tube at all frequencies. All that is necessary is to segregate the low voice from the high one and then re-combine them. Presto!

There is also a new antenna that promises much, for, according to a widely circulated advertisement, it meets the need of radio users, whether for small or large sets. It has been thoroughly tested for over two years under all kinds of conditions and on many kinds of sets. In every set, it has proved its many advantages:

1. Easy to put up or take down.
2. Picks up waves in any direction because it is round.
3. Proven more selective.
4. Greater volume.
5. Greater distance.
6. Helps eliminate static.
7. Small and compact.
8. Neat in appearance.
9. Low in cost—only $7.50.

What more could anyone want?

This kind of bunk is not only confined to the advertising pages of the media in question, sadly to recount. The following passages are quoted from a recent article describing a new and revolutionary receiver that anyone can build for about twice as much as he would have to pay for a well known and thoroughly engineered set.

"Its volume is due to the high amplification in the audio end of the circuit and to the fact that two 71 tubes in push-pull are used in the last stage."

Off hand this seems reasonable until one considers that there are three audio tubes—which furnish most of the amplification—and that there are eight tubes which precede them! It reminds us of the early days of radio when the Laboratory had its hands full weeding out the good apparatus from the poor. A receiver came to Garden City equipped with thirteen tubes, guaranteed to pick up any signal in any part of the world at any time. The total plate current of this super-receiver, including a power tube, was nine milliamperes. It seemed incredible—and was, until we discovered that eight of the thirteen tubes had no plate voltage on them. But let us continue with this totally new receiver.

"With all that amplification and power handling capacity there will be undistorted volume enough to make the welkin ring. But all of this would be merely potential volume were it not for the almost incomprehensible amplification in the intermediate amplifier. It is here where the weak signals from the remote stations are pulled from infinitesmal levels and placed on the plane of the signals from local stations. Both the amplification and selectivity could be expressed in numbers but they would be so large as to be meaningless to the human intelligence."

There you are, and five more columns of it for good measure!

THE NEW SCREENED GRID TUBE

The bulb of a "dead" UX-222 tube was broken so that this photograph of the interior construction might be taken. The RADIO BROADCAST Laboratory is expending considerable time experimenting with these tubes so that the information contained in articles in these pages might be backed up with actual experience. We can promise readers some particularly fine articles along such lines in the very near future

New Apparatus

DURING recent months, the Laboratory has received for test the following apparatus: Power units from Kellogg, Wise McClung, Valley, Universal, Briggs and Stratton, Boutin Electric Co., Sterling Mfg. Co., and Grigsby Grunow; tubes from the following tube plants, Arcturus, R. C. A., Cunningham, Supertron, CeCo, Manhattan Electric Supply Co., Connewey Laboratories, Zetka, Cable Supply Co., Televocal, Van Horne, De-Forest, and Supercraft; audio transformers from Modern, Silver-Marshall, Samson, Tyrman, Sangamo, Amertran, G. W. Walker; the new Eby sockets, a Muter double-impedance amplifier, a Pacent Phonovox electrical pick-up unit, the excellent looking Abbey receiver manufactured by Splitdorf and already illustrated in RADIO BROADCAST, a useful floor cord made by Belden which enables one to place wires under a rug without danger of tripping or of impairing the appearance of the room—the wires may carry house lighting current for a lamp, or loud speaker wires; a complete assortment of Acme Wire Co. Parvolt condensers; rheostats, etc. from Carter; a complete push-pull amplifier and B supply units from Samson, Thordarson, and General Radio; resistances for stabilizing grid circuits, for plate supply circuits, for center taps on a.c. tube circuits, etc., from General Radio, Electrad, Frost, Daven, Amsco, Gardner and Hepburn, Aerovox; and coils from Precision Coil Co.

Many other interesting pieces of apparatus have been received, previous mention of which has been precluded pending test and on account of space limitations. Among the larger items are Silver-Marshall's interesting Time Receiver, a huge and much involved horn loud speaker from Newcomb-Hawley, using a Baldwin Unit, and known as a Console Grand Reproducer, a Peerless loud speaker from the United Radio Corporation of Rochester, and a Holmes Piano loud speaker from the International Radio Corporation, of Los Angeles. The Newcomb-Hawley loud speaker has a very long air column secured by giving the neck several convolutions about the wide opening. The Peerless is an attractive loud speaker with an excellent element. Both loud speakers cover wide frequency ranges and go down particularly well.

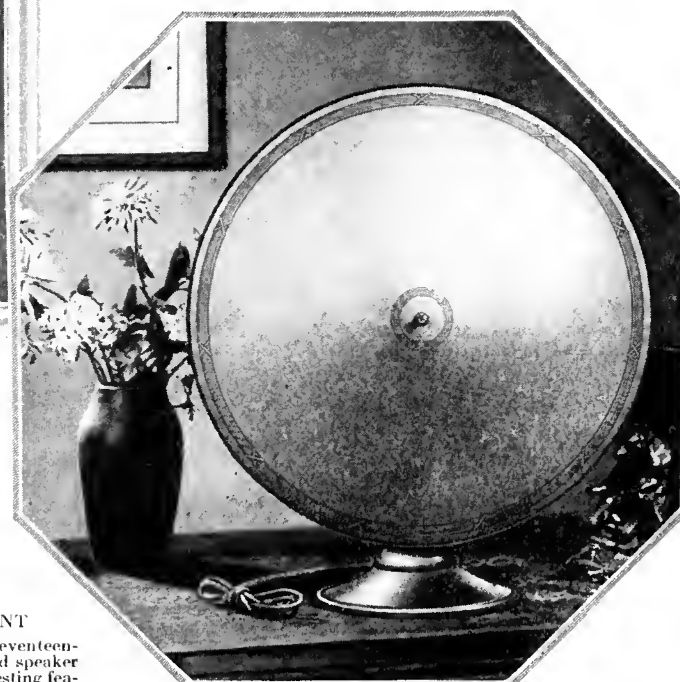
The Laboratory was especially interested to receive one of the "tuned" impedance amplifiers about which so much is heard, this one delivered by Mr. Kenneth Harkness in person, giving us the opportunity of meeting him for the first time. Frequency curves are being prepared on this amplifier, and will be ready soon.

Transformers for the new a.c. tubes were received from Amertran, General Radio, Mayolian, and Northern Manufacturing Company. New rheostats came in from Frost, Centralab, and Carter. Some large heavy-duty resistors from the Electro-Motive Engineering Corporation also made their appearance. Among the other items are new Samson apparatus, loud speaker units from the Balsa Wood Corporation, Engineers Service Company, Baldwin, Vitalitone, and Magnaphon Company, a series of new and probably very efficient inductances made by the Precision Coil Company, a "Subantenna" (is there any way of testing this antenna without digging up the garden?), two sheets of beautifully burnished copper for shielding, from C. G. Hussey & Company, of Pittsburgh, condensers from X-L Radio Laboratories, Electrad apparatus and a fine looking White socket power unit from Sioux City, Iowa.

Concomitants

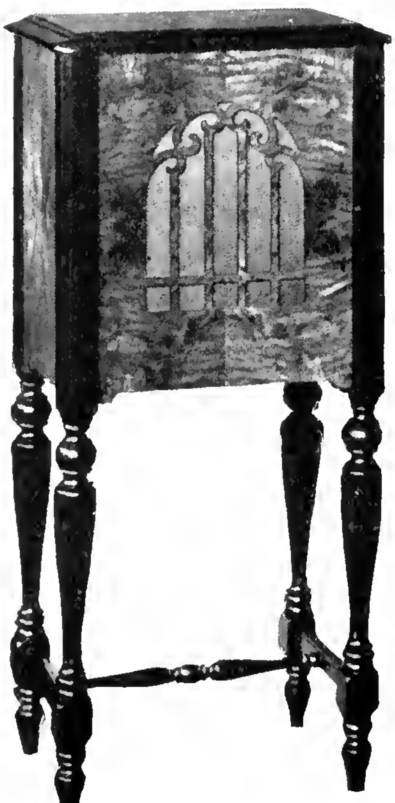
THE AMPLION "GRAND"

AS PLEASING to the eye as to the ear is this magnificent loud speaking device by Amplion. Contrary to what one might justly suppose upon first glance, the "Grand" does not use a horn inconceivably munificent in inches, but employs a combination cone and sound board. The "Grand" lists at $145.00. It is supplied with a 20-foot cord. The walnut cabinet measures 34" x 33" x 18"



BY PACENT

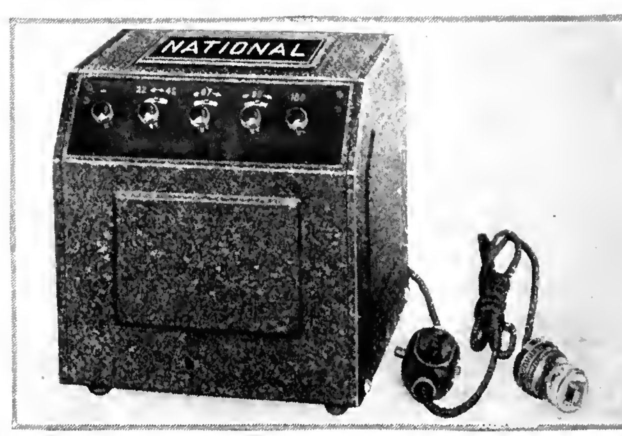
HERE is a seventeen-inch cone loud speaker with several interesting features. Its extreme ruggedness and responsiveness to weak signals are features. The manufacturer claims that this cone has a thirty per cent. greater frequency coverage and sensitivity than most of the popular model cones on the market. Price, $22.50



THE MAGNAVOX "ARISTOCRAT"

TO THE LEFT

IS A new power cone loud speaker employing electro-dynamic principles. Due to its unique construction, great volume may be handled without any possibility of rattling. An external source of direct current is necessary for operating this instrument. Either the storage battery or the electric light mains may be employed for this, depending upon which type of loud speaker is used. If the storage battery is employed, the current drain will not exceed that usually drawn by a 171 type tube. The price of the "Aristocrat" is $85.00 for storage battery operation or $90.00 for 110-volt d. c. operation



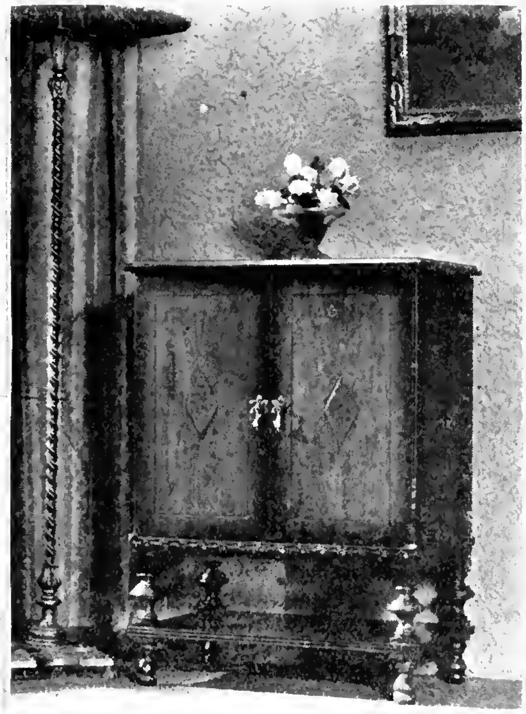
DESIGNED FOR HEAVY-DUTY WORK

THERE are four voltage taps on this new B supply device by National, three of which are adjustable. The detector voltage is from 22 to 45; the r.f. voltage, from 50-75; and the a.f. voltage from 90-135. The power-tube voltage tap delivers 180 volts. Price, with cord, switch, and plug, $40.00. Rectifier tube, $5.00

# of Good Quality

EXPONENTIAL HORNS

A GOOD exponential horn is capable of very excellent results so far as quality reproduction is concerned, and is exceptionally efficient. The Temple Console to the right employs a 75-inch exponential air column, and is priced at $65.00. The Temple Drum below also has an exponential air column and comes in two models, using 54-inch and 75-inch air columns, priced at $29.00 and $48.50 respectively

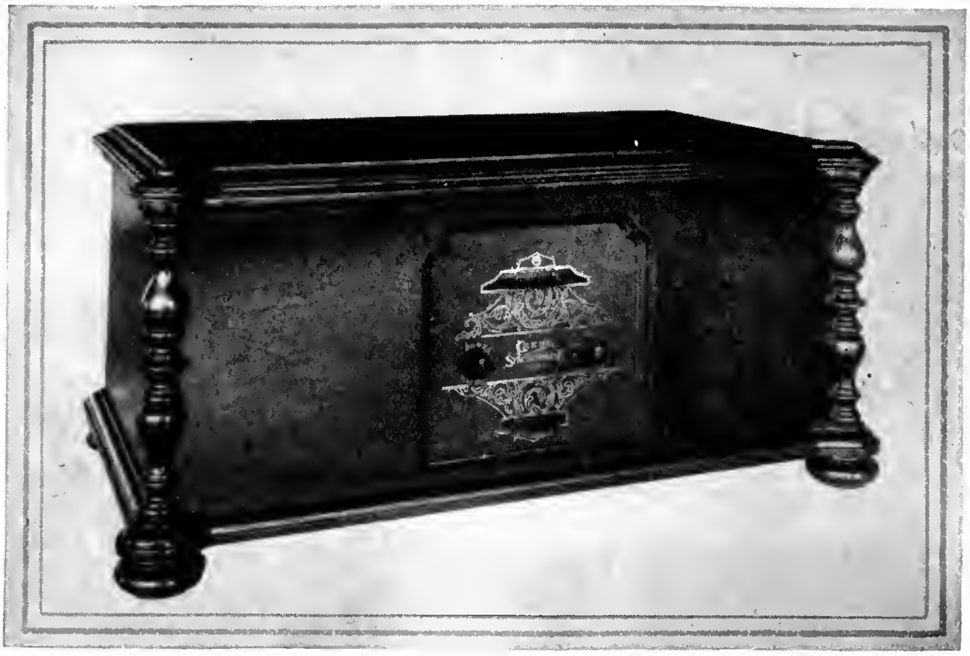


A NEW SOCKET-POWER DEVICE

TOGETHER with a relay which automatically switches the house electric light supply to the B device illustrated, or to a trickle charger, depending upon whether the set is in use or not. These devices are by Stromberg-Carlson, of Rochester, and retail at: B device, $63.00 (with tube); relay, $11.00

FOR THE PHONO-RADIO COMBINATION

THE Platter Cabinet Company, North Vernon, Indiana, is responsible for this attractive cabinet of walnut plywood, in which space is provided for a complete radio installation and a phonograph. The price of the cabinet is $72.00. The same manufacturer will supply turntable, motor (electrical or mechanical), radio receiver, electrical pick-up device, and loud speakers of many patterns to fit into the cabinet, if desired



THE GREBE "SYNCHROPHASE" SEVEN
The circuit diagram of this receiver is shown on the next page

How the "Synchrophase" Seven Was Developed

By John F. Rider

"WE REQUIRE a seven-tube receiver with single tuning control to be sold at a retail price of $135.00. Produce it."

Such, in effect, might have been the wording of a memorandum from the board of directors of A. H. Grebe to the engineers responsible for the design of the "Synchrophase" Seven. Thereupon, a tedious process of laboratory and mathematical experiment sets in, for the "cut and try" methods of "mediæval" radio days are forgotten, since present broadcasting conditions would make such procedure impracticable.

Being familiar with the congestion among stations, the transmitting characteristics of the broadcasting stations, and the power used by the stations, the radio engineering department was able to select the number of tubes to be used as radio-frequency amplifiers, decide upon the detector system, and arrive at a decision concerning the number of stages of audio-frequency amplification necessary to produce a satisfactory receiver output signal. They were aware of the operating channels used by broadcasting stations in various localities, hence they could judge if their tuning system would be capable of separating the stations and of providing radio reception without a background of interference from other stations.

This was, however, not all a matter of guess work. Such perfectly engineered radio receivers are first produced on paper, with the aid of mathematics and the "slip stick" (a nick-name for the slide rule). The amount of time put into the design of radio receivers of modern times is almost inconceivable when compared to that of six or seven years ago.

After due deliberation, the decision of the Grebe engineers was to employ four stages of tuned radio-frequency amplification, a non-regenerative detector, and two stages of transformer-coupled audio-frequency amplification. The question then arose relative to the design of the radio-frequency system. Should it be shielded or unshielded? Development carried out prior to this time resulted in the birth of a new type of fieldless inductance—an inductance which could be used in a multi-stage tuned radio-frequency receiver without fear of coil interaction. This coil, known as the "binocular" inductance, was the brain child of P. D. Lowell, and is the evolutionary development of the toroidal winding. Since this coil is fieldless, interstage shielding was unnecessary; two, three, or four stages of unshielded tuned radio-frequency amplification may, therefore, be used without worrying about excessive regeneration. Eliminate the coil fields and shielding is unnecessary, since coil interaction will not take place. The elimination of shielding means economy without any sacrifice.

The function of shielding is also to preclude direct coil pickup, but since the fieldless coil will not pick up any energy, shielding is unnecessary on this account. The binocular coil, therefore, solved several problems in the design of the "Synchrophase" Seven. The coil itself consists of two solenoidal windings mounted closely together with their axes parallel and with the two windings connected in such a manner that their electromagnetic fields are opposing each other. This means that, if one coil starts to radiate a magnetic field, the other coil simultaneously radiates a magnetic field of equal intensity but of opposite phase or direction, and the two fields combine and counterbalance each other. The result of the combined fields is zero. Hence, no reaction between the tuned transformers is evident.

The same phenomenon applies to the pickup of waves by the transformers. A voltage introduced in one coil is reacted upon by the voltage introduced in the other coil by that passing wave. The two induced voltages react upon each other and the resulting induced voltage is zero. Hence pickup of energy is not apparent. The fact that these coils are fieldless permits of a layout different from that possible when the coils used have strong fields. Interaction of fields is the greatest objection to the single-layer solenoid. It is a very efficient winding out possesses a very strong field, and total shielding is imperative in a receiver employing a number of single-layer solenoid radio-frequency transformers.

The next problem was the actual design of the binocular inductances. The mere selection of a form of winding does not complete the design problems of the tuned radio-frequency transformers. Solid wire is conventional for the average tuned radio-frequency transformer. Is it best for these coils? Does the form factor of the average coil apply to this type of winding? Can some other wire be used to greater advantage? Here is room for research and experiment.

The first binocular coils were wound with solid wire. Further experiments and calculations by the engineering department proved conclusively that "litz" wire improved the inductance-resistance ratio to a large extent and as far as practical results were concerned, coils wound with "litz" wire could be made to have a more uniform amplification curve over the broadcast frequency spectrum, in addition to improving the selectivity of the tuned circuit. Here again we find a deviation from the conventional path. "Litz" wire has frequently been frowned upon as unsuited for high-frequency work. The designers of the "Synchrophase" have overcome the difficulties and are utilizing "litz" to good advantage.

The occasion next arose for the development of an original system to overcome a frequently occurring fault with conventional tuned radio-frequency amplifiers. It is of paramount importance that the frequency response curve of the radio-frequency system be substantially flat. Furthermore it is desirable that the effects of the grid-filament capacity within the tube be so nullified that the purchaser can use whatever tubes he may choose without fear of upsetting the tuned circuit balance obtained in the factory when the receiver was first tested. With many receivers the neutralizing condenser (or condensers) has to be readjusted whenever any changes in the tubes are made. The frequency response curve of the average tuned radio-frequency amplifier shows maximum response on some short wavelength (high frequency) with a falling characteristic as the wavelength is increased (frequency lowered). The system represented in Fig. 1 by the variable condenser C_1 and the two resistances, R_1 and R_2, was developed and incorporated to attain the two objectives mentioned at the beginning of this paragraph. The action of these units is twofold. First, they eliminate the effect of the grid-filament tube capacity upon the tuned circuit, particularly on the low settings of the tuning condensers, in such manner that tubes may be changed without affecting the original resonance setting. Second, they control the voltage being fed into the grid-filament circuit of the amplifying tube, so that the radio-frequency voltage fed into the tube is practically uniform over the complete tuning scale and the frequency response curve of the tuned system is sufficiently flat. With this arrangement, and the inherent lack of regeneration in the system, a high degree of stability and amplification is afforded.

The four stages provide ample selectivity and sensitivity and are designed to possess sideband characteristics with minimized suppression above 1000 cycles. This consideration is very important, and the presence of excessive regeneration would tend to nullify all the effects of scientific design. But the properties of the fieldless coil guard against this deterimental effect. With sufficient spacing between the inductances, the very small amount of external field, which cannot be eliminated completely, does no harm. Hence the regeneration present is uniform over the scale and is at no time sufficient to cause uncontrollable oscillation.

The detector system is the grid leak-condenser arrangement, affording maximum signal sensitivity and intensity. The compensating system utilized in the radio-frequency stages, is also resorted to in the detector input circuit, thus permitting the use of any detector tube without unbalancing the tuning system. A non-regenerative detector was decided upon because the four stages of tuned radio-frequency amplification give sufficient sensitivity and selectivity. Furthermore, the sideband suppression characteristics of the radio-frequency system are known and the introduction of a variable constant, which would be encountered with a variable regenerative detector, would upset the balance between the radio and audio amplifiying systems.

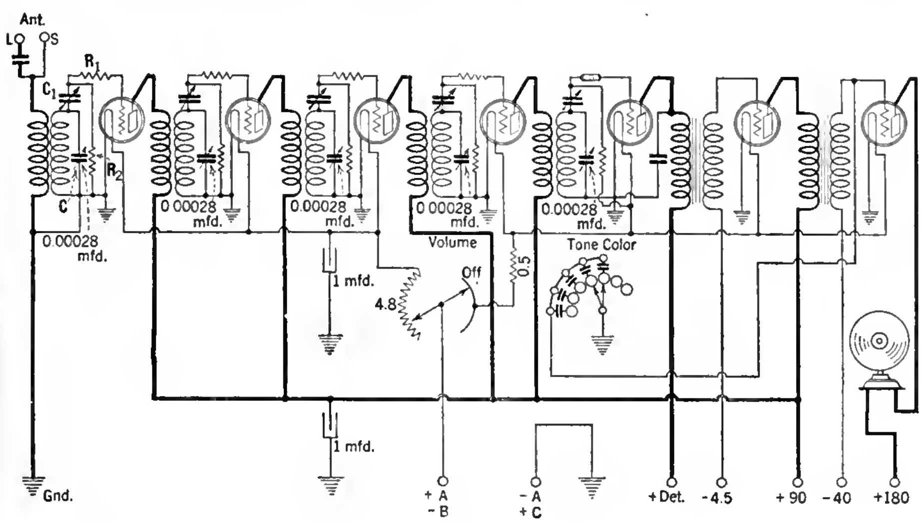


FIG. 1
Circuit diagram of the "Synchrophase" Seven

THE AUDIO CHANNEL

THE audio amplifying system is closely associated with the radio-frequency system; in fact, it must be, for the reason that the frequency characteristics of the audio-frequency amplifying transformers are governed by the sideband characteristics of the radio-frequency system. If the sideband suppression of the upper audio register is great in the radio-frequency amplifier, the audio system must possess a certain rising characteristic. The slope of the rise is governed by the degree of suppression in the radio-frequency amplifier. Hence the two systems are closely associated. Being familiar with the sideband suppression in the radio-frequency system, two audio stages are decided upon after a study of the amplifying powers of the system; these two stages possess sufficient magnifying power to afford a satisfactory output. The overall response curve of the audio system is shown in Fig. 2. The gain in transmission units is shown on the ordinate and the frequencies are shown on the abscissa. The curve is plotted on a logarithmic scale.

Particular consideration was given to the feminine speaking voice, the frequencies of which are difficult to amplify, and to the overtones of the high-frequency producing musical instruments. The result is that the transformers were designed to function satisfactorily on audio frequencies above 8000 cycles. This is easier said than done. A great deal of work was entailed before suitable transformers were produced. In order to realize satisfactory amplification on the upper audio register it was important to reduce the distributed capacitance of the secondary winding. This was accomplished by the use of three layers of insulation between each layer of winding. The distributed capacity of the secondary winding is approximately 18 micro-microfarads. The importance of a low distributed capacity can be appreciated when one realizes that the higher it is, the more limited will be the frequency range of the amplifying unit.

An example of vision, and a knowledge of the buying public's whims and fancies, is displayed in the inclusion of a device which permits tonal flexibility. The problem arose during the process of development when the sales staff mentioned the fact that the aural fancy of the listener-in was apt to vary over a wide range. Could not some device be incorporated which would permit variation of the tone of received speech or music, so as to satisfy the individual tastes of the multitude? Some fans prefer a preponderance of low tones, while others are not so anxious about these low frequencies. The engineers decided that the best location for such a unit would be in the audio amplifying system, but a continuously variable change in the physical structure of the audio-frequency transformers to produce different response was impractical. Hence the "tone color" unit, consisting of a number of fixed capacities which can be shunted across the secondary of the second-stage audio-frequency transformer to change its operating characteristic, was originated. The "tone color" is controlled by a knob on the front of the panel and, by its manipulation, the listener is able to adjust the tone to suit his own taste. The capacities in the "tone color" vary from 0.00008 mfd. downwards.

THE PROCESS OF TESTING

ENGINEERING and originality has made possible the manufacture of all the necessary equipment, exclusive of the cabinets, in the Grebe plant, at Richmond Hill, Long Island.

The manufacture and testing of the tuned radio-frequency inductances is of especial interest. The winding is spaced yet the winding form is not grooved. This is made possible by means of a grooved slider which carries the wire as it is wound on the winding form. The grooves on the slider space the wire, and the turns are kept in place by means of a layer of clear lacquer which is sprayed upon the coil before assembly. Ingenuity in testing now manifests itself. The wire, as mentioned before, is "litz," and it is extremely important that all the turns remain intact. If a single strand is broken it will result in a steep rise in the radio-frequency resistance of the wire, with consequent increase in losses, and lower selectivity. The condition of the finished coils is tested on a d.c. bridge, accurate enough to show one broken strand. The total resistance of all the strands is balanced against a known resistance. One broken strand in the "litz" cable will deflect the meter in the bridge, in which case the coil is rejected. The satisfactory coils' radio-frequency resistances are then measured. The inductance value of a completed coil should be 310 microhenries.

The condensers are matched on a capacity bridge, each one being individually tested against a standard. The condensers are then grouped according to their respective capacities. A control is arranged which shows a variation of 7 micro-microfarads for the complete scale, and extremely small variations are, therefore, detectable. By means of this control it is also possible to determine increased effective resistance of the condenser under test. The bridge is fed from

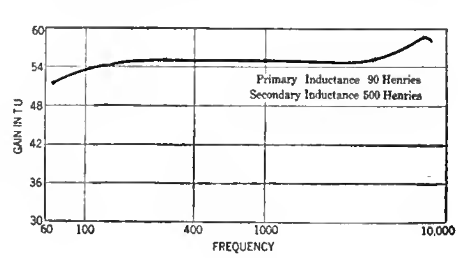
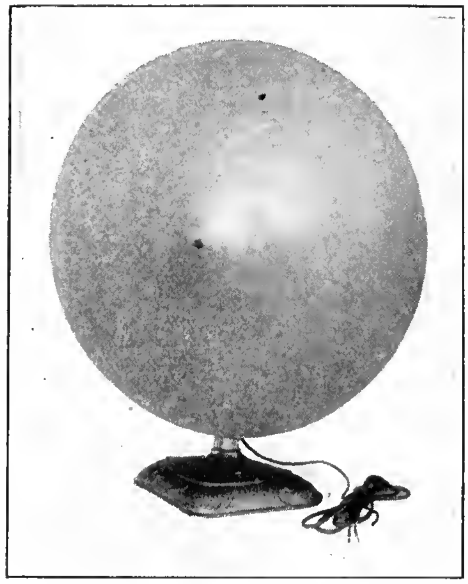


FIG. 2
The overall response curve of the "Synchrophase" Seven audio channel

a 1000-cycle source and the output of the bridge is connected to a single-stage audio amplifier, thus increasing the sensitivity of the system. The operator uses the headphone method of adjusting for capacitance by finding the minimum sound intensity. When the sound is minimum the capacity of the unknown is exactly that of the standard. A condenser with high losses does not permit of complete silence in the phones, and is rejected.

The audio-frequency transformers are also tested in an interesting manner. It is highly important to know the response of the transformers to be placed in the receiver, but it would be a tedious procedure to plot a response curve for each individual unit, hence each transformer is compared with a standard on certain frequencies. A tube oscillator, generating a 500-cycle note and a 6000-cycle note, is connected to a standard amplifier. The output of this amplifier is connected to the transformer to be tested, and the output of the transformer under test is connected to a vacuum-tube voltmeter, the output circuit meter of which gives visual deflections indicative of the response of the transformer under test. The circuit is so arranged that, by means of an anti-capacity switch, the transformer under test can be replaced by the standard and the deflections compared. By means of a switch, the oscillator can be adjusted to generate either the 500- or the 6000-cycle signal. This signal is free of harmonics and is constant at all times. The deflections with the standard transformer are therefore constant.

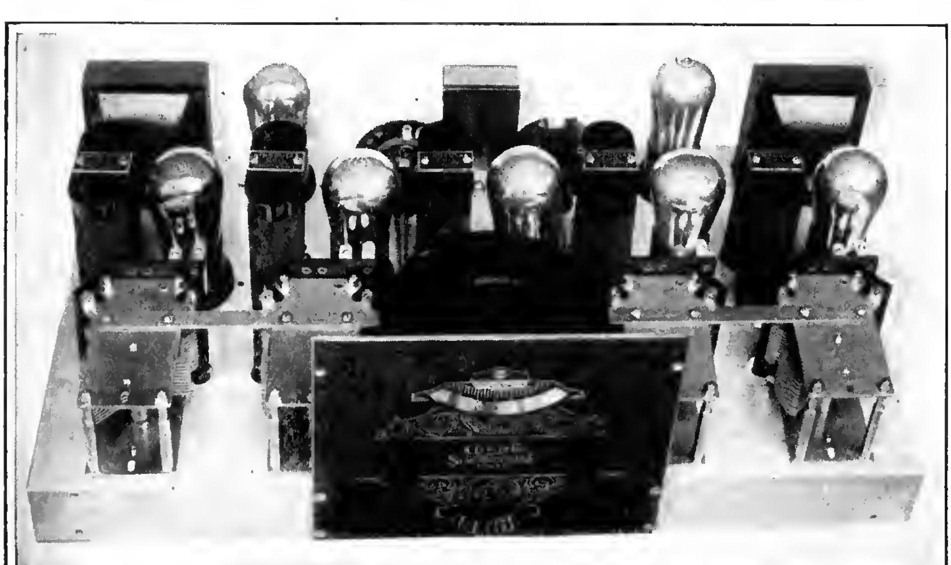
The complete receiver undergoes several tests, and the method of testing is also original and novel. A buzzer-modulated master oscillator, tuned to 200, 400, and 530 meters (1500, 750, and 566 kc.) feeds a master antenna. The buzzer modulation is accomplished by breaking the plate voltage supply with the interruptions of the buzzer. The operator testing the receiver (several operators are testing at one time) has his own antenna of standard inductance and capacitance value. He first adjusts the receiver at 200 meters by tuning it to resonance with the 200-meter oscillator signal. The receiver output is then noted by means of a tube voltmeter connected to the output circuit of the receiver. After the receiver is adjusted on 200 meters, adjustments are made on 400 and 530 meters, and the second harmonic of 530, which is 265 meters (1130 kc.). In this way each receiver is tested on four wavelengths. This is indeed a comprehensive test, for it will bring to light any defects in design upon any of the wavelengths within the range employed for broadcasting purposes. If the tube voltmeter does not show standard output on all four waves, the receiver is rejected for a re-examination.



THE GREBE CONE LOUD SPEAKER

The problem of conductive coupling in the receiver to adjacent leads was overcome by the use of the chassis as the negative filament lead, thus eliminating numerous long leads. The filament wiring in the receiver consists of only the positive polarity wires. The negative lead is formed by the chassis. The condensers are all grounded upon the chassis.

The mechanical alignment is facilitated by punching the complete chassis in one piece. It is made out of aluminum and stamped out on a 60-ton press. The chassis, after the stamping, carries all the mounting holes and brackets, thus assuring correct alignment. The receiver, from start to finish, is carried from one operation to another by means of a conveyer system approximately 1000 feet in length. This conveyer consists of a belt or a roller as the occasion demands, and the partially assembled receiver moves from one operation to another until it finally reaches the final department.



AN INTERIOR VIEW OF THE "SYNCHROPHASE" SEVEN

THE GREBE CONE

THE electrical development of the Grebe loud speaker is also of interest, particularly because this field of endeavor requires highly trained engineering. The development of a loudspeaker does not consist of the mere selection of steel, iron, wire, and a paper cone. Let us consider for a moment an important consideration which the fan generally passes over very lightly. This is the angle of the apex of the cone, and the size of the cone. The information relative to the size of the cone will doubtless be of interest to constructively inclined radio fans. According to the engineer in charge of cone construction, their experiments showed that a 20" cone was the best compromise and that increases above this diameter did not justify the additional space required. Experiments showed that very little is gained by using a cone of larger diameter. Reduction in size, however, showed a material loss.

As to the angle of the apex, 20 degrees is also the best compromise for efficiency and quality. The greater the angle, the greater the efficiency but the poorer the quality of reproduction. The 20-degree angle was considered the best for quality and efficiency. Many articles published in this and other periodicals have stressed the importance of a large value of inductance for loud speaker windings in order to produce satisfactory response on the low frequencies. With this in mind, a value of 1.7 henries was selected as the loud speaker coil inductance. The shape of the armature is also an important consideration, and by using an armature that is wide and short, the lowest moment of inertia is obtained. The selection of the material for the armature also requires care and silicon steel was chosen instead of Swedish iron, because the losses of silicon steel are less on the higher audio register. The difference between Swedish steel, iron, and silicon steel is not appreciable on the lower audio register but it approaches an appreciable value on the higher audio frequencies.

The elimination of harmonics in the average loud speaker is a paramount item because their presence will not permit true reproduction. To attain this result it is necessary to minimize magnetic saturation.

The testing of the loud speaker is carried out by first subjecting it to a series of audio frequencies obtained from a beat note oscillator. This beat note oscillator consists of two radio-frequency oscillators adjusted in a manner which permits the generation of a beat note; this note is passed through several stages of audio-frequency amplification and then into the loud speaker. One of the radio-frequency oscillators, is variable in tuning and the frequency of the beat note is variable between 50 and, approximately, 20,000 cycles. This test will bring to light any defects in the loud speaker mechanism which would result in a rasping sound or a rattle when it is placed into operation. Another test consists of the reproduction of an organ record played upon a talking machine and fed into the loud speaker by means of an electric pick-up and amplifier combination. The organ selection has a wealth of low notes, and these are particularly desired for testing purposes, since the amplitude of these low frequencies is high. This test will bring to light any defects in the placement of the armature. Another test consists of the application of the plate current of a 171 tube through the windings of the loud speaker, first in one direction and then in the other, to test for magnetic saturation when it is in operation.

AS THE BROADCASTER SEES IT

BY CARL DREHER

Technical Problems for Broadcasters and Others

TECHNICAL problems presented in this section in the past have consisted of numerical problems requiring more or less lengthy solutions, so that only one question could be allowed to an issue. We shall vary these occasionally by a series of questions requiring only brief answers, like those below. The subjects, while not strictly confined to the design and operation of broadcast transmitters and associated apparatus, will have some connection with those considerations of quality in reproduction which are of most interest to the professional broadcast technician.

QUESTION 1. Why does sharp tuning tend to drop out the high audio frequencies associated with a carrier?

Answer. The audio energy of speech or music exists in the side bands accompanying the carrier in question. If, for example, the carrier is of the order of 600 kilocycles, a frequency within the broadcast band, and the audio note being transmitted is 5 kilocycles, the side bands will have a frequency of 595 and 605 kilocycles. A sharply tuned circuit resonant to 600 kilocycles will include perhaps one kilocycle on either side, and will discriminate to a greater and greater degree against the higher audio frequencies, which lie further out from the central or carrier frequency. Hence the 595- and 605-kilocycle currents, in the present example, may be lost altogether, and with them the 5-kilocycle audio note which they would yield on demodulation. By this mechanism, called "side band cutting," the higher musical frequencies are likely to be lost.

QUESTION 2. Why does slight detuning of a sharply resonant circuit, with reference to the carrier frequency, tend to reinforce the higher notes contained in the modulation?

Answer. See Fig. 4, which has reference to the same example used to illustrate the answer to Question 1. Now, however, the circuit has been tuned so that the peak of the resonance curve occurs at 602.5 kilocycles instead of at the carrier frequency of 600.0 kilocycles. As a result, the peak of receptivity, after demodulation, has been shifted from currents of frequencies in the neighborhood of zero cycles to currents in the neighborhood of 2500 cycles per second. If, owing to the steepness of the resonance curve, the cut-off characteristic of the circuit becomes serious one kilocycle to either side of the peak, as assumed in the answer to Question 1 above, with the peak set at 602.5 kilocycles the audio frequencies up to 3.5 kilocycles are nevertheless included in the received band. It will be seen that through this mechanism a sharply tuned radio frequency circuit may be used to some degree as an equalizing or frequency correcting device in reception. This observation may be checked in practice. A similar phenomenon is found in some super-heterodyne receivers.

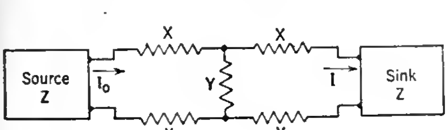


FIG. 1

QUESTION 3. What change in loudness is normally noticeable by the human ear?

Answer. A change of 3 TU is usually observed in speech or music even by listeners who are not expecting it. This corresponds to a change in energy of 2:1. A practiced listener looking for a change may detect differences of the order of 1 TU in a sustained note, without much difficulty. This is equivalent to an energy change of about 25 per cent.

QUESTION 4. What size steps, in TU, would you allow in a smooth gain control?

Answer. Since, according to the answer to Question 3 above, a change of 3 TU is noticeable, the maximum allowable step in a smooth gain control is 2 TU.

QUESTION 5. What error do non-technical observers invariably make in estimating relative loudness of sounds?

Answer. They underestimate radically. As is well known, the human ear follows a logarithmic response characteristic, which is as much as to say that a large increase or decrease in the stimulating energy results in a slight change in the loudness subjectively perceived. Or, more definitely, *multiplying* the energy by a fixed ratio results only in *adding* to the loudness an increment proportional to the logarithm of the energy ratio. This is expressed mathematically in the formula for the telephonic transmission unit, which is a measure of subjective loudness:

$$TU = 10 \log P_1/P_2$$

where P_1 and P_2 are the powers corresponding to the two telephone currents under comparison. Non-technical listeners, being unaware that hearing is a logarithmic process, usually apply to sounds the standards of measurement and estimating to which they are accustomed in dealing with distances, for example. A broadcast listener, comparing reception from two stations, one of which is a stage of audio amplification above the other, will say that the first station is "fifty per cent. louder," or "one hundred per cent. louder." Actually one a. f. stage may correspond to 20 TU, or a sound energy ratio of 100. In other words, a non-technical listener is apt to speak of an energy ratio of the order of 2:1 where the actual figure is of the order of 100:1.

Commercial Technical Publications

AMONG catalogs and technical publications received we must mention the September, 1927 issue of the General Radio *Experimenter*, a four-page paper sent out monthly to concerns and individuals on the mailing list of the General Radio Company of Cambridge, Massachusetts. [This publication may be secured by our readers by filling out the "Manufacturers' Booklet" coupon appearing in the advertising section in this and other issues. Booklet number 74.—*Editor.*] Thi firm, as is well known, specializes in communication laboratory and measuring apparatus, such as standards of inductance, resistance, and capacitance, oscillators, oscillographs, audibility meters, bridges, artificial telephone lines, etc. Its engineers have played no small part in reducing radio designing to a respectably exact science. The September, 1927 issue of the *Experimenter* is of special interest to broadcasters in that it contains an article on "Design and Use of Attenuation Networks," by Horatio W. Lamson. The subject was discussed, it may be remembered, in this department for September, 1927 (Pages 293–294). Mr. Lamson's paper covers the same ground, in part, with the addition of a number of formulae and a detailed description of the General Radio Company's variable attenuation networks. Given, as in Fig. 1, a source of impedance Z and an absorbing circuit or "sink" of the same impedance, joined by an H-network as shown, with currents I_0 and I leaving the source and entering the sink, respectively, for a definite number of transmission units of attenuation N we may calculate the arms X and Y from

$$X = \frac{Z}{2}\left(\frac{k-1}{k+1}\right) \qquad (1)$$

$$Y = 2Z\left(\frac{k}{k^2-1}\right) \qquad (2)$$

$$\text{where } k = \frac{I_0}{I} > 1 \qquad (3)$$

or, in TU

$$k = 10^{n/20} = \text{Antilog } n/20 \qquad (4)$$

If, as shown in Fig. 2, we make all five branches of the H-network adjustable by steps, moving five switch arms in unison to the proper switch points through a single control, the characteristic impedance Z of the network may be maintained constant to match the impedances to either side, while the attenuation is varied in steps. This is the principle of the Type 239 Variable Attenuation Network supplied by the General Radio Company. The box is equipped with two multiple switches. In the size which affords a total attenuation of 55 TU, one decade is calibrated in steps of 5 TU, and the other in steps of 0.5 TU. Another size goes up to a total of 22 TU, and in this case the steps are 2TU and 0.2 TU. Characteristic impedances of 600 and 6000 ohms are carried in stock or built to order. Some types are provided with a center tap for the Y-branch, where a ground may be applied.

A somewhat older type of variable pad supplied by the same manufacturer is adjusted by the addition or subtraction of fixed sections, which are cut in or out by means of four-pole double-throw switches, as shown in Fig. 3. This is known as the Type 249. The manipulation of this form is necessarily somewhat less convenient, but in many cases it serves the same purpose and the cost is about half of the rotary switch form. There are eight-section boxes affording a total attenuation of 110 TU in steps of 1 TU, and six-section boxes with a total of 63

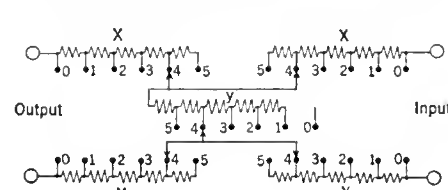


FIG.2

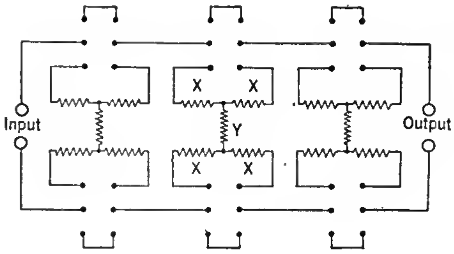


FIG. 3

TU in the same steps. The same characteristic impedances, 600 and 6000 ohms, are available. As explained in the September, 1927, RADIO BROADCAST discussion, the simpler T-networks may be used in place of the H-type where a balanced circuit is not essential. The General Radio Company also supplies the sectional networks in the T-connection, at a somewhat lower price, inasmuch as the number of coil-taps and switch-arms required is less.

The Portrait of the Author

MR. FRANKLYN F. STRATFORD, who embellishes these articles with clever pictures, sometimes sketches my likeness for the customers, so that they may not shoot the wrong man when they take offense at my sooth-sayings. In so doing Mr. Stratford has perpetrated a libel on me. I ask that interested readers turn to the illustration in the November, 1927 issue, over the quotation, "Let the ghost call at my office." The picture includes the ghost, myself, and part of the office. About the ghost I say nothing; Mr. Stratford's idea of a ghost is no doubt as good as anyone's. And my own likeness is not bad. It is true that my nose is depicted as about the size of Cyrano de Bergerac's, and not as well-shaped, but so God made me. My head has a contour not unlike that of a truncated cone, in Mr. Stratford's sketch, but such geometrical outlines are not lacking in esthetic value, and it would be worst if the cone were upside down. What I object to is the office furniture, and particularly the desk. The desk depicted seems about four feet wide. I wish the world to know that my office boy sits at such a desk. My own desk was made to order in Circassian walnut, and cost $3000. The top is a solid piece of Florentine marble, 150 square feet in area. Nymphs and satyrs are painted on the sides. When next Mr. Stratford draws my desk let him take an extra column and do justice to his subject.

Linguistic Observation

THE vilest French and German I have ever heard—in the sense of execrable accent, not of content, be it said—is on radio broadcast programs, and I refer to many large stations as well as small ones, if you please. The radio announcers, with a trifling number of exceptions, pronounce foreign languages like so many high school freshmen. The better vaudeville circuits are vastly superior in this detail. When a girl like Kitty Doner spills some French before the assembled intelligentsia at the New York Keith's 81st Street, it is Parisian French as you might hear it on the boulevards. But the announcers drive any half-way educated listener to thoughts of homicide whenever they have occasion to pronounce a simple phrase like *Danse Russe* or *Wiener Blut*. What ails the announcers and their bosses? Don't they know any better? Then let them go back to school. Or don't they care? Then let them seek some business in which they don't have to appear before the public.

Memoirs of a Radio Engineer: *XXI*

INSTEAD of going forward a few more months in the recital of these memories, at this point I wish to regress briefly in order to include an incident which was omitted in its proper place. It returns to my recollection when I hear of some broadcast listener ending his mortal existence by throwing a length of antenna wire across a high tension line, or through a fall from a roof. Such fatalities are too infrequent to deserve mention, perhaps, in a country which takes no account of some 100,000 deaths in four or five years through automobile accidents, but the victims are just as dead, although not killed in a popular manner. I might have joined their number, thus

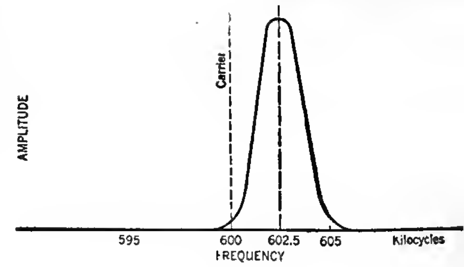


FIG. 4

swelling the total slightly, but for luck. The time was about 1914, when I was feeding a crystal receiving set from a one-wire antenna about four hundred feet long. So long was it, in fact, that it crossed a city street. After some months of fine reception, during which I was able to boast to the other amateurs about the great distances from the phones at which signals might be heard at my house, the antenna yielded to the elements one night, and in the morning it was down. On the street which it crossed there was an electric power line, the cross arms carrying six or nine heavy rubber covered wires. My copper strand now lay across these conductors. I went to the house at the end of the block and looked up at the transmission line. It did not appear dangerous, and I decided that it must be a 110-volt circuit, and that nothing much could happen. However, I decided to be very prudent, so I went below for a bamboo trout rod, made a cast for my antenna wire, hooked it, and lifted it off the transmission line. It fell back, however, and I grasped it impatiently in my bare hands and swung it clear. Nothing happened. What could happen even if a boy radio operator got his antenna tangled up with a 110-volt line covered with an eighth of an inch of rubber? But the other day I passed along that block, and, thirteen years older, looked up at the transmission line, which was unchanged in equipment and fittings, as far as I could judge. It is not a 110-volt line, and probably never was one. It may be carrying its load at a tension of 2200 volts, or perhaps 4400. Either would have been enough. Some people have luck. The insulation on the wires was not frayed.

The Radioman's "Britannica"

DRAKE'S RADIO CYCLOPEDIA. By Harold P. Manly. Published by Frederick J. Drake and Company, Chicago. Price $6.00. Pages, about 800. Illustrations, 950.

MR. MANLY'S "Cyclopedia" is a comprehensive compilation of all the conceivable information which a set builder and designer needs for ready reference. The reviewer could not, of course, read the entire work in detail because that would require several weeks, but many pages were critically examined. The first impression gained is the completeness with which the author covers his subject.

As an example of the wealth of detail on a particular subject, under the heading of "Receiver, Audio Amplifier for," constructor's circuit diagrams, showing the arrangement of parts, wiring, outstanding performance qualities, and specifications of components, are given for fifteen types of audio amplifier systems, including three-stage choke-coupled, three-stage transformer-coupled, one transformer and two choke-coupled, three-stage double impedance, one transformer and one push-pull stage, two push-pull stages, three resistance-coupled stages, one transformer and three resistance stages with output choke, two transformer stages with output transformer, two transformer stages with parallel output tubes, two transformer stages with potentiometer control.

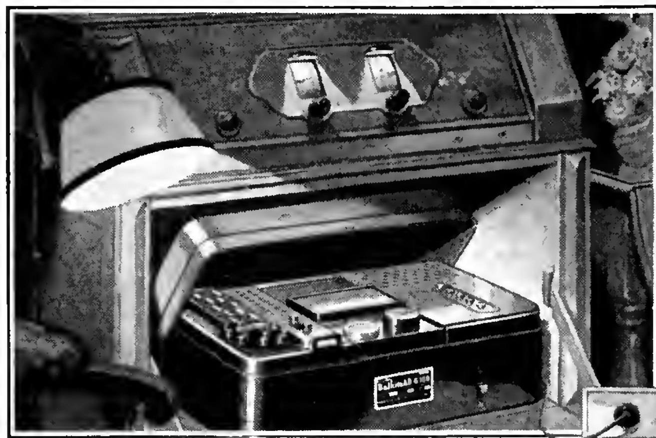
In the matter of receiving circuits, the following types are described: Browning-Drake, crystal, four-circuit, long-wave, loop, "N" circuit, neutrodyne, one-tube, regenerative, Rice, Roberts, short-wave, single-circuit, single-control, super-heterodyne (13 pages), super-regenerative, and tuned radio-frequency.

A table, "Coil Design, Advantages and Disadvantages of Types of Coils," is an example of the practical kind of information collected in a manner suited to easy reference. This table lists various elements of coil design, such as type of winding, shape of winding, proportion of winding, wire insulation, wire size, material of winding form, design of winding form, fastening of winding, material of supports and connections to winding, and gives under each of these headings three to six different practices which may be followed. For example, under "Material of Form," paraffined paper or cardboard, fibre and "mud" dielectrics, dry paraffined wood, hard rubber, phenol, bakelite, and glass are listed. Under each of these design possibilities, the characteristics of each type is given in the simplest terms, "poor, fair, good, and best," for the following factors: Durability, most inductance, least resistance, little distributed capacity in small field. Thus, "type of winding, (1) cylindrical, single wire, close wound," is declared the "best" from the standpoint of durability, most inductance, and least resistance, but "poor" from the standpoint of less distributed capacity and small field. Honeycombs, on the other hand, are good from the standpoint of durability, inductance, less distributed capacity, and small field, but only fair from the resistance standpoint. By the aid of the table, the designer may select the type of winding form which best suits his purpose.

In addition to covering constructional information, due space is given to practical operation, general theory, and design. Power supply for A, B, and C potential, design of receivers with alternating-current supply for filament lighting, single-control, shielding, are some of the subjects fully treated, indicating the volume to be up to the minute.

One mysterious feature of the whole work is that hardly a single line of credit is given for sources of information and assistance. Not a page in this book is numbered. The reviewer does not believe, however, that a more satisfactory addition to the experimenter's library, in any one volume, can be made.

—E. H. F.



LICENSED UNDER ANDREWS HAMMOND PATENT

Now AC Electric Radio

Licensed under Andrews-Hammond patent

To owners of a "B" eliminator:

Balkite "A" is like Balkite "AB" but for the "A" circuit only. It enables you to make an electric installation at very low cost. $35.

Balkite "B"

The accepted, tried and proved light socket "B" supply. One of the longest lived devices in radio. Three models, $22.50, $35, $42.50.

Balkite Chargers

Standard for "A" batteries. Noiseless. Can be used during reception. High rate or trickle. Three models, $17.50, $9.50, $7.50.

There are special models for 25-40 cycle current at slightly higher prices. Prices are higher West of the Rockies and in Canada.

Without the uncertainty of untried apparatus

And without any sacrifice in quality of reception

Of course you want an AC electric receiver. For its convenience. Now you can have it, without the uncertainty of untried apparatus and without sacrificing quality of reception.

Simply by adding Balkite *Electric* "AB" to your present radio set. Balkite *Electric* "AB" replaces both "A" and "B" batteries and supplies radio power from the light socket. It contains no battery in any form. It operates only during reception. It makes any receiver an electric set.

This method makes possible the use in electric reception of standard sets and standard type tubes. Both are tried and proved, and give by far the clearest and truest reproduction. With this method there is no waiting for tubes to warm up. No difficulty in controlling volume. No noise. No AC hum. No crackling or fading of power. Instead the same high standard of reception to which you are accustomed.

In this method there is nothing experimental, nothing untried. It consists of two of the most dependable products in radio—a standard set and Balkite. And if you should already own a radio set, the cost of equipping it with Balkite is only a fraction of the cost of a new receiver.

By all means go to AC reception. Its convenience is the greatest improvement in radio. But be as critical of an AC receiver as you would of any other. That your AC receiver be a standard set equipped with Balkite *Electric* "AB." Then it will be as clear and faithful in reproduction as any receiver you can buy.

Two models, $64.50 and $74.50. *Ask your dealer.* Fansteel Products Co., Inc., North Chicago, Illinois.

> *Chicago Civic Opera*
>
> on the air Thursday Evenings, 10 o'clock Eastern time. Over stations WJZ, WBZA, WBZ, KDKA, KYW, WGN, WMAQ, WBAL, WHAM, WJR, WLW, WENR. 10:30 Eastern time: WEBH, KSD, WOC, WOW, WCCO, WHO, WDAF.
>
> BALKITE HOUR

Balkite

ELECTRIC AB

[contains no battery]

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. In July, 1927, an index to all Sheets appearing up to that time was printed.

All of the 1926 issues of RADIO BROADCAST 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 occur, a new Laboratory Sheet with the old number will appear.

—THE EDITOR.

No. 153 RADIO BROADCAST Laboratory Information Sheet January, 1928

Standard- and Constant-Frequency Stations

BROADCASTERS WITH ACCURATE FREQUENCIES

THE *Radio Service Bulletin*, published monthly by the Radio Division of the Department of Commerce, Washington, District of Columbia, contains a list of standard and constant frequency broadcasting stations as determined by the Bureau of Standards. This bureau makes measurements on an average of about three times a month on the transmissions of a small number of stations and as a result of these tests data are published in the *Bulletin* on those stations which have been found to maintain a sufficiently constant frequency to be useful as standards. These are known as "Standard Frequency Stations." The list of "standard frequency stations" is supplemented with a list of "constant frequency stations." No regular tests are made on these latter stations but each station in the list employs a special device, such as a crystal, to maintain its frequency accurately so that they can be generally relied upon to maintain their correct frequency.

STANDARD FREQUENCY STATIONS

Call Letters	*Frequency Kc.*
WEAF	610.00
WRC	640.00
WJZ	660.00
WGY	790.00
WBZ	900.00
KDKA	950.00
WBAL	1050.00

CONSTANT FREQUENCY STATIONS

Call Letters	*Frequency Kc.*
WMAQ	670
WJAD	670
WCCO	740
WTAM / WEAR	750
WBBM	770
KGO	780
KTHS	780
WCAD	820
WJJD	820
WLS	870
WSM	880
WKAQ	880
KOA	920
KFAB	970
WBAA	1100
WHK	1130
WMBI	1140
WABQ	1150
WEBJ	1170
KWUC	1230
KFVS	1340

No. 154 RADIO BROADCAST Laboratory Information Sheet January, 1928

The 112-A and 171-A Type Tubes

OPERATING CHARACTERISTICS

TWO new power tubes have recently become available; they are designed especially for use in the output of a receiver. These new tubes employ an improved type of filament which gives high emission at a filament current of 0.25 amperes at 5 volts. They are exactly similar to the older UX-112 and UX-171 type tubes with the exception that the filament consumption is only half that of the older types. The filament of the corresponding 112 and 171 type tubes is 0.5 amperes at 5 volts. The other characteristics of these new tubes remain the same as those of the 0.5 ampere filament tubes. These characteristics are given below.

The UX-112-A (CX-312-A) may be satisfactorily used as a detector, general-purpose tube, or as a power tube in the last stage of a receiver. When used as a detector, the plate voltage should be 45 volts. The UX-171-A (CX-371-A) must only be used in the last stage of a receiver, and a choke-condenser combination or output transformer should be used in the plate circuit to keep the plate current out of the loud speaker.

The advantage of these new tubes is in their greater efficiency. Under the same condition of plate voltage they produce the same plate current as the corresponding 0.5-ampere tubes, with only half as much filament current.

These tubes must not be substituted for the UX-112 (CX-112) or UX-171 (CX-171) types in a receiver without changing the values of fixed filament control resistances or rheostats if they are used. Since they take the same filament current as a 201-A type tube, it follows the filament control resistances designed for the latter tube may be used in conjunction with these new tubes.

Type	Filament Volts	Filament Current	Plate Voltage	Negative Bias	Plate Impedance	Amp. Constant	Plate Current	Output Milliwatts
UX-112-A	5	0.25	90	6	8800	8	2.5	40
(CX-312-A)			135	9	4800		6	120
			157½	10.5	5500		8	195
UX-171-A	5	0.25	90	16.5	2500	3	10	130
(CX-371-A)			135	27	2200		16	330
			180	40.5	2000		20	700

SM

We Could Charge More— But a *Better* Transformer Can't Be Made

IMITATED everywhere—never equalled—the S-M 220 audio transformer stands out to-day as the finest for audio amplification that money can buy just as it did when introduced a year and a half ago. The 220 has been copied in one or more of its characteristics by every high-grade transformer put on the market since then—in the rising low note or in 5000 cycle cut-off, features first offered by S-M. That's proof that the principles the 220 introduced are right—that the market is still trying to catch up with the leader.

Don't be misled by exaggerated claims—for it takes plenty of core and wire to make a good transformer. The 220 has from 25 to 50 per cent more steel and copper in its construction than any other transformer on the market. That alone means the high primary impedance through which real bass note amplification is made possible.

That's why S-M 220's and 221's are specified in more popular receiver designs—why they have outsold every other transformer in their price field. That's why they're sold on an unconditional money-back guarantee to give better quality than any other audio amplifying device available.

We could charge from 25 to 50 per cent more than we do, but at no price can you get a better transformer. The 220 audio is $8.00, and the 221 output is $7.50. They are priced low, but, you can't buy a better audio coupler at any price, for there's none better made.

Just as the 220 transformer, compared with all other makes, gives you the sense of Gibraltar-like sturdiness and dependability truly in a class by itself, so does its performance far outclass that of other transformers.

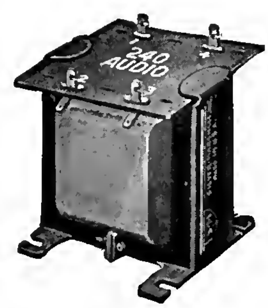
The Finest Tone You've Ever Heard

—and complete A. C. operation. Complete light socket operation of the Improved Shielded Six using A. C. and power tubes is an accomplished dependable fact. You may build either the battery model with standard tubes or the A. C. model with the new C-327 and CX-326 tubes—and at a cost of less than half what you'd pay for nearly equivalent performance in a factory-built set.

Every one of the thousands who built last year's Shielded Six said the same thing—"The Six has the finest tone I ever heard." And now the new and improved 1928 model of this famous receiver, with the same fine tone as the original, and tremendously improved selectivity and distance getting ability is available for light socket, battery, or eliminator operation. Above all the Six is guaranteed to have finer tone than any other set you can build or buy. The 630 Shielded Six kit in the battery or eliminator model is $95.00 and for complete light socket operation $99.00.

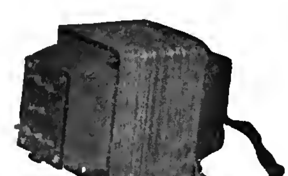
The New 240 Audios

We can't make the 220's cheaper but if you desire a transformer somewhat lower in price, taking up a little less room, and with a little less core and wire, the new 240 audio and 241 output transformers are available—superior to most other transformers, and far and away ahead of anything in their price field. They have the same general characteristics as the famous 220's and 221's, but provide slightly less accentuation of frequencies below 80 cycles. They have the same 5000 cycle cut-off for which 220's are famous, eliminating the objectionable whistles and heterodyne squeals of congested broadcasting. The 240 audio sells for $6.00 and the 241 output at $5.00. Hard to beat at any price, they are impossible to *equal* at these prices. And—you can bring your old set up to the minute using them—they're small enough to fit in most anywhere.



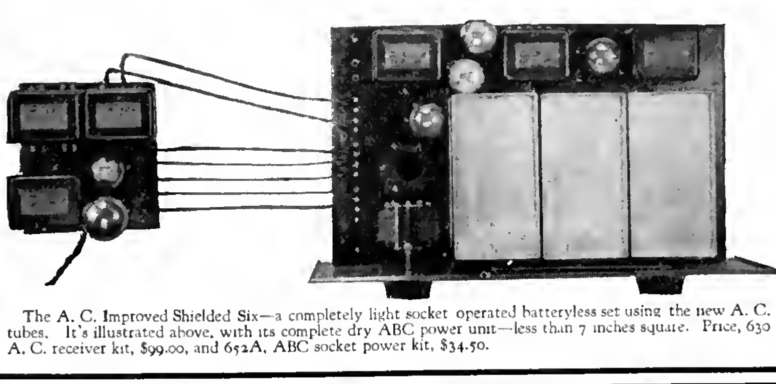
328 Super Power Transformer

A heavy power transformer for either full wave or half wave rectifiers—for UX-281 (or UX-216-B) rectifier tubes. Will furnish 480 volts at 100 milliamperes of thoroughly filtered direct current using two UX-281 tubes, the S-M 331 Unichoke, and only six microfarads of filter condenser. This is power for a 210 push-pull amplifier at full voltage and to furnish receiver B power as well. Consists of two 550 volt secondaries, two 7½ volt, 2½ ampere filament windings and one 1½ volt, .2 ampere filament winding for UX-226 tubes. Price $18.00.



SILVER-MARSHALL, Inc.

838-B West Jackson Blvd. Chicago, Ill.



The A. C. Improved Shielded Six—a completely light socket operated batteryless set using the new A. C. tubes. It's illustrated above, with its complete dry ABC power unit—less than 7 inches square. Price, 630 A. C. receiver kit, $99.00, and 652A, ABC socket power kit, $34.50.

Only a few of the real S-M developments are listed here. 10¢ in stamps will bring you more real information on power equipment, A.C. operation, and other pertinent subjects than you can read in a week.

SILVER-MARSHALL, INC.
838-B West Jackson Blvd., Chicago.

Please send me all data on S-M audio transformers, power equipment, and new A.C. improved Shielded Six.

Name ....

Address ....

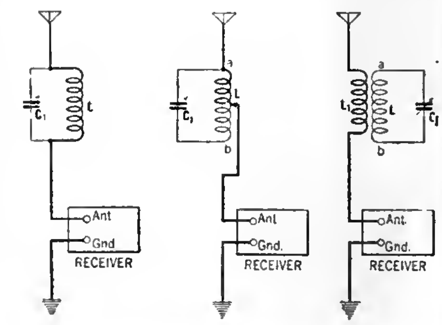
No. 155 RADIO BROADCAST Laboratory Information Sheet **January, 1928**

Wave Traps

THREE CIRCUITS

THE trend of broadcasting, for sometime, has been toward the use of high power, and this has made the problem of selectivity a serious one for many listeners located within a few miles of a high-power broadcasting transmitter. When difficulty is experienced in satisfactorily tuning-out such a station, it will be advisable to incorporate a wave trap in the antenna circuit. Wave traps are very easily constructed and cost little. They consist of any ordinary coil and a condenser, connected in the antenna circuit, and adjusted to absorb a large amount of the energy being received from the interfering station. The traps may be connected in several ways, as indicated on the diagram. The arrangement shown at A will give most complete elimination of the undesired signal but may also cause a considerable decrease in volume of stations operating on adjacent channels. The arrangement shown at B is probably the most flexible manner in which to connect a wave trap. If the coil is arranged with several taps an adjustment can be arrived at which gives most satisfactory results. Arrangement C is only useful in case of mild interference. The circuit tunes very sharply and will effectively eliminate interference provided it is not too great.

In constructing a wave trap, coil L may consist of 47 turns of No. 22 wire on a 3-inch diameter form if the tuning condenser C_1 has a capacity of 0.0005 mfd.; with a 0.00035 condenser coil L should consist of 60 turns. With either size, coil L_1 may consist of about 15 turns wound at the b end of the secondary coil. With arrangement B taps should be made at about every 10 turns.



No. 156 RADIO BROADCAST Laboratory Information Sheet **January, 1928**

Wavelength-Frequency Conversion

A TABLE FOR THE BROADCASTING BAND

ON LABORATORY Sheet No. 157 is given a wavelength-frequency conversion table covering the broadcasting band. Broadcasting is assigned to channels 10 kc. apart on frequencies that are divisible by 10. It is simple to use the table. If we knew that some station was transmitting on 1000 kc. we can determine from the table the corresponding wavelength, which in this case is approximately 300 meters. The wavelength corresponding to any given frequency can be determined by dividing the frequency in kc. into 300,000.

A 10-kc. separation between broadcasting stations is necessary to prevent bad interference between two stations on adjacent channels. When a broadcasting station is transmitting it actually uses a band of frequencies (side bands) 10,000 cycles wide—5000 cycles either side of the "carrier" frequency. The carrier frequency is the frequency assigned a station by the Federal Radio Commission, but as mentioned above, in the ordinary process of modulation a frequency band 10,000 cycles wide is used.

When a station is transmitting it also radiates a frequency exactly double its carrier frequency. The additional wave is called the second harmonic, being equal in frequency to the carrier frequency multiplied by two. Careful design and operation of the transmitter will keep these harmonics small in amplitude and this is essential if interference is to be prevented. If a station transmits on, say, 600 kc. and also radiates a strong second harmonic with a frequency of 1200 kc., it will interfere with another station transmitting on a carrier frequency of 1200 kc.

Any radio station might be considered to have two ranges; first the broadcasting range, being the distance area over which the program on the station may be received satisfactorily and, secondly, the interference range, being the area over which a station causes interference due to the production of a heterodyne whistle between its carrier and the carrier of another station. The first range is much smaller than the second and a station having a service area of 100 miles will have an interference range of probably about 1000 miles.

No. 157 RADIO BROADCAST Laboratory Information Sheet **January, 1928**

Table for Wavelength-Frequency Conversion

Kc.	Meters	Kc.	Meters	Kc.	Meters	Kc.	Meters
550	545.1	800	374.8	1,050	285.5	1,300	230.6
560	535.4	810	370.2	1,060	282.8	1,310	228.9
570	526.0	820	365.6	1,070	280.2	1,320	227.1
580	516.9	830	361.2	1,080	277.6	1,330	225.4
590	508.2	840	356.9	1,090	275.1	1,340	223.7
600	499.7	850	352.7	1,100	272.6	1,350	222.1
610	491.5	860	348.6	1,110	270.1	1,360	220.4
620	483.6	870	344.6	1,120	267.7	1,370	218.8
630	475.9	880	340.7	1,130	265.3	1,380	217.3
640	468.5	890	336.9	1,140	263.0	1,390	215.7
650	461.3	900	333.1	1,150	260.7	1,400	214.2
660	454.3	910	329.5	1,160	258.5	1,410	212.6
670	447.5	920	325.9	1,170	256.3	1,420	211.1
680	440.9	930	322.4	1,180	254.1	1,430	209.7
690	434.5	940	319.0	1,190	252.0	1,440	208.2
700	428.3	950	315.6	1,200	249.9	1,450	206.8
710	422.3	960	312.3	1,210	247.8	1,460	205.4
720	416.4	970	309.1	1,220	245.8	1,470	204.0
730	410.7	980	303.9	1,230	243.8	1,480	202.6
740	405.2	990	302.8	1,240	241.8	1,490	201.2
750	399.8	1,000	299.8	1,250	239.9	1,500	199.9
760	394.5	1,010	296.9	1,260	238.0		
770	389.4	1,020	293.9	1,270	236.1		
780	384.4	1,030	291.1	1,280	234.2		
790	379.5	1,040	288.3	1,290	232.4		

KARAS A-C-FORMER

FILAMENT SUPPLY

TYPE 12

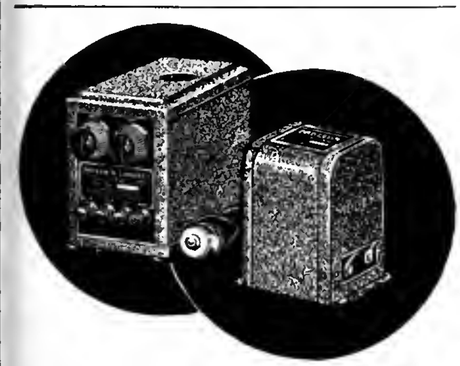
LIST PRICE $13.50

NO HUM!

At last you can step down your 110 volt A. C. house current to operate your set with standard A. C. tubes such as Cunningham, RCA and CeCo, without having to use separate device for center tap, and with ABSOLUTELY NO HUM. Let the Karas A-C-Former Filament Supply, Type 12, replace your "A" Battery and charger. Will operate 8 1½-volt Type 226 or 326 Tubes, 2 2½-volt Type 227 or 327 Tubes, and 2 5-volt Type 177 Tubes at one time. Compact, powerful, sturdy and built the Karas Way—by precision methods. Write for complete information about the new Karas A-C-Former and also data on the Knickerbocker 4 and Karas 2-Dial Equamatic.

KARAS ELECTRIC COMPANY
4033-A North Rockwell Street **Chicago**

2-DIAL KARAS EQUAMATIC
USE
KARAS
PARTS
KNICKERBOCKER "4"



Two Aids to Better Radio

MODERN

"B" Compact

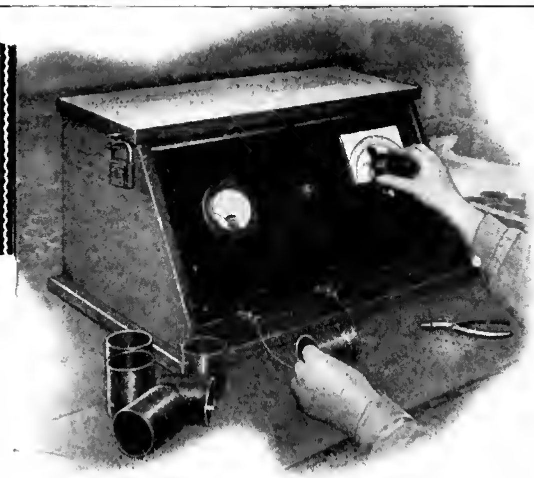
Type M Transformers

To improve your set or get the best results with any set you contemplate building, install Modern Type M Transformers, and then use a Modern "B" Compact—the dependable B current supply.

Modern radio products are designed and manufactured by engineers who know how to get results. They are guaranteed to serve you to your satisfaction and you are not enjoying radio to the fullest extent if you have not installed Modern Type M Transformers and a Modern "B" Compact.

Write for Type M audio amplifier circuits and booklet on "B" power unit operation. Address Dept. RB1.

THE MODERN ELECTRIC MFG. CO.
Toledo, Ohio



Scientific measurement of inductance has made Hammarlund Space-wound Coils the most efficient and dependable ever devised.

Hammarlund Coil Inductance

Scientifically Measured

NOT very long ago, so many turns of wire on such and such size core were considered accurate enough for inductance measurement.

But in this age of multi-tuned, single-control circuits, guesswork is out of the question. Coils must be matched to the finest degree.

Not satisfied merely with producing the most efficient type of coil, Hammarlund devised the instrument pictured above, to insure accurate measurement of inductance values.

You can depend on Hammarlund precision. It means standardized quality and assurance that you get what you pay for.

Your dealer sells Hammarlund Matched Coils for the latest popular circuits.

HAMMARLUND MANUFACTURING COMPANY
424-438 West 33rd Street, New York

More than a score of radio designers officially specify Hammarlund Precision Products for their newest circuits

For Better Radio
Hammarlund
PRECISION
PRODUCTS

Dealer inquiries invited concerning several new and appealing Hammarlund developments, having a wide sales demand.

Electrostatic condensers for all purposes

Faradon

WIRELESS SPECIALTY APPARATUS COMPANY
Jamaica Plain
Boston, Mass.

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SPECIAL CIRCUIT PACKAGES

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RADIO ACCESSORIES at WHOLESALE

Radio Sets, "B" Eliminators, Chargers, Tubes, Kits, Parts—everything new in Radio at lowest wholesale prices. Thousands of nationally advertised bargains. All listed and illustrated in my Big New Catalog and **FREE Call Book.**

132 Pages of valuable Radio information—trouble finding, set building—Radio knowledge of all kinds. Write today. HARRY SCHWARTZBERG PRES.

FREE

AMERICAN AUTO & RADIO MFG. CO.
Dept. 124 American Radio Bldg.
Kansas City, Missouri

No. 158 RADIO BROADCAST Laboratory Information Sheet January, 1928

The Three-Tube Roberts Reflex

CIRCUIT CONSTANTS

THERE have been many requests from readers for further information on the Roberts 3-tube receiver illustrated in the August, 1927 issue of RADIO BROADCAST on page 209. This receiver is a reflex set consisting of a stage of r.f. amplification, a regenerative detector, one stage of reflexed transformer-coupled audio amplification, followed by another straight audio stage. The circuit, which was not given in the article mentioned above, and which many readers have requested, is published on Laboratory Sheet No. 159. The list of parts is given below.

L_1, L_2—R. F. transformer. L_2 may consist of 45 turns of No. 24 wire wound on a 3-inch tube. L_1 should contain 40 turns of No. 24 wire with a tap at each 10 turns. L_1 should be wound alongside the filament end of L_2.

L_3, L_4, L_5—Interstage r.f. transformer. L_3 and L_4 have the same specifications as L_1 and L_2 with the exception that L_3 should be wound with No. 26 or No. 28 wire and should only be tapped at the exact center instead of at every 10 turns. That end of L_3 nearest the grid end of L_4 should connect to the plate of the r.f. tube, the center tap connects to transformer T_2, and the other end of L_3 connects to the neutralizing condenser. L_5 is a movable tickler coil consisting of 20 turns of No. 26 on a 1½ inch tube.

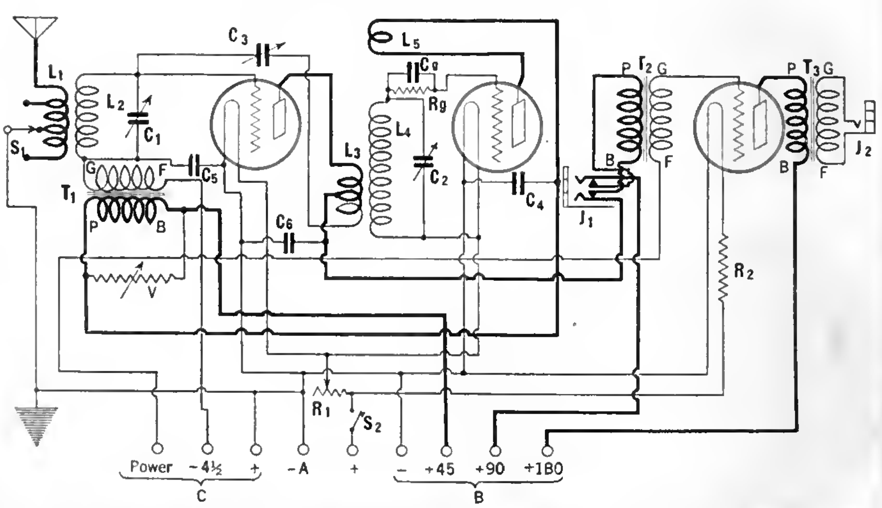
T_1, T_2—Any good audio transformers.
T_3—Any good output transformer.
C_1, C_2—0.0005-mfd. variable condensers.
S_1—Antenna tap switch.
S_2—Filament switch.
J_1—Double-circuit interstage jack.
J_2—Single-circuit jack.
V—Volume control, 50,000-ohm variable resistance.
C_3—Neutralizing condenser, 0.000015 mfd.
C_g—Grid condenser, 0.00025 mfd.
R_g—4-megohm grid leak.
R_1—10-ohm rheostat.
R_2—0.5-ampere fixed filament control resistance.
C_4—0.001-mfd. fixed condenser.
C_5—0.0001-mfd. fixed condenser.
C_6—0.00025-mfd. fixed condenser.
Eleven binding posts
Three sockets
Hook-up wire

For best results a power tube should be used in the last socket. If a 171 type tube is used with 180 volts on the plate, the C bias required is 40.5 volts.

When the receiver has been completed it should be neutralized by tuning-in some station, adjusting the tickler until the detector oscillates and a whistle is heard and then varying the neutralizing condenser until the whistle changes in pitch the least amount (its loudness will change considerably) as C_1 is varied.

No. 159 RADIO BROADCAST Laboratory Information Sheet January, 1928

The Three-Tube Roberts Reflex



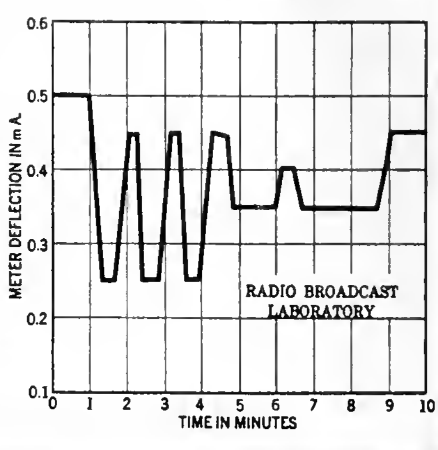
No. 160 RADIO BROADCAST Laboratory Information Sheet January, 1928

Fading

HOW IT MAY BE PLOTTED

ON THIS Laboratory Sheet is published a curve showing how the signal strength from station WGY varied over a period of about 10 minutes during a fading test on this station made during the early part of November.

Anyone can make these measurements. To make fading measurements of this sort the only instrument needed is a 1.5-or 2-mA. milliammeter. The meter is connected in the B plus lead to the detector tube; it will read about 1 mA. if the detector is a 201-A type tube using a grid leak and condenser for detection with 45 volts on the plate. When a signal is tuned-in the meter deflection will decrease, the amount of the decrease depending upon the strength of the signals. If the meter deflection with the signal tuned-in is subtracted from the meter deflection when not receiving a signal, the difference will be the amount the meter deflection has changed due to the signal. If the normal plate current is 1 mA. and the signal causes the values to decrease to 0.6 mA. then the deflection due to the signal is 0.4 mA. If this value varies with time it indicates fading and can be plotted as a curve, as shown on this Sheet. An examination of this curve indicates that at the start of the test the meter deflection due to the signal was 0.5 mA. but that after about one minute the signal strength quickly fell to 0.25 mA. and then increased and decreased several times in rapid succession.



"RADIO BROADCAST'S" DIRECTORY OF MANUFACTURED RECEIVERS

¶ A coupon will be found on page 258. 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 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. 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. Milliammeter 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 60¼ 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. 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. 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, $2.50

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 NRII

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. 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 7⅛ 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. 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. 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 8¼. Price: $130 without accessories.

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. 522. CASE, 62B AND 62C

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 62B, 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. 542. PFANSTIEHL JUNIOR SIX

Six tubes: 3 t. r. f. (01-A), detector (01-A), 2 audio. Pfanstiehl circuit. Volume control: variable resistance in r. f. plate circuit. One dial. Shielded. Battery cable. C-battery connections. Etched bronze panel. Antenna: outdoor. Cabinet size: 9 x 20 x 8 inches. Price: $80, without accessories.

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 15mA. 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. 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 5½ x 7⅝. 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 24 MA. Volume control: rheostat on r. f. Coils shielded. Battery cable. C.-battery connections. Headphone connection. Antenna: outdoor. Cabinet size: 20 x 13¾ x 10½ 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: 43,A. 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 13¾ x 11½ inches; console, 29 ~ 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 to35mA. 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 25mA. 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: 35mA. 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 65 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: 22½ 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 25mA. "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: 42mA. 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: 25mA. 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: 19mA. 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: 40mA. 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. 547. ATWATER KENT, MODEL 33

Six tubes; 3 t. r. f. (01-A), detector (01-A), 2 audio (01-A and 71 or 12). One dial. Volume control: r. f. filament rheostat. C-battery connections. Battery cable. Antenna: 100 feet. Steel panel. Cabinet size: 21⅛ x 6¾ 6¼ inches. Price: $75, without accessories.

NO. 544. ATWATER KENT, MODEL 50

Seven tubes; 4 t. r. f. (01-A), detector (01-A), 2 audio (01-A and 12 or 71). Volume control: r. f. filament rheostat. C-battery connections. Battery cable. Special bandpass filter circuit with an untuned amplifier. Cabinet size: 20¾ x 13 x 7¾ inches. Price: $120.

NO. 452. ORIOLE 90

Five tubes; 2 t. r. f., detector, 2 transformer audio. All 01-A tubes. "Trinum" circuit. Two dials. Plate current: 18mA. 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 45 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 8¾ 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 rubes, 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 13⅛ 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: 35mA. Antenna: 100 feet. Prices: Model 61A, $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

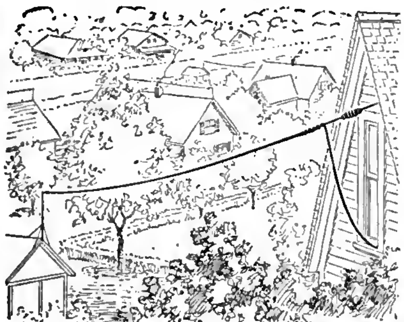
Five tubes; 2 t. r. f. (01-A), detector (01-A), 2 audio (01-A). Two controls. Volume control: rheostat. C-battery connections. Binding posts. Antenna: 75 feet. Prices: Model 27, $65; Model 271, $99.50; Model 272, $125.

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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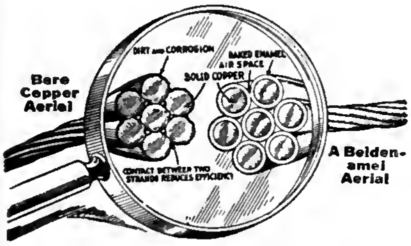

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245 Fifth Avenue New York City

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 X 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: 16mA. 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: 20mA. 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 14½ inches. Price not established.

NO. 542 RADIOLA 16

Six 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: 16 x 8¾ 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: 19⅝ 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: 45mA. 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 40mA. 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. 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. 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 25mA. Volume control: resistance in r. f. plate. Shielded. Battery cable. C-battery connections. Antenna: 80 feet. Cabinet sizes: No. 705 table, 26⅛ x 11¼ x 13 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 11/16 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 35mA. 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 7/16 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 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. 472. VOLOTONE VIII

Six tubes. Same as No. 471 with following exceptions; 2 t. r. f. stages. Three dials. Plate current: 2-mA. Cabinet size: 26½ x 8 x 12 inches. Price $140.

NO. 546. PARAGON "CONGRESS"

Six tubes; 2 t. r. f. (01-A), detector (01-A), 3 impedance-coupled audio (two 01-A and 12 or 71). One main control and three auxiliary adjustments. Volume control: resistance in r. f. plate circuit. Plate current: 40 mA. C-battery connections. Tuned double-impedance audio amplifier. Output device. R. F. coils are shielded. Cable or binding posts. Cabinet size: 7 x 18 x 19 inches. Price $90.00; without cabinet, $80.00.

THIS RADIO CHRISTMAS

by

Zeh Bouck

LIKE all people, I hate to brag. And I sincerely believe that there is no one in this world who knows more about giving things radio for Christmas than the writer. I have had a radio laboratory for some ten years now, to which manufacturers send samples of their products. With the exception of an occasional birthday, or a debt here and there, this apparatus accumulates until around this time of the year. And I'd give away a lot more Christmas presents if radio manufacturers only supplied green tissue paper and red ribbons.

So it is most fitting that I should be telling you how to spend your money on radio Christmas presents—or perhaps it isn't. I find myself in somewhat the reverse situation of Oscar Wilde's cynic who knew the price of everything but the value of nothing. At any rate, our ever-increasing horde of radio burglars will find what I have to say of unequalified use.

From One Dollar Up

WE—or rather you—may start your purchases from a dollar up. (Make sure you do not start them with a dollar down. This stretches Christmas out over too long a period of time with rather fatal results to the Christmas spirit.)

In the case of a radio Christmas present, not everything within the various price ranges can be considered. There are many parts particularly designed for special circuits and receivers, and unless you are aware that the recipient is interested in this particular apparatus you will do well to confine yourself, for the greater part, to accessories.

One Dollar to Three Dollars

This class recommends itself to gifts among the family—to brother, sister, cousins, aunts, and all the rest sacred to Gilbert and Sullivan. The following are really too useful for gifts:

One or two 01A type tubes
A loud speaker extension cord
A battery cable
A light socket antenna (for the gentleman with the loop set)
An antenna set
A set of 0.5, 1.0, 1.5, 2.0, 3.0, and 5.0-megohm metallic grid leaks

At the very beginning we run into the inevitable book. The following are on our own shelves:

For the Engineer: *Engineering Mathematics*, D. Van Nostrand and Company

For the Amateur: *The Radio Amateur's Handbook*, The American Radio Relay League, Hartford, Connecticut, $1.00.

For the Average Fan: *The Outline of Radio*, by John V. L. Hogan, Little Brown and Company, or *How Radio Receivers Work*, by W. Van B. Roberts, published by Radio Broadcast, Garden City, N. Y., $1.00

A subscription to *The Bell Technical Journal* (195 Broadway, New York City) at $3.00 will be gratefully received by the engineer in the family, and a subscription to QST (American Radio Relay League, Hartford, Conn.) at $2.00 by the amateur or even broadcast fan.

Three Dollars to Five Dollars

As we go up a bit in price, the charity that should begin at home evidences itself in gifts outside the family—our purse strings loosen and we splurge with:

Output filters
A set of five 1.0-mfd. bypass condensers
A telephone headset
A power tube
A filament relay

The following books for engineering folk:

Theory of Vibrating Systems and Sounds by Crandall, $5.00. (D. Van Nostrand & Co.)

The Thermionic Vacuum Tube by H. J. Van de Bijl, (McGraw Hill), $5.00

A most acceptable and unique gift may be effected by obtaining a copy of *Radio Instruments and Measurements* from the Bureau of Printing and Engraving, Government Printing Office, Washington, for $.75 (no stamps) and having it bound by Brentano's or some similar establishment.

And a subscription to Radio Broadcast is never out of place.

Five Dollars to Ten Dollars

A slide rule is always an acceptable present to the engineering friend who possesses the inevitable book, if he hasn't a slide rule. Get a Keuffel and Esser Polyphase Mannheim ten-inch rule. Do not succumb to the seductive technicalities of various "duplex" and "log log" designs. The engineer would thank you, of course, for these last types, and use it, perhaps. as a straight edge; but that's about all.

You can always determine whether your technical friend has the book you want to give him or not. Just say to him, "I understand that in hyperbolic space the characteristic constant is negative, the degree of negativity varying directly with the divergence from Euclidean space. I want to check up on this. Lend me your Crandall, or your Morecroft or your Van de Bijl, will you?"

If he tells you he hasn't the book, you will know he has it but doesn't want to loan it to you.

The following are indispensable books:

The Manual of Radio Telegraphy and Telephony, Admiral S. S. Robison, United States Naval Institute, Annapolis, Md. $5.50

Principles of Radio Communication, J. H. Morecroft, John Wiley and Sons, New York City, $7.50 (and worth it!)

An electrical Engineering Handbook

Among parts and accessories, we have:

A QRS or Raytheon Rectifying tube
An output filter
A resistance-coupled amplifying kit
A filament control relay (to control your power unit and A battery from the set's on-off switch)
A tube rejuvenator
A Balsa Speaker kit
A loud speaker unit

Ten Dollars to Fifteen Dollars

The customary way to give Christmas gifts is to establish the understanding that you do not believe in the exchange of gifts—that you are giving nothing except cards—and then give presents anyway to make your friends uncomfortable. We suggest the following in the line of this expensive misanthropy:

An "A" supply filter such as the "A-Box"
A *good* trickle charger
A ——— kit.
A Balsa speaker kit

Fifteen Dollars to Twenty Dollars

We are fairly well above the usual engineering books, but you might try a set of Rabelais. Boni and Liveright have a new limited edition selling for $20.00

Then there are:

A complete set of "B" batteries (a really fine present!)
A cone loud speaker
A set of good audio transformers
A ——— kit
A standard high-rate charger
A Balsa speaker kit

Twenty Dollars to Twenty-Five Dollars

We may now leave on the price tags, and suggest—

A cone loud speaker
A complete set of A-C tubes
An "A" battery and charger combination
A ——— kit
A radio table (a good one).

Twenty-Five Dollars to Fifty Dollars

We now leave gifts to the family and friends and consider presents for elevator boys, postmen, janitors, ice-men and others requiring special attention.

A very fine cone or Balsa speaker.
A well-designed "B" and "C" battery eliminator.
A ——— kit

From Fifty Dollars up

We started with gifts for the family, and we conclude with the same. If there is a very expensive bit of apparatus for which you have long yearned—some deluxe speaker, perhaps a Norden Hauck Super or a Radiola Borgia model, or maybe a Wheatstone Bridge or a Leeds & Northrup type K potentiometer—why give it to the family for Christmas.

And in closing let me advise you to do your Christmas shopping early—early on the morning of December twenty-fourth.

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-milliampere 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.

103. A. C. TUBES—The design and operating characteristics of a new a. c. tube. Five circuit diagrams show how to convert well-known circuits. SOVEREIGN ELECTRIC & MANUFACTURING COMPANY.

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.

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.

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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.

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.

105. COILS—Excellent data on a radio-frequency coil with constructional information on six broadcast receivers, two short-wave receivers, and several transmitting circuits AERO PRODUCTS COMPANY.

106. AUDIO TRANSFORMER—Data on a high-quality audio transformer with circuits for use. Also useful data on detector and amplifier tubes. SANGAMO ELECTRIC COMPANY.

107. VACUUM TUBES—Data on vacuum tubes with facts about each. KEN-RADIO COMPANY.

108. VACUUM TUBES—Operating characteristics of an a.c. tube with curves and circuit diagram for connection in converting various receivers to a.c. operation with a four-prong a.c. tube. ARCTURUS RADIO COMPANY.

109. RECEIVER CONSTRUCTION—Constructional data on a six-tube receiver using restricted field coils. BODINE ELECTRIC COMPANY.

110. RECEIVER CONSTRUCTION—Circuit diagram and constructional information for building a five-tube set using restricted field coils. BODINE ELECTRIC COMPANY.

111. STORAGE BATTERY CARE—Booklet describing the care and operation of the storage battery in the home. MARKO STORAGE BATTERY COMPANY.

112. HEAVY-DUTY RESISTORS. Circuit calculations and data on receiving and transmitting resistances for a variety of uses, circuits for popular power supply circuits, d.c. resistors for battery charging use. WARD LEONARD ELECTRIC COMPANY.

113. CONE LOUD SPEAKERS—Technical and practical information on electro-dynamic and permanent magnet type cone loud speakers. THE MAGNAVOX COMPANY.

114. TUBE ADAPTERS—Concise information concerning simplified methods of including various power tubes in existing receivers. ALDEN MANUFACTURING COMPANY.

115. WHAT SET SHALL I BUILD?—Descriptive matter, with illustrations, of fourteen popular receivers for the home constructor. HERBERT H. FROST, INCORPORATED.

104. OSCILLATION CONTROL WITH THE "PHASATROL"—Circuit diagrams, details for connection in circuit, and specific operating suggestions for using the "Phasatrol" as a balancing device to control oscillation. ELECTRAD, INCORPORATED.

A KEY TO RECENT RADIO ARTICLES

By E. G. SHALKHAUSER

THIS is the twenty-fifth 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.

R402. SHORT-WAVE SYSTEMS. SHORT WAVES, *$\frac{3}{4}$-Meter*
QST. Aug., 1927. Pp. 9–14.
"The $\frac{3}{4}$-Meter Band Officially Opened," B. Phelps and R. S. Kruse.
Detailed information on $\frac{3}{4}$-meter transmitting and receiving sets is presented. It is stated that tubes having the XL filaments have a very short life at these frequencies, best results being obtained from the old UV-202 tubes, The antenna system, and the methods used in determining the length of the wave transmitted, are shown. The field tests indicate the manner in which signals decrease in strength and show the location of dead spots.

R132.1. AMPLIFYING ACTION: INDUCTIVE COUPLING. AMPLIFIERS, *Audio*
QST. Aug., 1927. Pp. 15–20.
"Better Audio Amplification for Short-Wave Receivers," L. W. Hatry.
The writer shows the practical use of more than one audio stage of amplification for short-wave receivers. In order to insure more uniform volume from headphones, whether listening to foreign or domestic stations, a switching or a shunt resistance system is described. The type of audio transformer to be used depends greatly upon the type of reception desired, a scheme being shown whereby an amplifier may be made either peaked or flat by using a tuned rejector circuit.

R346. RADIO TELEPHONE SETS (ELECTRON-TUBE). TRANSMITTER, *Short-Wave Crystal.*
QST. Aug., 1927. Pp. 21–24.
"Cuban 6 XJ," F. H. Jones and H. P. Westman.
The construction and the tuning of a first-class phone station operated on 20 meters, are outlined. A crystal, having a natural period of 159.6 meters, controls the transmitted frequency. The set consists of an oscillator and three amplifiers. Instead of using the Heising constant-current method of modulation, the series method of plate modulation is employed with good results. A circuit diagram and a list of parts are shown.

R213. HARMONIC METHODS. HARMONICS, *Determination of.*
QST. Aug., 1927. Pp. 34–35.
"The Identification of Radio-Frequency Harmonics," J. E. Waters.
A method of determining and identifying radio-frequency harmonics when making measurements of radio-frequency oscillations is outlined. Use is made of a standard wavemeter, an oscillator, and a receiver.

R113. TRANSMISSION PHENOMENA. TRANSMISSION, *Short-Wave.*
QST. Aug., 1927. Pp. 36–42.
"Short-Wave Radio Transmission and Its Practical Uses," C. W. Rice. (Continued.)
The variation of signal strength with distance is discussed, taking into consideration the effect of multiple reflection. In order to choose the proper wavelength to use for distant transmission in summer daylight, a theoretical chart is prepared, showing probable performance of different waves. Conclusions drawn point to the following: Below 10 meters distant communication is impossible; the plane of polarization in the sky wave is no determining factor for energy flux density and for ray paths; different waves give best results between two given points; low-angle radiation is best for long-distance work.

R281.71. QUARTZ. QUARTZ.
RADIO BROADCAST. Sept., 1927. Pp. 271–273.
"Piezo-Electric Crystals," M. T. Dow.
The writer explains the use of quartz crystal oscillators in the calibration of frequency meters. How to distinguish between the harmonics that are heard when two oscillators are in operation, is fully outlined. Photographs and circuit diagrams illustrate the points in question.

R113. Transmission Phenomena. Transmission, *Short-Wave.*
Proc. I. R. E. June, 1927. Pp. 501–517.
"Some Practical Aspects of Short-Wave Operation at High Power," H. E. Hallborg.

Propagation data on the frequency range of 3000 to 30,000 kilocycles are submitted. A correlation is shown between wave frequency and angle of projection of the wave front. The effect of ionization on the angle of projection is indicated. Some calculations are given of probable values of attenuation constant.

The importance of frequency stabilization is discussed, and three typical circuits for utilizing control crystals are described. Features of the design and adjustment of a 20-kw. power amplifier are also outlined. Antenna and antenna feed systems are discussed, and graphical results of comparisons of various antenna types are given. The relative importance of static at short wavelengths is considered. The author's anticipation of the density of the short wave is summarized.

R612. Short-Wave Stations. Stations, *Short-Wave.*
Proc. I. R. E. June, 1927. Pp. 467–499.
"Short-Wave Commercial Long-Distance Communication," H. E. Hallborg, L. A. Briggs, and C. W. Hansell.

The development of short-wave communication by the Radio Corporation of America is outlined. A summary of short-wave installations, with call letters, wavelengths, and services to which each installation is assigned, is submitted.

Traffic charts showing the diurnal and seasonal characteristic of various wavelengths over typical circuits are also shown. An outline of the technical problems inherent to the development of tubes and transmitter circuits is discussed. Methods are described for obtaining proper operation of tubes and transmitters at these very short wavelengths. The paper is illustrated with typical pictures and charts showing transmitter development and traffic performance.

R800 (512.82). Complex Variables. Functions.
Proc. I. R. E. June, 1927. Pp. 519–524.
"Maximization Methods for Functions of a Complex Variable," V. B. Roberts.

The maxima and minima of a function of a real variable are found by equating to zero the derivative of the function. In the case of a function of a complex variable, however, the derivative is a vector quantity, so that conditions may be imposed upon its direction as well as upon its magnitude. These various conditions lead to maxima and minima of the various aspects of the function. Rules are developed for setting up equations giving the various maximizing conditions, and a simple example is given illustrative of the use of the rule.

R240. Phase Difference. Phase Relations.
Radio, Aug., 1927. Pp. 21-ff.
"Phase Relations in Radio," J. E. Anderson.

Of importance to radio experimenters is this discussion on the effect of phase relation between current and voltage in amplifier circuits. To illustrate the point, the phase conditions in a 4-tube resistance-coupled amplifier are analyzed in detail. Impedance- and audio-transformer coupled circuits are also discussed and the points to be observed are mentioned.

R334. Four-Electrode Tubes Four-Electrode Characteristics.
Radio. Aug., 1927. P. 23–24.
"The Static and Dynamic Characteristics of a Double-Grid Vacuum Tube," H. R. Lubcke.

Static and dynamic characteristics of Van Horne double-grid vacuum tubes are graphed and discussed. It is noted that (1) a change in characteristics accompanies a change in frequency; (2) high plate voltages should be used because of hi-mu characteristics; (3) the inner grid should have a 1-volt C bias and the outer grid a 3-volt C bias; (4) the plate impedance of the tube should match that of the transformer primary in radio-frequency amplification.

R800. (530.) Physics. Ultra-Violet Rays.
Radio Broadcast. Sept., 1927. Pp. 263–265.
"A Discovery That Newton Missed," J. Stokley.

The history of ultra-violet rays, starting with the time of Newton two centuries ago, continuing with their discovery by Ritter, and ending with an explanation of their use made to-day in medical sciences, is given.

RR356. Transformers. Transformers, *Construction of.*
Radio Broadcast. Sept., 1927. Pp. 274–278.
"Home-Constructing Transformers and Chokes for Power-Supply Devices," H. S. Davis.

By means of charts and certain fundamental mathematical formulas, sufficient information may be obtained to design and construct power transformers and choke coils for use in a.c. operated receivers. Of importance is said to be the characteristics of secondary windings, *i. e.*, voltage current and power values, total turns in each winding, size and amount of core and wire, etc.

R330. Electron Tubes. Electron Tubes, *New A. C.*
Radio Broadcast. Sept., 1927. Pp. 284–285.
"The New A. C. Tubes," Radio Broadcast, Laboratory Staff.

Information and data on the operation of various a.c. tubes now on the market show how these may vary in performance. From the writers viewpoint, a.c. operated tubes still belong in the experimental class.

Erratum

An error occurred in the circuit diagram of the "Shielded Six" receiver published in the November, 1927, issue of Radio Broadcast. The connection indicated between terminal No. 6 of the third coil socket and the negative terminal of the detector tube socket, should be ignored. If this connection is made the C battery will be short-circuited and the detector will operate very inefficiently.

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 258 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 $30.00.

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.

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 Improved Super 10—Ten tubes; five stages of tuned radio frequency, detector, and four stages of choke- and transformer-coupled audio frequency. Two controls. Price $260.00.

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.

What Kit Shall I Buy? (*Continued*)

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 dectector, 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.

224. Browning-Drake—Five tubes; one stage tuned radio frequency (with special neutralization system), regenerative detector (tickler control), three stages of audio (special combination of resistance and impedance-coupled audio). Two controls.

225. Aero Short-Wave Transmitting Kit consists of interchangeable coils to be used in tuned-plate tuned grid circuit. Kits of coils, two choke coils, and mountings, can be secured for 20-40 meter band, 40-80 meter band, or 90-180 meter band, for $12.00

USE THIS COUPON FOR KITS

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Garden City, New York.
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Name..

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(Number) (Street)

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(City) (State)

ORDER BY NUMBER ONLY. This coupon must accompany each order.
RB 1-28

A New R. F. System

The De Forest Company, which from the beginning has been one of the principal opponents of the rapidly augmenting position of the Radio Corporation in the radio patent field, recently announced that Dr. George A. Somersalo, a Finnish physicist, has developed a new system of radio-frequency amplification which does not conflict with the Alexanderson tuned radio-frequency patent. This system depends upon the use of a filter ahead of the first radio stage, the radio-frequency amplifier being untuned. The Alexanderson patent, however, is not the only one possessed by the Radio Corporation of America and a great battle of wits lies ahead for those who want to do entirely without Radio Corporation licenses. No one who has had extensive contact with the American inventor, however, would venture to predict that it cannot be done.

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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....

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Name..

Address ....
(*Number*) (*Street*)

....
(*City*) (*State*)

ORDER BY NUMBER ONLY
This coupon must accompany each order. RB 1-28

RADIO BROADCAST

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The Facts About Output Devices

Tested Uses for the New Screen-Grid Tube

A Directory of Manufactured Radio Receivers

An A-C Push-Pull Amplifier and B Supply

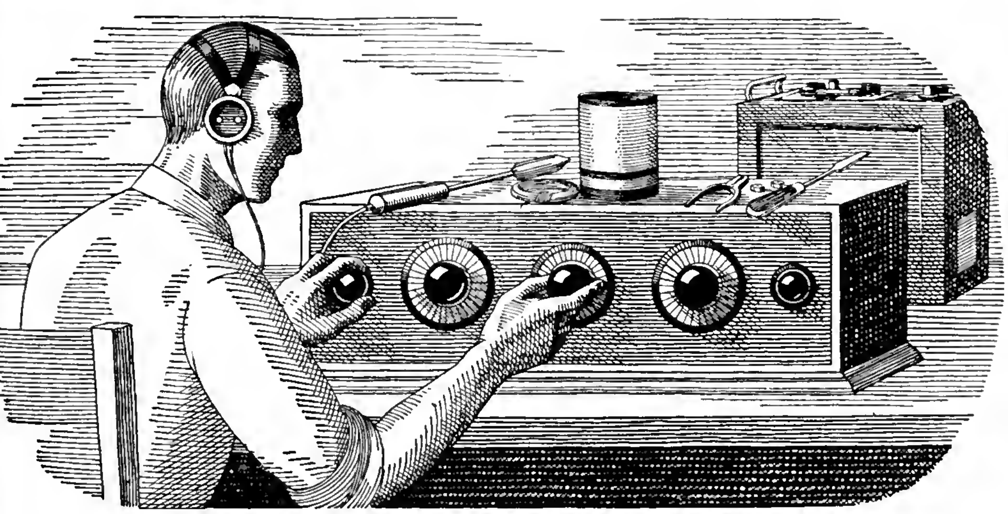
How to Build an A-C Super-heterodyne

The Eyes of a Future Air Liner

35 Cents

Doubleday, Doran & Company, Inc.
Garden City, New York

FEB - 1928



If all the Radio sets I've "fooled" with in my time were piled on top of each other, they'd reach about half-way to Mars. The trouble with me was that I thought I knew so much about Radio that I really didn't know the first thing. I thought Radio was a plaything—that was all I could see in it for me.

I Thought Radio Was a Plaything

But Now My Eyes Are Opened, And I'm Making Over $100 a Week!

$50 a week! Man alive, just one year ago a salary that big would have been the height of my ambition.

Twelve months ago I was scrimping along on starvation wages, just barely making both ends meet. It was the same old story—a little job, a salary just as small as the job—while I myself had been dragging along in the rut so long I couldn't see over the sides.

If you'd told me a year ago that in twelve months' time I would be making $100 and more every week in the Radio business—whew! I know I'd have thought you were crazy. But that's the sort of money I'm pulling down right now—and in the future I expect even more. Why only today—

But I'm getting ahead of my story. I was hard up a year ago because I was kidding myself, that's all—not because I had to be. I could have been holding then the same sort of job I'm holding now, if I'd only been wise to myself. If you've fooled around with Radio, but never thought of it as a serious business, maybe you're in just the same boat I was. If so, you'll want to read how my eyes were opened for me.

When broadcasting first became the rage, several years ago, I first began my dabbing with the new art of Radio. I was "nuts" about the subject, like many thousands of other fellows all over the country. And no wonder! There's a fascination—something that grabs hold of a fellow—about twirling a little knob and suddenly listening to a voice speaking a thousand miles away! Twirling it a little more and listening to the mysterious dots and dashes of steamers far at sea. Even today I get a thrill from this strange force. In those days, many times I stayed up almost the whole night trying for DX. Many times I missed supper because I couldn't be dragged away from the latest circuit I was trying out.

I never seemed to get very far with it, though. I used to read the Radio magazines and occasionally a Radio book, but I never understood the subject very clearly, and lots of things I didn't see through at all.

So, up to a year ago, I was just a dabbler—I thought Radio was a plaything. I never realized what an enormous, fast growing industry Radio had come to be—employing thousands and thousands of trained men. I usually stayed home in the evenings after work, because I didn't make enough money to go out very much. And generally during the evening I'd tinker a little with Radio—a set of my own or some friend's. I even made a little spare change this way, which helped a lot, but I didn't know enough to go very far with such work.

And as for the idea that a splendid Radio job might be mine, if I made a little effort to prepare for it—such an idea never entered my mind. When a friend suggested it to me one year ago, I laughed at him.

"You're kidding me," I said.

"I'm not," he replied. "Take a look at this ad."

He pointed to a page ad in a magazine, an advertisement I'd seen many times but just passed up without thinking, never dreaming it applied to me. This time I read the ad carefully. It told of many big opportunities for trained men to succeed in the great new Radio field. With the advertisement was a coupon offering a big free book full of information. I sent the coupon in, and in a few days received a handsome 64-page book, printed in two colors, telling all about the opportunities in the Radio field and how a man can prepare quickly and easily at home to take advantage of these opportunities. Well, it was a revelation to me. I read the book carefully, and when I finished it I made my decision.

What's happened in the twelve months since that day, as I've already told you, seems almost like a dream to me now. For ten of those twelve months, I've had a Radio business of my own. At first, of course, I started it as a little proposition on the side, under the guidance of the National Radio Institute, the outfit that gave me my Radio training. It wasn't long before I was getting so much to do in the Radio line that I quit my measly little clerical job, and devoted my full time to my Radio business.

Since that time I've gone right on up, always under the watchful guidance of my friends at the National Radio Institute. They would have given me just as much help, too, if I had wanted to follow some other line of Radio besides building my own retail business—such as broadcasting, manufacturing, experimenting, sea operating, or any one of the score of lines they prepare you for. And to think that until that day I sent for their eye-opening book, I'd been wailing "I never had a chance!"

Now I'm making, as I told you before, over $100 a week. And I know the future holds even more, for Radio is one of the most progressive, fastest-growing businesses in the world today. And it's work that I like—work a man can get interested in.

Here's a real tip. You may not be as bad off as I was. But think it over—are you satisfied? Are you making enough money, at work that you like? Would you sign a contract to stay where you are now for the next ten years—making the same money? If not, you'd better be doing something about it instead of drifting.

This new Radio game is a live-wire field of golden rewards. The work, in any of the 20 different lines of Radio, is fascinating, absorbing, well paid. The National Radio Institute—oldest and largest Radio home-study school in the world—will train you inexpensively in your own home to know Radio from A to Z and to increase your earnings in the Radio field.

Take another tip—No matter what your plans are, no matter how much or how little you know about Radio—clip the coupon below and look their free book over. It is filled with interesting facts, figures, and photos, and the information it will give you is worth a few minutes of anybody's time. You will place yourself under no obligation—the book is free, and is gladly sent to anyone who wants to know about Radio. Just address J. E. Smith, President, National Radio Institute, Dept 2O, Washington, D. C.

J. E. SMITH, President,
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Dear Mr. Smith:

Please send me your 64-page free book, printed in two colors, giving all information about the opportunities in Radio and how I can learn quickly and easily at home to take advantage of them. I understand this request places me under no obligation, and that no salesman will call on me.

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RADIO BROADCAST

FEBRUARY, 1928

WILLIS KINGSLEY WING, Editor
KEITH HENNEY, Director of the Laboratory
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Vol. XII, No. 4

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AMONG OTHER THINGS. . .

WASHINGTON is distinctly the center of radio interest these days. One important conference which means much to radio all over the world is barely concluded with the closing of the International Radio Convention on November 25th when the Federal Radio Commission announces that public hearings will be held in Washington about the middle of January on the question of short-wave allocations. The thoughts of everyone have turned toward the short waves, and the Commission is very wise in holding hearings to enable some sort of ordered development to take place in these many vital channels now and in the years to come. Now in the short-wave channels are government, commercial, military, marine, naval, and amateur services. And, in addition, these channels contain some genuine experimental broadcasting stations and many more stations operating under experimental licenses which are broadcasting without any intelligent reason at all. The Commission is to be praised for its foresight in throwing this question open before it is too late.

THIS issue of RADIO BROADCAST contains articles of undoubted interest. "The Eyes of a Future Air Liner," for example, points out how radio can be applied to the present problems of air navigation. "Anonymous" cloaks the identity of an authority on radio and aviation—a man who is better qualified to write on these twin subjects than any one we know. There has been much almost hysterical writing about the wonderful possibilities of the screened-grid tube, recently announced, and precious little genuine information about actual experiment with the possibilities of this very interesting tube. The Laboratory Staff, in the article on page 282, presents actual facts about what this tube can do, highly important to every experimenter whose interests lie in this direction. . . . For the first time, too, as far as we know, the facts about output devices are related. From the story by Keith Henney on page 294 you can learn exactly what the different types are, what they will do, and how best to use each type.

REGULAR broadcasting in the New York area of photographs sent by the Cooley Rayfoto system will be established before this issue is in the hands of readers and, accordingly, we publish a story by the inventor, Austin Cooley, presenting some additional technical information about the receiver which is now available in parts form to every interested constructor. Many readers write to request their names be forwarded to the manufacturers of the essential products. Any reader who has not yet done so should address a letter to the undersigned who will forward the request to the companies concerned. Picture broadcasting is here and we prophesy that in the not too distant future great numbers of experimenters will take this field for their own, completely fascinated by it.

WE SHALL soon publish the descriptions of a remarkably inexpensive receiver using the screened-grid tube, a new receiver design by Glenn Browning, a technical description with circuit diagrams and data on the Crosley "Bandbox" set, and an interesting kit for an A-socket power supply which will furnish enough A potential for ten quarter-ampere tubes.

—WILLIS KINGSLEY WING.

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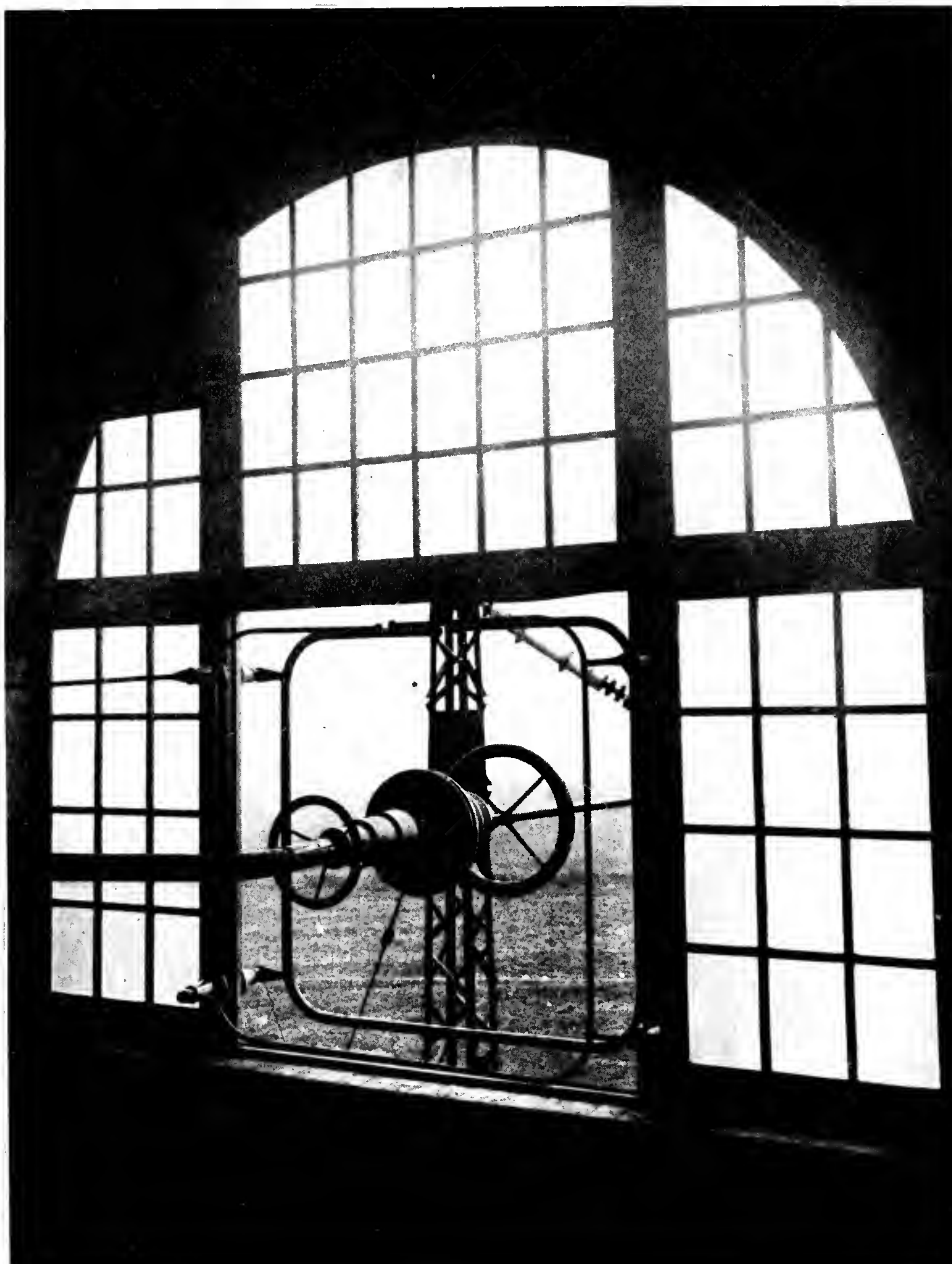
TERMS: $4.00 a year; single copies 35 cents.



At the Rugby High-Power Station of the British Post Office

The antenna lead-in as seen from the interior of the transmitter house. This station is one of the transmitters built in England by the British Marconi Company for the British Post Office, for communication with the Dominions. The British transmitter for the transatlantic radio telephone circuit is located at Rugby and the high-power radio telegraph transmitter is used for direct communication with Australia

OUT OF TOUCH WITH THE WORLD
One need not be a meteorologist, versed in the significance of the clouds, to know what weather is ahead and below, after flying in the upper atmosphere for many hours. A simple application of modern scientific principles will supply the information to pilots out of sight of the terrain

The Eyes of the Future Air Liner

"Anonymous"

DURING one of the ill-fated attempts to fly to Hawaii this summer the short-wave signals from the radio transmitter aboard the plane were copied in New York. Entire messages were easily received and the progress of the flight followed by newspaper reporters at the receiving stations, although the power of the transmitter wasn't enough to thoroughly warm up a curling iron.

It was a dramatic occurrence. Soon after the pilot took his heavily-loaded, single-engine plane off the runway and headed it westward over an unmarked trail traveled by few, cheerful messages came flashing back telling of the progress of the flight. The confident jaunty messages continued for some time. Then suddenly came warning of disaster. "We're in a spin," was the startling and serious message. The pilot was evidently able to momentarily bring his ship out of the spin, and put it back on an even keel. But not for long for the next message announced that the plane was again in a tailspin. And that was all, the last that was ever heard from that plane. Undoubtedly, the plane, loaded to the limit, was unstable. It could not be held in level flight in a fog or clouds, and stalled, with the resultant crash to the water below. Radio told of the end.

Over 3000 miles away newspaper reporters listening to these messages were impressed with the distance of transmission. In certain New York newspapers much was made over this feat of short-wave transmission. Reading these articles, one was ready to believe that something phenomenal in radio communication had taken place, and that the solution for problems of aircraft radio could be readily found in the use of short waves.

It is not believed that this is exactly so. Every radio amateur knows what can be done with low power on short waves. Bouncing his waves off a reflecting medium which scientists have named the Heaviside Layer, he is able to hop his signals all over the globe. He might well be something of a billiard player to properly angle his da-dit-dit-das so as to drop them on a friend's antenna perhaps on the other side of the world. But the amateur found that there were places, usually not so far away, where his waves could not be received, and other places close to him that reported considerable "fading." This much is known about short-wave transmission. But communication from plane to ground will be useless if not reliable over the entire route of flight. The "skip-effect" and the "fading" characteristic of waves much shorter than 80 meters makes their use in aircraft communication of little value. For what good will be the reception in San Francisco of a message sent by a plane flying from New York to Chicago when the message is intended for someone in New York?

The "skip" distance, or immune zone, is known to vary with the wavelength, the time of day, the time of year, the kind of antenna, and the nature of structures surrounding the antenna. There is a great deal to be learned about short-wave transmission from an airplane before the adoption of a definite near-short wave can be decided upon. The low power required, the simplified apparatus, the light weight, small size, and cost of short-wave equipment tempts one to jump at the proposition of equipping commercial craft with these sets. But research work in this connection must be exceedingly thorough. This means that the period of research must be extended to include all conditions as to season, time of day, and kind of terrain flown over, if work with short waves is to result in anything conclusive.

Before such research is begun it would be well to make a survey of the needs of commercial aviation with regard to radio service. Let us consider this point very briefly. First of all it appears that radio can be put to at least two very good uses on regular express and passenger air lines. Some means of telling the pilot in flight what is happening to the weather along the route ahead of him as well as at his destination would seem to be very desirable. Equally desirable would be a means for telling the pilot when he was off his course and to help him get on it again. These two are the most important requirements at the present time. Nothing need be invented to provide this assistance to aërial travel. It is but a question of application of things now known.

To see just how the two kinds of radio service mentioned might be utilized, let us use our imagination and picture an airway of the near future.

We may start where the most imagination is required and visit New York's great municipal airport. It is just dark and we have arrived in plenty of time for a glance around before we take the early evening express plane for Chicago. There are a number of planes on the "flying line." Busy mechanics are fussing around these while other mechanics and helpers push and wheel planes into and out of the huge squat hangars. Twinkling red, green, and white lights outline the boundary of the airdrome. The red lights indicate obstacles; the green lights show favorable approaches to the landing area, while the white lights show the general outline of the field. A flood light illuminates like day much of the landing area. Smaller lights flood the hangars and the concrete "aprons" between. A huge beacon flashes from a low tower on one of the hangars.

A SPERRY REVOLVING BEACON

This particular one was installed by the Department of Commerce

We approach the "flight office" and here we see a busy official marking up on a bulletin board news of the movement of "ships" on the various airways terminating at New York. Another official is marking the latest weather reports on a large weather map of the United States. Here we also see posted forecasts of the weather to be expected along the different airways. We read with no feeling of glee that on the route to Chicago we may expect rain, and low clouds through the mountain region, and somewhat higher clouds with showers from Cleveland to Chicago. Anxiously we go to inquire if in view of the weather prospects the Chicago express will leave to-night. We are assured that it will, and are advised to go aboard soon, as the "take-off" will not be delayed.

Aboard the big three-engined air liner we soon find that most of the twenty seats in the cabin are already occupied. We have seats near the front fortunately, and can observe through a doorway the controls and instruments in the pilot's cabin.

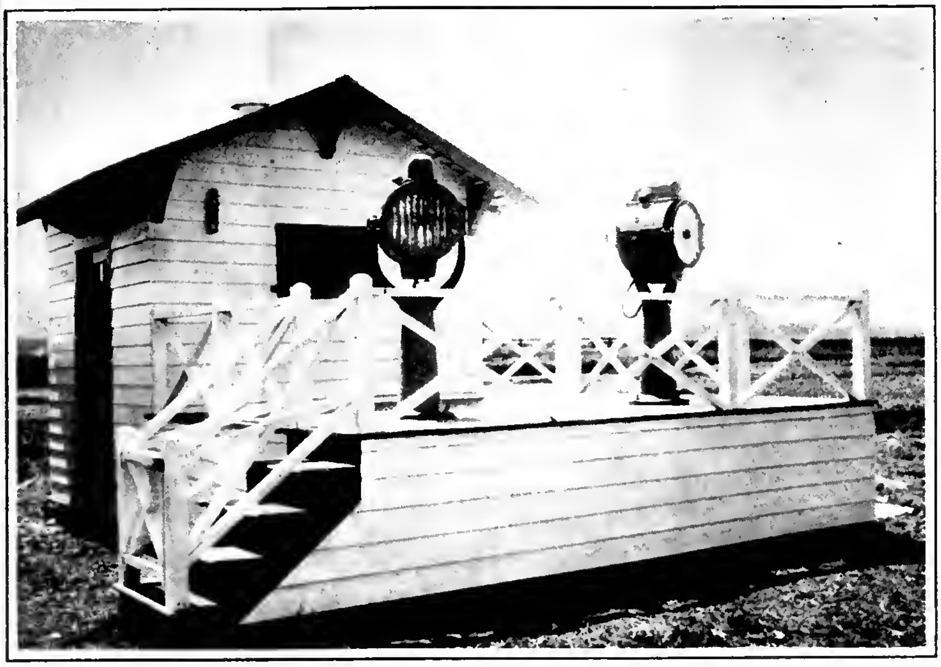
The engines have been warmed up and tested at full throttle and now are idling, the metal propellers turning over lazily, awaiting only the will of the pilot. He is getting into his seat and is talking to his mechanic in a seat at his side, when an official comes aboard to converse a moment with these members of the "crew." We are being "cleared" for Chicago. The official leaves, the doors are secured and we are off. The rumbling muffled roar settles down into a droning beat as the three engines are synchronized in speed.

Below, the twinkling lights of suburban towns glitter against the black of night. Soon, however, we leave the region of more thickly clustered lights and then we are able to pick up some of the rotating lights of marker beacons which show the way westward. They blaze a trail all the way to our destination which will be easy to follow if bad weather is not encountered.

Our attention having been directed so much below we failed to see the mechanic reel out his trailing wire antenna and tune the receiver located in front of him. Now we notice a small panel on the instrument board, just below a compass indicator. In this panel a small white light is blinking slowly—on-off, on-off, without a break. This is evidently a signal. After a time we notice other lights on this panel. There are combinations of reds, greens, and whites, that come on for a few seconds, change, and then go out. More signals. The pilot and mechanic evidence interest but do not seem perturbed.

Looking out of the window at our side we see but a gray black nothingness faintly lighted by the illumination from the lighted cabin. We can see nothing below, and we realize that we are in clouds or fog. A large altimeter in the front wall

OFF FOR CHICAGO. THE NIGHT AIR MAIL LEAVES HADLEY FIELD, NEW JERSEY, BY THE AID



HIGH-INTENSITY LANDING FIELD FLOOD LIGHTS
One of these Sperry lights will illuminate a 50-acre field

of the cabin shows that we are 3200 feet above sea level. We are in the clouds. If they continue and we cannot fly beneath them and see the trail of lights on the ground, how are we to find our way? How will we know when it is safe to come down again?

We will watch the little panel with the steadily blinking white light and the peculiar combinations of colored lights that come only occasionally. As we watch, the white light blinks unsteadily and then changes to green and flashes regularly once more. We are off our course, to the right, we are told by a passenger just behind us. He has been over this route before and tells us that when the green light flashes we are to the right of the course. If it shows red, we are to the left. When it is white we are exactly on our course. The color combinations which we saw appear for only a short time on the panel were signals concerning the weather ahead. It was in this way that the pilot knew that it was safe to climb up into the clouds, and so avoid the storm below, and yet steer clear of mountain peaks—reefs in this ocean of air.

For hours we fly through the night, yet there is no sensation of flying. That is because we are unable to see anything but the dense fog of the cloud bank through which we pass. Our feeling is that our comfortable, lighted cabin is floating in space. The vibration of the engines and the muffled drone of the exhaust nearly lulls us to sleep. We see the needle of the altimeter crawl slowly up. Five thousand feet, six thousand; perhaps the pilot seeks to climb above the cloud into the moonlight which should be above. But no, the altimeter now shows that we are descending a little. Evidently the cloud bank is very thick, and it is not worth while to go above it.

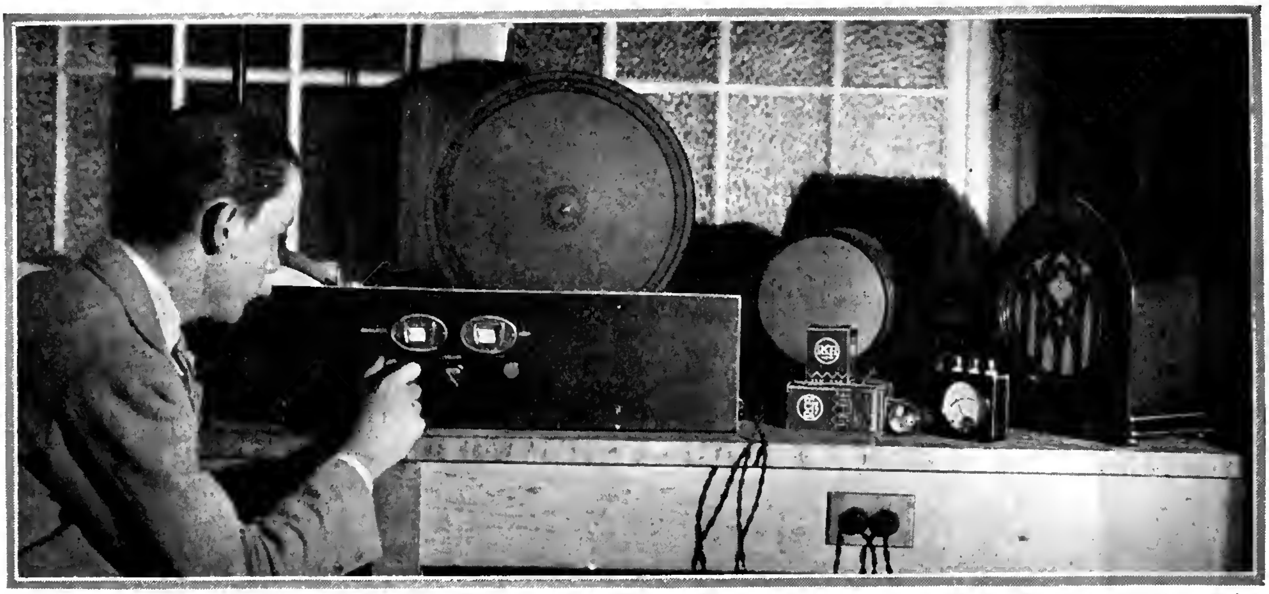
We should be nearing our destination, that is if these red and green and white lights have been faithful to their trust. And the combinations of colored lights, which now again are gleaming in the dimness of the pilot's compartment. Have they been unerring too? We shall soon know. The engines have been throttled a little. The floor of our cabin slopes forward and the needle of the altimeter is dropping slowly. We are losing altitude, and soon should burst through the "ceiling" of cloud. Suddenly the gray black mass which has engulfed us for hours is swept away. Twinkling lights appear below showing towns and lighted highways. Off to our left we see the rotating beam of a marker beacon, and, some little way ahead, another. We are on our course. Ahead there is a great glow in the sky, and as we draw nearer we realize that it is the light from a large city reflected against the clouds.

Now we pick up a bright flashing red light. It marks the airport of this city. Soon we are circling over it, and can see the line of lighted hangars and a brightly lighted letter "T" on the ground. This is to indicate the direction of the surface wind. We glide smoothly down, circle once more, and come in to land. Leveling off we float along hugging the ground and then with a few gentle bumps and a short roll we come to rest. To taxi up to the line in front of the flight office, and disembark, requires but a moment. We are in Chicago.

Radio has done its work. It told the pilot when he was off his course, and how to get on it again. It told him this and more, by very simple signals. Signals he could see. It told him of storms ahead, of cloud levels, and winds, and he was able to fly over disturbed areas and dangerous areas, and to come down safely at the proper time. No uncomfortable head-phones in a helmet were required, and it was not necessary that he know a telegraph code.

Some, perhaps many, may think the picture drawn is fantastic and only a dream. That remains to be seen. As for the ability to fly in the manner described, through clouds and fog, there are ships and pilots in plenty equal to the task. Let others apply things already known in the radio art, and the radio aids to aërial navigation which have been pictured will be a reality. Short waves may ultimately be the medium whereby this is accomplished, but considerable experiment will be necessary before the vagaries of these high frequencies will be fully understood.

WERFUL FLOOD LIGHTS. THE MAIL WILL BE DELIVERED IN CHICAGO TOMORROW MORNING



RADIO BROADCAST Photograph

OBTAINING SOME DATA ON THE A. C. SUPER-HETERODYNE IN THE "RADIO BROADCAST" LABORATORY

Whenever receivers are described constructionally in RADIO BROADCAST, they are invariably tested out in the magazine's laboratory first. Frequently changes are recommended to the designers, and the technical staff does not give its O. K. unless the receiver comes up to expectations

A 45-Kc. A. C. Super-Heterodyne

By DORMAND S. HILL

IN A season during which a bewildering array of super-heterodyne receiver designs are offered to the radio fan and home builder, it is felt that, in presenting still another "super" to the readers of RADIO BROADCAST, it would be well to define, if possible, the relation of such a receiver to other designs, and to point out just why it was felt necessary that another entry should be made in an already too crowded field.

The forty-five kilocycle socket-powered super-heterodyne described here has as the greatest argument in its favor the fact that, though it is fully as sensitive and selective as the majority of eight, nine, and ten-tube sets of its class, its tuning controls are so simple that peak results are always at the command of even the novice operator, its tone quality is unusually good for super-heterodynes and, possibly most important, it derives all power from any sixty-cycle alternating-current home light socket.

The set is entirely self-contained, power unit and set being housed in a standard seven by twenty-four inch cabinet, twelve inches deep. The only external equipment required is a good loop and a modern loud speaker. Since there is not a single battery to run down, and as the power unit is entirely dry, the servicing problem becomes one of occasional tube replacements only. The new a.c. tubes, which make possible the socket powered super-heterodyne described here, give promise of greater average life than is experienced with five-volt battery-type tubes.

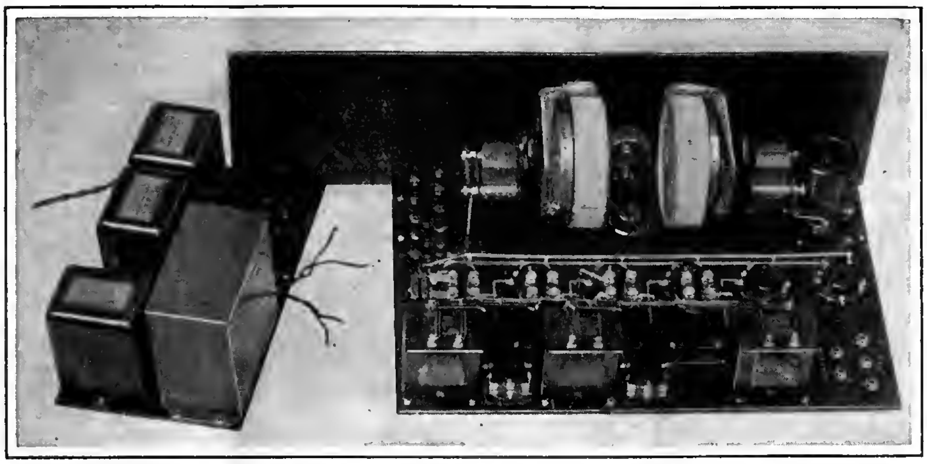
In view of the foregoing advantages—better performance, excellent tone, and complete self-contained light socket operation—it is felt that the appeal of this super-heterodyne set should be indeed great. There is another factor which tremendously enhances the value of the receiver—its low initial cost. The entire receiver and power unit, constructed of the finest quality parts throughout, will cost only about $145.00, or, with a beautiful walnut cabinet, about $22.00 more. Thus, for less than $170.00 at list prices, the radio fan, or even the novice, can build for himself a full socket-powered super-heterodyne and obtain exceptional selectivity and sensitivity, while the 45-kc. super-heterodyne rivals one-dial sets in the simplicity of its tuning. Another factor in the home-built set is the beauty of finish of each individual part—a factor often neglected in all but the most expensive factory-built sets.

The forty-five kilocycle super-heterodyne employs eight tubes in a new a.c. tube circuit, carefully tried and tested. It possesses a great factor of "hum safety" due to the generous use of C-327 (UX-227) heater tubes instead of the greater hum-producing CX-326 (UX-226) type tubes. One C-327 type tube is used as a grid-tuned oscillator, one in a conventional Rice regenerative split loop first detector circuit, and three more follow in a forty-five kilocycle intermediate amplifier, which, in turn, works into a C-327 second detector. Then follows a two-stage low-frequency transformer-coupled amplifier employing a CX-326 (UX-226) first-stage tube, and either a CX-112 (UX-112) or CX-371 (UX-171) output tube with output transformer. The power supply consists of the conventional B device circuit using a CX-380 (UX-280) thermionic rectifier and a special filament heating transformer for all tubes. The power unit delivers 1.5, 2.5, and 5 volts a.c. and 200 to 220 volts pure d.c. to the receiver A, B, and C circuits.

A description of the individual circuit sections will help to provide a clear understanding of the unusual simplicity of the set, and the ease with which it may be built. On the front panel are three knobs. Two of these control the two illuminated tuning drums affecting the 0.00035-mfd. variable condensers, one of the two tuning the loop and the other tuning the oscillator, both with high reduction vernier drives and well-spaced 360-degree scales, numbered 0 to 200. In tuning, both dials tally approximately, stations being heard loudest at one point on the loop drum and at two points on the oscillator drum, although powerful local stations may be heard at more than two points. The third knob, a volume control, provides adjustment from absolute zero to a full maximum. It is not critical as to setting, but if turned too far to the right, will cause the intermediate amplifier to block.

Looking down into the set from above, at the left front is the plug-in oscillator coil, L_1; behind it is the oscillator tube socket, and to the coil's right is the oscillator condenser, C_2, and drum. At the left rear are the loop and loud speaker connection tip jacks; and at their right, along the rear of the Micarta chassis, is the audio amplifier. The latter consists, from left to right, of an output transformer T_3, the output tube, a 3:1 ratio audio transformer, T_2, the CX-326 (UX-226) first-stage tube, and then the first-stage 3:1 transformer, T_1. The filament balancing resistors, R_1 and R_2, on the audio tube sockets, are clearly visible. The frequency characteristic of the audio amplifier is practically flat from 100 cycles to over 5000 cycles, and then falls off for reasons to be given later. The voltage gain of the audio amplifier, with CX-326 (UX-226) and CX-112 (UX-112) tubes is about 400 overall.

Just in front of the output transformer, and behind the first detector tube socket (second from left), is the knob of the loop regeneration condenser, C_3 in Fig. 1. To the right are the four forty-five kilocycle intermediate transformers, L_2, L_3, L_4, L_5, with the three amplifier and second detector (at right) tube sockets in front of them. At the center of the front panel is the loop tuning drum and condenser, C_1. Between the two tuning drums is the 5000-ohm volume-control potentiometer R_3, and on the sub-base also between the drums is a knob controlling the radio-frequency amplifier C bias by means of the potentiometer, R_4. The first transformer, L_2, of the intermediate amplifier is untuned; the next, L_3, is a tuned stage (an XL 0.0005-mfd. Variodenser, C_4, below the chassis, with adjusting screw projecting up, is used for tuning this filter). Then follows a second untuned transformer, L_4, and, at the right, a second tuned transformer L_5, feeding the de-



POWER UNIT AND RECEIVER PROPER

In the event that the power unit is to be mounted elsewhere than right beside the receiver, the front panel for the latter may be smaller

tector tube. This latter stage is tuned by means of a fixed condenser, C_6.

The power unit, consisting of a power transformer, T_4, a condenser block, C_{12}, filament transformer, T_6, and Clough selective filter choke, L_6, with tube socket, and binding posts (and resistor, R_{10}, below), is on a seven-by-twelve inch chassis at the right of the set chassis, the two being cross-connected by the use of Eby binding posts as shown. An under-chassis view shows the voltage dividing resistor, R_{10}, beneath the power unit chassis, and other obvious parts beneath the receiver chassis. The simplicity of wiring is evident.

SELECTIVITY

THE selectivity of the set is quite good, and allows of ten- to fifteen-kilocycle separation of powerful local and weak out-of-town stations. The frequency band passed is a good ten kilocycles wide in normal operation, thus providing excellent tone quality with the audio channel used. This audio channel, due to its cut-off above 5000 cycles, materially aids the apparent selectivity of the radio-frequency circuits; in fact, the frequency characteristics of radio and audio circuits match very nicely.

An examination of the circuit indicates that all grid returns are brought back to the common B minus lead. First detector and oscillator are operated with approximately forty-five volts plate potential, and with zero grid potential; the grid-circuit returns and heater tube cathodes connect to the B minus lead. The three radio-frequency amplifiers derive an adjustable C bias from the 400-ohm potentiometer, R_4, which is connected between their cathodes and the B minus lead (a voltage is developed by virtue of the plate currents flowing through this resistor). The best bias is one-half to one volt, and, once set, varies automatically with changes in plate voltage. The C bias resistor and the plate voltage potentiometer are bypassed with 1-mfd. condensers, C_6 and C_7, to prevent radio-frequency coupling. Plate voltage on the radio-frequency amplifier can be varied from zero to about ninety volts, using the 5000-ohm potentiometer (volume control knob), and generally about forty to forty-five volts gives greatest volume and sensitivity without amplifier oscillation. C bias for the detector is obtained from a 5000-ohm resistor, R_5, between the B minus lead and the detector cathode, shunted with a 0.0005-mfd. bypass condenser, C_8.

The C bias for the first audio stage is obtained across a 1500-ohm resistor, R_6, between the B minus lead and the center tap of a 64-ohm resistor, R_1, shunting the filament of the CX-326 (UX-226) audio tube. C bias for the second audio tube is similarly obtained by a 2000-ohm fixed resistor, R_7, between B minus lead and the center tap of a second 64-ohm balancing resistor, R_2, across the last audio tube's filament. This 2000-ohm resistor is bypassed with a 1-mfd. condenser, C_9, to improve low-frequency reproduction. For safety, a 64-ohm resistor, R_8, connected across the $2\frac{1}{2}$-volt heater circuits of the CX-327 (UX-227) tubes, leads to plus 45 volts to prevent hum. The plate voltage of the first audio stage is about 90 volts; the C bias should be 5 to 6 volts—correct for CX-326 (UX-226) tubes. The last audio tube may be interchangeably a CX-112 (UX-112) or a CX-371 (UX-171) type tube, the former for greatest amplification, the latter for best quality on strong signals. With a CX-112 (UX-112) tube, C bias is about 20 volts and the plate voltage about 200—a safe value and one at which the performance of the 112 type tube is quite creditable. The C bias for a CX-371 (UX-171) tube would be about 38 volts, and the plate potential, about 170 volts—entirely satisfactory values, and slightly below the tube's rated maximum.

The construction of the set is quite simple, involving the use of the following parts. If the exact values specified are used, all adjustments for proper a.c. operation are automatic. Substitution may necessitate experiment:

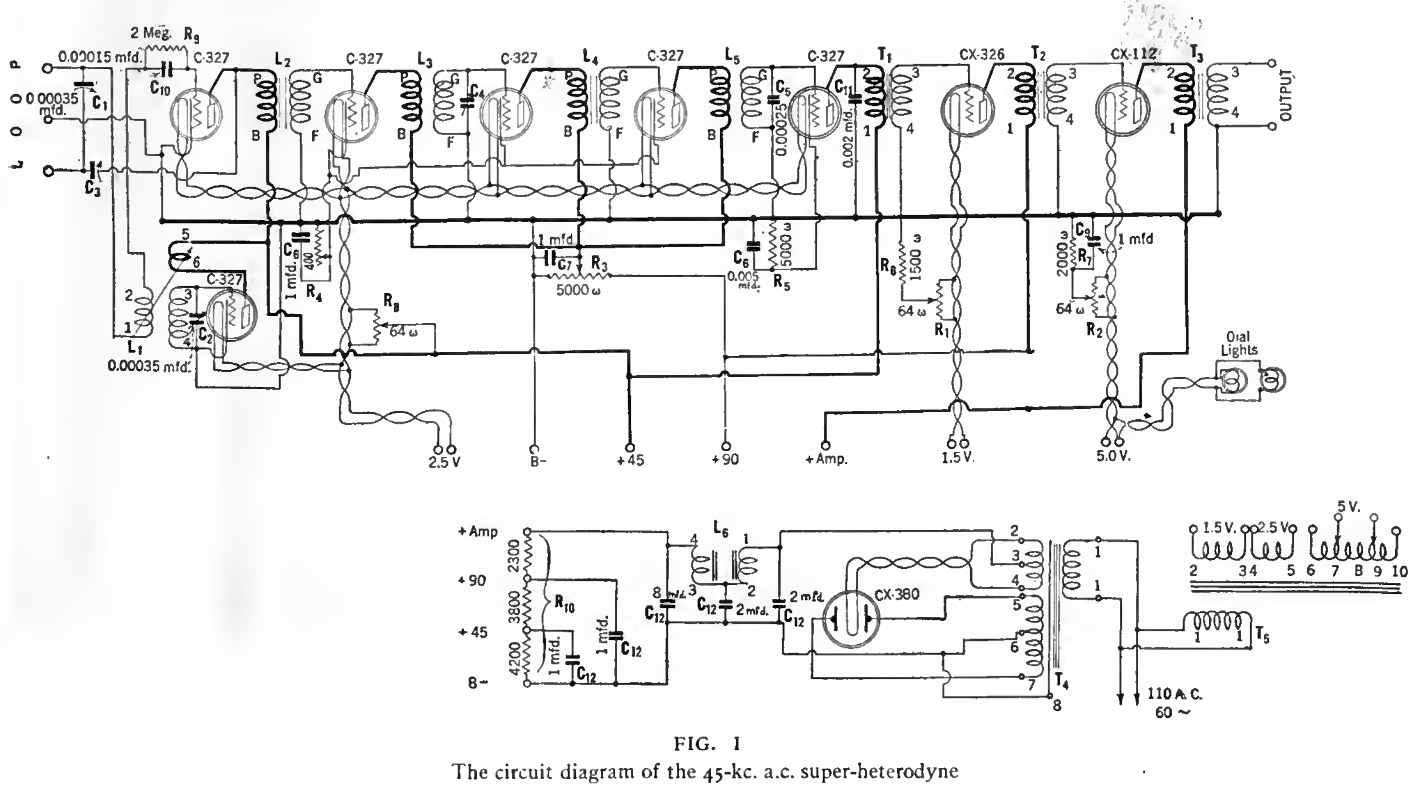


FIG. I

The circuit diagram of the 45-kc. a.c. super-heterodyne

PARTS LIST

Two Remler 100 Universal Drum Dials	$9.00
L_2, L_4 Remler 600 Interstage Transformers	12.00
L_3, L_5 Remler 610 Tuned Stage Transformers	10.00
C_1, C_2 Remler 638 type 0.00035-Mfd. Condensers, Variable	10.00
T_1, T_2 S-M 240 Audio Transformers	12.00
T_3 S-M 241 Output Transformer	5.00
Six S-M 512 Five-prong Tube Sockets	4.50
Two S-M 511 Tube Sockets	1.00
One S-M 515 Coil Socket	1.00
L_1 S-M 111A Coil	2.50
Two Pairs S-M 540 Mounting Brackets	1.40
C_3 S-M 340 Midget Condenser	1.50
C_{10} Polymet 0.00015-Mfd. Condenser, with Clips	.45
C_5 Polymet 0.00025-Mfd. Condenser	.35
C_{11} Polymet 0.002-Mfd. Condenser	.40
C_8 Polymet 0.005-Mfd. Condenser	.60
R_9 Polymet 2-Megohm Grid Leak	.25
C_6, C_7, C_9 Polymet 1-Mfd. Bypass Condensers	3.00
R_6 Frost F1500 Resistor	.50
R_7 Frost F2000 Resistor	.50
R_1, R_2, R_8 Frost FT64 Resistors	1.50
Five Frost 253 Tip Jacks	75
R_3 Frost 5000-Ohm De Luxe Potentiometer	2.25
R_5 Polymet 5000-Ohm Resistor	1.00
R_4 Frost 400-Ohm De Luxe Potentiometer	1.25
C_4 XL Model G "Variodenser"	1.50
Sixteen Eby Binding Posts: (8-plain, 2 B−, 2 B+Det., 2 B+Amp., 2 B+Int.)	2.40
Westinghouse Micarta Walnut Panel 7 x 24 x $\frac{3}{16}$ inches	8.00
1 Westinghouse Micarta Sub Panel 12 x 17 x $\frac{3}{16}$ inches	9.00
TOTAL	$103.60

POWER SUPPLY PARTS LIST

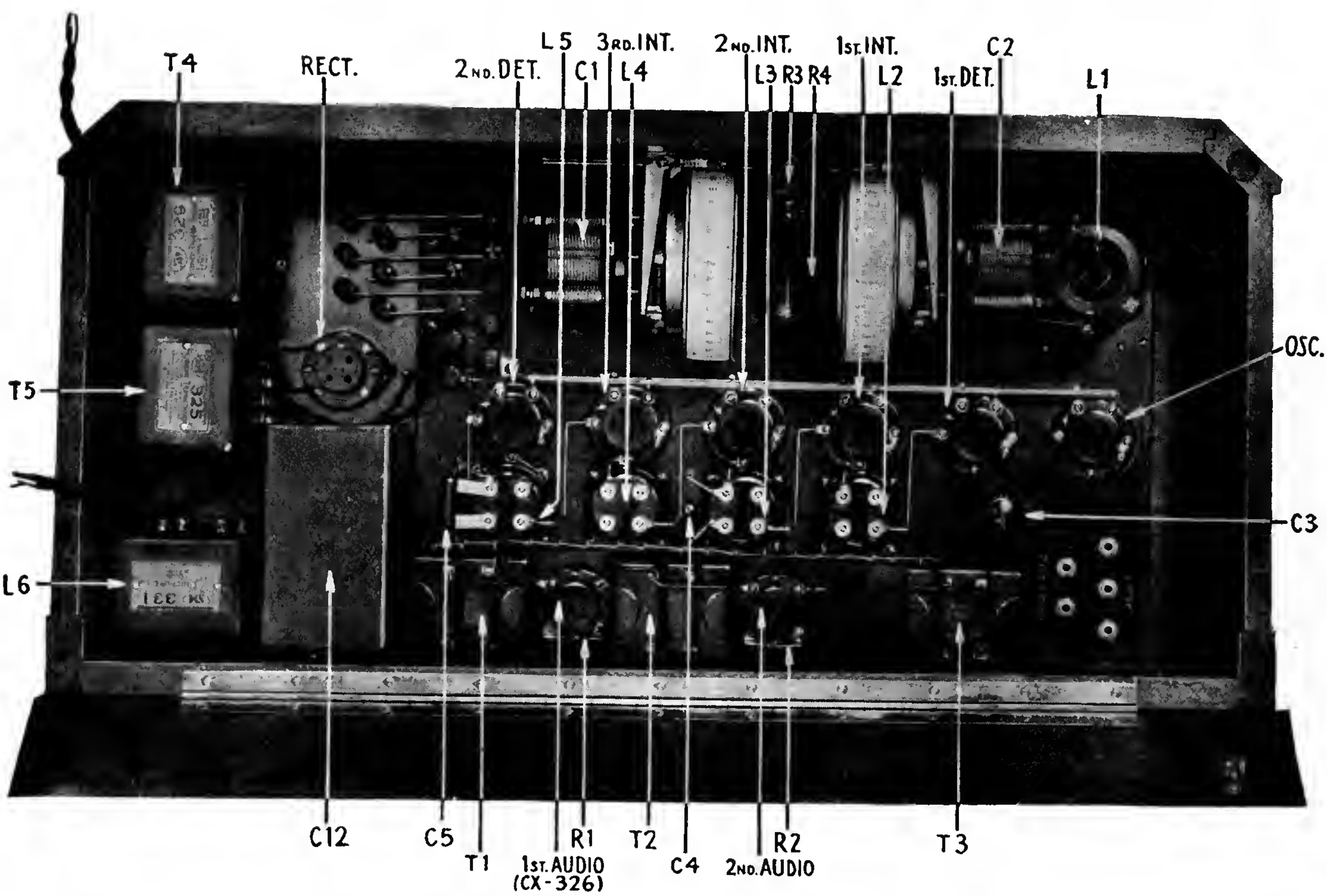
T_4 S-M 329 Power Transformer	9.00
L_6 S-M 331 "Unichoke"	8.00
T_5 S-M 325 Filament Transformer	8.00
S-M 511 Tube Socket	50
Pair S-M 540 Mounting Brackets	.70
C_{12} Polymet 14-Mfd. Condenser Block	9.50
R_{10} Ward-Leonard 659 Resistor	2.50
Westinghouse Micarta Power Unit Base, 12 x 7 x $\frac{3}{16}$ Inches	4.00
8 Eby binding posts: (4Plain, 1 B—, 1 B + Det., 1 B + Amp., 1 B + Int.)	1.20
TOTAL	$43.40

Panels can either be drilled, following the apparatus layout of the photographs, or procured drilled and engraved from any Micarta dealer. The apparatus should be mounted on them after careful study of the photographs, and in the positions shown. One point to observe is that all cathode leads from the C-327 (UY-227) tubes should be brought out below the chassis by one of the socket mounting screws, as this is good practice to follow wherever practicable.

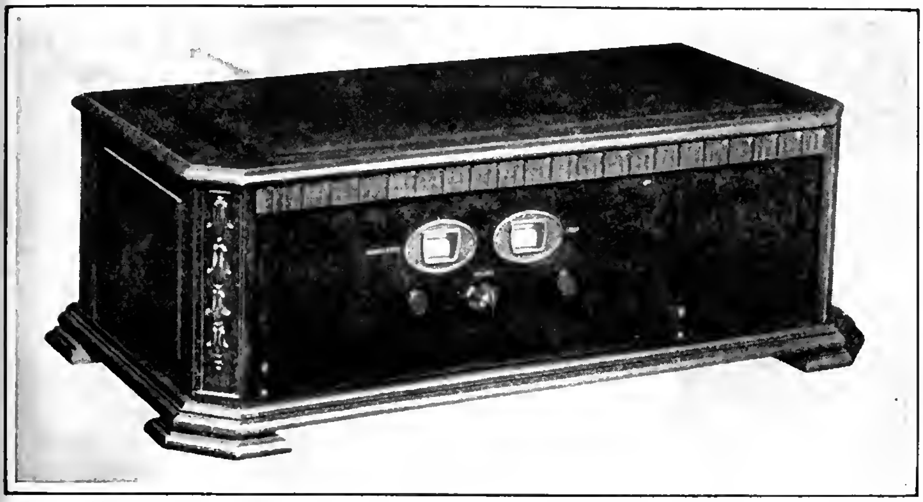
In wiring the set and power unit, all 1.5-, 2.5-, and 5-volt a.c. leads should be twisted to localize their fields. All grid and plate leads should be of busbar, in spaghetti where necessary, as should the leads to the tuning condensers, while all other low-potential wiring should preferably be of Kellogg switchboard wire. The leads from the 2.5-volt binding posts of the receiver to F posts of the five-prong tube sockets are each composed of two No. 14 tinned wires in parallel, for high current-carrying capacity. All metal parts of the set and power unit, such as transformer frames or shells and condenser bank case should ground to B minus. The drum dial frames, carrying the dial lights, are taken care of through the lamp wiring to the 5-volt a.c. circuit, which grounds through the F2000 C bias resistor, R_7.

TEST AND OPERATION

AFTER finishing the set and power unit, it would be well to check voltages with a high-resistance voltmeter (1000 ohms per volt). The power unit not connected to the receiver should show about 70 to 80 volts on the 45-volt tap; 120 to 130 on the 90-volt tap; and 220 or more on the high tap. Next, the power unit should be connected to the receiver, no tubes being inserted in the set, and voltages again checked (for short circuits). All voltages should have fallen somewhat. The audio tubes should now be inserted in the set and the loud speaker connected. A strong hum evidences proper operation of the audio channel if B and C voltages (as given previously) check out *approximately*. If posts Nos. 1 and 2 of the first audio transformer are short-circuited, the hum will fall to the actual operating value; it should be so low as not to interfere with reception at average speaking volume. If the hum is stronger, ground the B minus post to a water pipe. If the hum is still too high (and it may be under unusual line or set assembly conditions), the solution is to move the power unit away from the set. If all CX-327 (UX-227)



LOOKING DOWN INTO THE CABINET OF THE A.C. SUPER-HETERODYNE
The various parts are lettered so that they may be easily identified by cross reference to Fig. 1, on the previous page



THE COMPLETE RECEIVER AND POWER UNIT

It is here shown in an attractive looking cabinet, a product of D. H. Fritts and Company, Chicago, Illinois

heater tubes are inserted, the hum pitch will vary as the tubes warm up and, after a minute, will decrease to the average operating value observed with posts Nos. 1 and 2 of the first a.f. transformer shorted (this very low hum is always experienced with CX-326 [UX-226] or other "raw a.c." tubes.)

To operate the set, set the midget condenser all out, connect a Bodine L350 or equivalent good loop to the loop posts, and tune-in stations with the two drums. Set the C bias potentiometer to include ⅛ to ¼ of its total resistance in circuit which will give ½ to 1 volt negative bias on the r.f. amplifiers. A good starting point would be KDKA, tuned in at about 53 on the loop, and 46 or 58 on the oscillator, or WDAP, at 120 on the loop and 103 or 130 on the oscillator. If the volume knob is set as far as it will go to the left, no signal will get through; advancing the knob right up to the oscillation point (sometimes called "spill-over," "plunk," or "squeal" point) will increase volume. If the volume knob is turned to the right of this point, only squeals will be heard. Remember, no squeals should be heard on the set, other than station heterodyne squeals of substantially unvarying pitch. On a short-wave station, the midget condenser should be turned in slightly to increase sensitivity; if turned in too far, only squeals will be heard—bear this in mind. Once set, leave it alone, but in the first case, be sure to set it on a 210-or 220-meter (1430 or 1360 kc.) station. The oscillator coil rotor should generally be set at about a 45-degree position. There are four of these points in the full 360-degree arc of rotation. Remember that full 180-degree rotation from any of these points will cause either upper or lower oscillator dial setting to give strongest signals on any particular station. Therefore, set the rotor on a weak 300- or 325-meter (1000-or 920-kc.) station to produce greatest volume with good selectivity on *either* upper or lower oscillator dial setting, then use whichever point (upper or lower) is loudest, in tuning all other stations. On a weak signal, adjust the XL Variodenser for strongest signals and sharpest tuning of the oscillator dial.

TROUBLE-SHOOTING

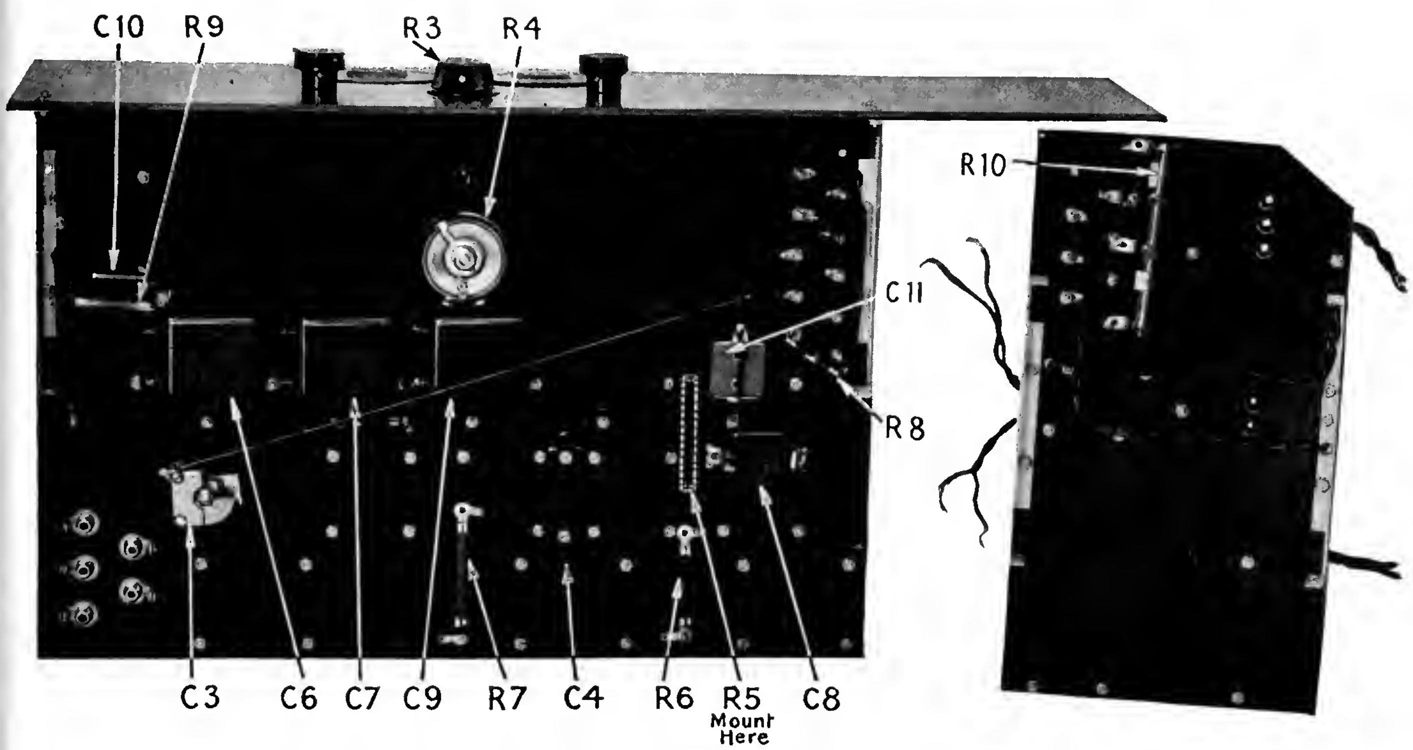
REMEMBER, if the set does not give as good results for sensitivity and selectivity or tone as any other average eight- or nine-tube "super," or seven- or eight-tube t.r.f. set, under *identical and simultaneous* operating conditions, it simply is not put together or operated in accordance with the foregoing paragraphs. Therefore, look for your trouble in your own work.

The set should not squeal in operation; if it does, incorrect operation is the cause—look to midget condenser and volume control settings more carefully.

Lack of sensitivity and selectivity should cause careful readjustment of the XL condenser and midget condenser, and a comparison against some other set of known performance.

Hum should be checked as outlined for the a.f. amplifier. If it tests out correctly, and there is hum coming through the r.f. circuits, the trouble is an open grid-circuit and most probably due to poor or incorrect wiring. If loud hum is in the audio amplifier (with first a.f. transformer primary posts, Nos. 1 and 2, shorted) look for defective wiring, open balancing resistor, or poor tubes. Move the power unit several feet away from the set when making this test.

In proper operation the receiver should give good super-heterodyne performance, say, average 500- to 2000-mile loud speaker range, on all good stations, hum so low as not to be noticeable through station announcements at average speech volume, and absolutely dependable operation in the hands of a novice, with practically no servicing problem—and all at an operating cost of less than ten cents an hour.



UNDERNEATH THE SUB-PANEL

Here again the parts have been lettered for easy reference. The grid bias resistance for the detector tube was being experimented with at the time this picture was taken, and, therefore, its correct location has been indicated by means of dotted lines

THE MARCH OF RADIO

NEWS AND INTERPRETATION OF CURRENT RADIO EVENTS

The Commission Improves Broadcasting Conditions

THIS month we chronicle what should be an improvement of a most pleasing nature in the broadcasting situation, the clearing of 25 of the 36 channels between 600 and 1000 kc., accomplished by the Federal Radio Commission's General Order No. 18. Perhaps, by the time these lines are published, the entire 36 channels will be cleared. "Clearing" means that in most cases many stations operating on one channel have been placed elsewhere and coast-to-coast duplication of stations now obtains which "clears" the channel for all practical purposes.

But we thirst for even greater improvement. Having tasted the gratification which comes of the Commission's firm and commendable action, we hope for more. Every move in the direction of clearing channels means larger audiences and, in consequence, still better broadcasting.

With amazing strides in program development and with a Federal Radio Commission working for the best interests of broadcasting, we hope that, sooner or later, ideal reception conditions will be attained. Indeed, the order clearing channels from 600 to 1000 kilocycles, truly a drastic move, promises to bring good reception not only to urban districts but to rural as well, where radio is becoming the most important and essential form of home entertainment and education.

So many listeners who write us are unfair in laying the blame for heterodyne whistles upon the incompetence of the Federal Radio Commission. The Commission is not incompetent; it is impotent. No five men under the sun could solve the present broadcasting tangle without having undisputed power to eliminate stations from the broadcasting band.

In spite of any congressional declarations that the ether may be regulated in the public interest and that none have vested rights to use it, it is quite generally assumed that broadcasting stations have established what amounts to vested rights in the ether. Having invested capital and legally conducted a public service, station owners contend that they cannot be deprived of the opportunity of continuing that service without compensation. Be that as it may—we contend that stations, which had to wait for broadcasting licenses until the regulatory powers of the Department of Commerce were nullified by unfavorable court decision, have no right on the air. If property confiscation is necessary to secure good broadcasting, let us find a way to confiscate worthless broadcasting stations.

The elimination of two or three hundred of the smaller stations, accomplished by a board with confiscatory powers, need not cost more than two or three million dollars, really a small sum when the social and economic importance of broadcasting and the magnitude of the industry serving it are considered.

We make a serious suggestion for a tax on commercial broadcasting. We realize that our numerous friends among broadcasting station owners will regard us, for a moment at least, as an enemy, seeking to add another to their already numerous burdens. A tax on commercial broadcasting would, at first, certainly penalize the good stations in favor of the bad. But a two per cent. tax, spent solely upon compensating the owners of confiscated stations, could bring radical improvements in broadcasting, such that audiences would be enormously increased, with inevitably augmented revenues to broadcasting stations and improved program standards.

Furthermore, the amount of tax paid by stations would serve as an indisputable guide to their value. Educational and religious stations, now operating at considerable losses, could charge the organizations sponsoring them, on an hourly basis, an amount sufficient to cover their deficits and thus, having established revenue, suffer no penalty for their non-commercial status. A definite principle of compensation for station condemnation could be established, based upon a year's commercial revenue, plus the physical value of its equipment. Three years of taxation of commercial broadcasting and an honestly administered and efficient condemnation board would leave a strong broadcasting structure, consisting only of the most popular and successful stations, with the weak sisters bought out at minimum cost, and clear channels for the remaining. The stations to continue would be selected not only upon the basis of economic value but upon a definite and scientifically organized plan, taking into account power, service area, and geographical location.

The ultimate effect of such a policy would certainly double, triple, and fourfold the value of commercial broadcasting to program sponsors. Interference-free reception and increased coverage would inevitably result in program improvement. The clear reception of a program on every channel would threefold the usefulness of the receiver and increase program choice, serving as another incentive to add to the listening audience. The radio industry would, therefore, prosper by the sale of more receiving sets. On every hand, for the listener, station owner, and manufacturer, there would be greater prosperity and greater service.

We are indeed aware that, at first sight, to burden a harassed broadcasting industry, suffering from interference and insufficient

© Henry Miller

THE FEDERAL RADIO COMMISSION

This view was taken a few days before the death of the Chairman, Admiral Bullard, who is third from the left. Harold A Lafount, the new Commissioner appointed to succeed John F. Dillon, deceased, is shown at the extreme right. Until a Chairman is chosen, Eugene O. Sykes is acting as Vice-Chairman. From left to right: Sam Pickard, E. O. Sykes, W. H. G. Bullard, Carl H. Butman, secretary, O. H. Caldwell, H. A. Lafount revenue, is not likely to be popular among the commercial broadcasters. Too often, when taxation is suggested as a remedy, the cure is worse than the disease.

The Commission, by its recent allocations, has clearly demonstrated that fewer stations per channel means improved reception. But it has made its progress by virtually destroying almost two thirds of the broadcasting frequencies in order to make one third capable of performing maximum service. Is it efficient utilization of valuable ether channels to impair two thirds of those available so that one third may be of maximum service?

The only sensible ideal is to make every channel useful to the utmost of its capacity. Any channel, which serves as a graveyard for ten, twenty, or thirty stations, represents the confiscation of a substantial investment on the part of receiving set owners. If we value the receiving sets in service at $450,000,000—and this is a conservative estimate—broadcast listeners have spent some $5,000,000 a channel. Confiscating two thirds of the broadcast band, by allotting it to chaos, represents a loss of $300,000,000 to listeners.

Is the listener not entitled to free and complete use of his apparatus, considering that his collective investment is much larger than that of the broadcasting stations? Broadcasters who wail about destroyed investments are themselves guilty of destruction a thousandfold greater than that which they suffer.

If confiscation of property is necessary to establish good broadcasting, let us give the Federal Radio Commission full power to condemn broadcasting stations and the funds with which to purchase them. We do not hesitate to condemn private property in order to build improved highways, a process which has made the automobile business one of America's greatest and most serviceable industries. Now let us condemn private property in order to have good highways of the ether. It will make radio a truly great industry, serving every American family and home.

Who Buys This Year's Radio Sets?

THE replacement market will be radio's most profitable sales field this year. The listener who has had experience and contact with radio is readier to appreciate the advantages of socket power operation and the greatly improved tonal quality attained by this year's better receiving sets. The radio trade quite generally overlooks the replacement market, although receivers of two, three, four and five years ago are still widely used. The automobile industry is now subsisting very largely upon replacements which reach a dollar total far in excess of new owner purchases.

To the radio industry, this is a new problem and the approach to the replacement market requires fundamental changes in sales and advertising methods. The industry should seize upon its opportunity enthusiastically because three fourths of the selling resistance has already been eliminated by the set owner's previous experience. He is ready to understand and appreciate the significance of modern improvements, with but a simple explanation, laid before him where he is accustomed to absorb his radio knowledge.

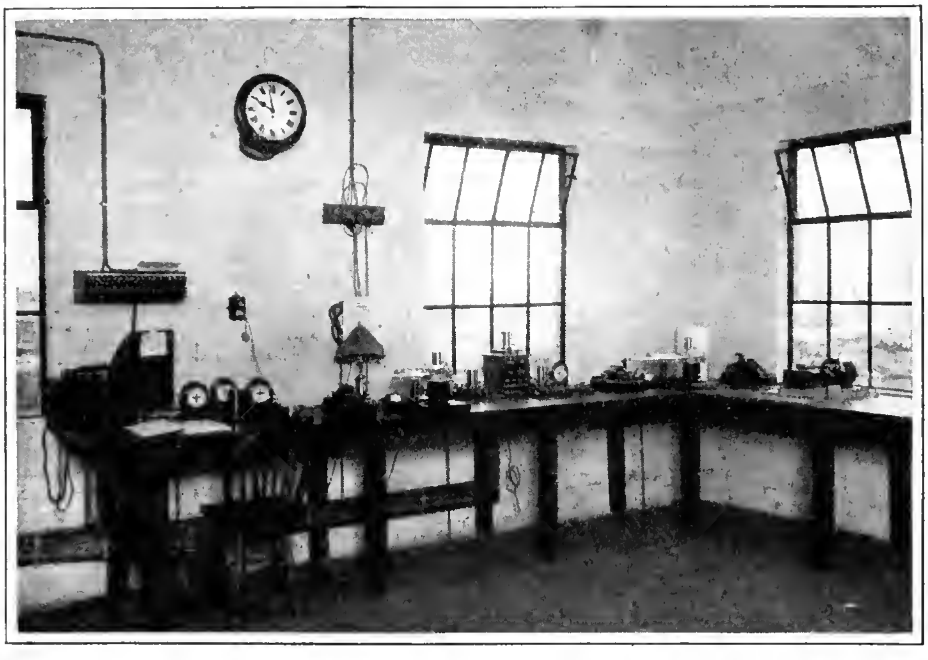
The replacement market has the fortunateadvantage that those most enthusiastic about radio are efficiently reached through specialized mediums which appeal to the more ardent and, consequently, more responsive radio follower. The publications in the radio field have a combined circulation of nearly one million and, therefore, reach the best one fifth or one sixth of the entire replacement market. Those who purchase radio consumer magazines are naturally more interested in radio than those who do not. They have followed radio for several years at least, and are the most likely to possess obsolete sets. This invaluable group is reached at a lower cost than an equal number of prospects among general magazine circulations. Popular magazines, serving every class of society instead of singling out especially fruitful groups, reach an insignificantly small proportion of already interested buyers and persons sold on radio by actual experience. A general magazine is fortunate if one out of twenty of its readers have the slightest interest in its radio advertising; every reader of a radio magazine is a prospect for a 1928 radio.

Since the general spirit of the better radio magazines is no longer predominantly technical, but covers all phases of the radio science, art, personality, broadcasting, as viewed behind the microphone and heard before the speaker, progress in manufactured receivers, telephotography and television, and numerous other fields of wide appeal, circulations have changed in character so that they include not only the home constructor and radio engineer, but the dealer and jobber, the wealthy and ardent listener, and the most liberal purchasers of radio equipment. The new situation offers a great opportunity to the manufacturer to sell his wares at minimum cost.

A prophet is without honor in his own country and the radio manufacturer is quite inclined to regard the radio enthusiast as a sort of demented crank who has no influence upon the purchase of radio sets. However, he readily admits, when pinned down, that it was this very element which built up his industry and that, instead of being cranks, they are pioneers and leaders. Of course, there are a few manufacturers who cannot profitably address themselves to this discriminating and well-informed group, because they do not make a product fit to offer to an expert radio enthusiast. But, in general, the products of the radio industry have reached a standard which makes them highly acceptable to the man with some technical knowledge and appealing to him is an asset which means the sale of not only one but usually a good many radio receiving sets.

Rural Radio Listeners Served by Re-allocations

IN A statement issued by the Commission shortly after its clearing of the 600-to 1000-kc. channels, it points out that millions of listeners in remote communities, presumably a good two thirds



A BRITISH MARCONI SHORT-WAVE RECEIVING STATION

This receiving unit, located at Skegness, England, was built by the Marconi company for the British Post Office and is used as the British end of the India and Australia service. The view above shows a corner of the land line connections and high speed recording instruments. On the left are key and sounder for communication with the transmitting station and Radio Central in London; next are two sets of high-speed recorders with tape pullers and a Wheatstone transmitter for sending to the London Central office of the radio audience, who have little or no choice of local programs, are especially benefited by the new allocations. It is this group which leans most heavily upon radio's utilitarian and entertainment service. The Commission states that, although the DX listener is served by these reallocations, its principal purpose is to make radio more acceptable to the rural listener.

There is some criticism due to the fact that the thirty or more stations which now have clear channels are affiliated with one or the other of the networks. Therefore, a rural listener, going down the dials on a clear night, would find only three programs available to him, although he may tune-in twenty of the stations. Ultimately, this situation may be alleviated by the assignment of all chain stations to a single channel. This is not feasible at this time because of the great cost entailed in synchronizing stations, a complete and extra wire network being necessary to accomplish this, and, furthermore, because the affiliated stations do not receive their programs exclusively from the chain source. The better stations throughout the country have affiliated themselves with chain organizations and it is therefore inevitable that they should receive favored consideration in the matter of being assigned clear channels. Consequently, the Commission's action is unavoidable and it cannot rightly be accused of favoritism.

Sooner or later, however, it will be necessary to synchronize stations so that the same channel will be used by all stations radiating a program. This will give an added advantage to the rural listener because he will derive signal energy, not only from the nearest of the chain stations to which he tunes, but the combined signal energy from all the stations which energize his set. The Blue Network, for example, combined on a single channel by synchronous broadcasting, would deliver an adequate local service signal almost anywhere in the eastern part of the United States.

It has been suggested that a single synchronizing signal be broadcast from which all stations are to derive the carrier signal. Such a synchronizing signal would have to be of a frequency low enough that its harmonics would include every broadcasting channel. Thus a 10,000-cycle synchronizing signal, radiated by modulating a high-frequency carrier, would be received at every broadcasting station in the country. Those assigned to a 500-kc. frequency, for example, would, by means of a harmonic producer, pick off the fiftieth harmonic of the 10,000-cycle synchronizing signal. This would be sufficient to serve as the carrier for the station. The 51st harmonic would provide the 510-kc. signal and so on throughout the broadcasting band.

Although this process appears to be a simple solution of the frequency stability problem, it is, unfortunately, full of technical pitfalls, sufficient to prevent its immediate general utilization.

We are unable to build harmonic producers of sufficient reliability to obtain the selected harmonic with unfailing certainty. Much investigation is necessary before reliable harmonic producers to cover the entire broadcast band would be available so that they could be employed by the usual broadcasting station technical staff. The harmonic producer is still a laboratory product, requiring the highest kind of engineering talent to secure satisfactory results.

Technical aids will certainly come to the help of the broadcasting situation, but they cannot be relied upon to give prompt and substantial relief, in our present knowledge of the radio art. The mills of the gods and the laboratories of scientists grind slowly, but, fortunately, they never cease grinding.

Frequency Allocation Outstanding Achievement of International Conference

IT REQUIRES a careful study of the allocations adopted by the International Radio Telegraphic Conference to appraise the labors of that body briefly and it is premature to report on more than its outstanding and obvious achievement, the establishment of a complete schedule of international wavelength allocations. In examining this schedule, it must be borne in mind that nations may permit any kind of emission to any radio station under their jurisdiction at any frequency, under the sole condition that such emission does not interfere with any other country. To stations, which, by their nature, are known to be capable of causing material international interference, the contracting parties agree to assign frequencies in accordance with the schedule which appears below.

The assignments made to amateurs represent a curtailment of their present wide range of channels, although they have not lost completely the right to any of their accustomed bands. Those bands, designated as "amateur" without restriction or division, are exclusive amateur bands and therefore available for international communication. As to the broadcasting bands, the American standard has been adopted, although a few channels in the 150-kc. region have been made available for European broadcasting. A number of small but well distributed short-wave bands for international links are also provided, which take into account the possibilities of both daylight and night transoceanic rebroadcasting. The Conference, evidently, listened appreciatively to the advice of experts in selecting these short-wave bands.

How Radio Channels Are Internationally Assigned

10 to 100 kilocycles (30,000 to 3000 meters)—Point to point service.
100 to 110 kilocycles (3000 to 2725 meters)—Point to point and mobile service.
110 to 125 kilocycles (2725 to 2400 meters)—Mobile.
125 to 150 kilocycles (2400 to 2000 meters)—Mobile, maritime service, general public correspondence only.
150 to 160 kilocycles (2000 to 1875 meters)—(a) Broadcasting, (b) point to point, (c) mobile. Subject to agreement as follows: All regions where broadcasting stations now exist working below 300 kilocycles (above 1000 meters)—Broadcasting; other regions, (b) point to point, (c) mobile. Regional agreements will respect the rights of one another in this band.
194 to 285 kilocycles (1550 to 1050 meters)—(a) Mobile, (b) point to point, (c) broadcasting. Subject to regional agreement as follows: Europe (a) Mobile (aircraft only). (b) point to point (air services only), (c) point to point (NGP) from 250 to 285 kilocycles (1200 to 1050 meters); (a) broadcasting from 194 and 224 kilocycles, (1550 to 1340 meters); other regions; (a) Mobile, except commercial ships, (b) point to point (aircraft only), (c) point to point (NGP).
285 to 315 kilocycles (1050 to 950 meters)—Special (radio beacons).
315 to 350 kilocycles (950 to 850 meters)—Mobile (aircraft service only). See Note 1.
350 to 360 kilocycles (850 to 830 meters)—Mobile (NGP).
360 to 390 kilocycles (830 to 770 meters)—(a) Special (direction finding); (b) mobile, where it does not interfere with direction finding.
390 to 460 kilocycles (770 to 650 meters)—Mobile.
460 to 485 kilocycles (650 to 620 meters)—Mobile, except damped and radio telephone waves.
485 to 515 kilocycles (620 to 580 meters)—Mobile (distress calling, &c). See Note 2.
515 to 550 kilocycles (580 to 545 meters)—Mobile (not open to general public correspondence), except damped and radio telephone waves.
550 to 1300 kilocycles (545 to 230 meters)—Broadcasting. See Note 3.
1300 to 1500 kilocycles (230 to 200 meters)—(a) Broadcasting, (b) mobile (on the frequency 1364 kilocycles only, wave length 200 meters).
1500 to 1715 kilocycles (200 to 175 meters)—Mobile.
1715 to 2000 kilocycles (175 to 150 meters)—Mobile, fixed and amateurs.
2000 to 2250 kilocycles (150 to 133 meters)—Mobile and fixed.
2250 to 2750 kilocycles (133 to 109 meters)—Mobile.
2750 to 2850 kilocycles (109 to 105 meters)—Fixed stations.
2850 to 3500 kilocycles (105 to 85 meters)—Mobile and fixed.
3500 to 4000 kilocycles (85 to 75 meters)—Mobile, fixed and amateurs.
4000 to 5500 kilocycles (75 to 54 meters)—Mobile and fixed.
5500 to 5700 kilocycles (54 to 52 meters)—Mobile.
5700 to 6000 kilocycles (52.7 to 50 meters)—Fixed.
6000 to 6150 kilocycles (50 to 48.8 meters)—Broadcasting.
6150 to 6675 kilocycles (48.8 to 45 meters)—Mobile.
6675 to 7000 kilocycles (45 to 42.8 meters)—Fixed.
7000 to 7300 kilocycles (42.8 to 41 meters)—Amateurs.
7300 to 8200 kilocycles (41 to 36.6. meters)—Fixed.
8200 to 8550 kilocycles (36.6 to 35.1 meters)—Mobile.
8550 to 8900 kilocycles (35.1 to 33.7 meters)—Mobile and fixed.
8900 to 9500 kilocycles (33.7 to 31.6 meters)—Fixed.
9500 to 9600 kilocycles (31.6 to 31.2 meters)—Broadcasting.
9600 to 11,000 kilocycles (31.2 to 27.3 meters)—Fixed.
11,000 to 11,400 kilocycles (27.3 to 26.3 meters)—Mobile.
11,400 to 11,700 kilocycles (26.3 to 25.6 meters)—Fixed.
11,700 to 11,900 kilocycles (25.6 to 25.2 meters)—Broadcasting.
11,900 to 12,300 kilocycles (25.2 to 24.4 meters)—Fixed.
12,300 to 12,825 kilocycles (24.4 to 23.4 meters)—Mobile.
12,825 to 12,350 kilocycles (23.4 to 22.4 meters)—Mobile and fixed.
12,350 to 14,000 kilocycles (22.4 to 21.4 meters)—Fixed.
14,000 to 14,400 kilocycles (21.4 to 20.8 meters)—Amateur.
14,400 to 15,100 kilocycles (20.8 to 19.85 meters)—Fixed.
15,100 to 15,350 kilocycles (19.85 to 19.55 meters)—Broadcasting.
15,350 to 16,400 kilocycles (19.55 to 18.3 meters)—Fixed.
16,400 to 17,100 kilocycles (18.3 to 17.5 meters)—Mobile.
17,100 to 17,750 kilocycles (17.5 to 16.9 meters)—Mobile and fixed.
17,750 to 17,800 kilocycles (16.9 to 16.85 meters)—Broadcasting.
17,800 to 21,450 kilocycles (16.85 to 14 meters)—Fixed.
21,450 to 21,550 kilocycles (14 to 13.9 meters)—Broadcasting.
21,550 to 22,300 kilocycles (13.9 to 13.45 meters)—Mobile.
22,300 to 23,000 kilocycles (13.45 to 13.1 meters)—Mobile and fixed.
23,000 to 28,000 kilocycles (13.1 to 10.7 meters)—Not reserved.
28,000 to 30,000 kilocycles (10.7 to 10 meters)—Not reserved.
30,000 to 56,000 kilocycles (10 to 5.35 meters)—Not reserved.
56,000 to 60,000 kilocycles (5.35 to 5 meters)—Amateurs and experiments.
60 kilocycles (5 to 0 meters)—Not reserved. Note 1—3331 kilocycles (900 meters) is the international aircraft calling and listening frequency.

Note 2—500 kilocycles (600 meters) is the international calling and distress frequency. It may be used for other purposes when it will not interfere with calling.

Note 3—Mobile services use the band 550 to 1300 kilocycles (545 to 230 meters) on the condition that they do not interfere with the services of any nation using this band exclusively for radio telephone broadcasting.

Note—NGP means: Not for general public correspondence.

New Commissioner Appointed

ON NOVEMBER 14, President Coolidge announced the appointment of Harold A. Lafount of Utah as a member of the Federal Radio Commission to fill the vacancy created by the death of John F. Dillon. Mr. Lafount has used a radio receiving set and therefore approaches the problems of broadcast regulation with a confidence equal to that with which we would assume the command of a battle fleet after a visit to a navy yard. The new commissioner may prove to be the dark horse who brings an ultimate victory over confusion and we wish him every success. But certainly, it has been amply demonstrated that the Commission's problems are highly technical and that the Commissioners are handicapped in their work until they have, at great cost of time and effort, learned the intricacies of broadcasting.

Inside the Radio Industry

A CLASSIFICATION of questionnaires returned by 3546 dealers, made by the Electrical Equipment Division of the Department of Commerce, indicates that 26 per cent. are electrical supply dealers, 20 per cent. radio dealers, 13½ per cent. hardware dealers, 8½ per cent. dealers in musical instruments, and 6 per cent. automobile dealers, 5½ per cent. battery and ignition supplies, 4½ per cent. tires and tire repair shops, and smaller percentages to other classes. A total of 68 different varieties of retail outlets is represented in the classification. It is rather surprising to find the hardware retailer so prominently represented and the music dealer outlet so small in proportion to the whole.

Another comprehensive statistical survey, to be a quarterly investigation conducted by the Department of Commerce, is an enumeration of the stock of radio sets and their principal accessories in dealers' and jobbers' hands. The survey is national in scope and the first returns are based upon 7718 filled-in questionnaires. This number of dealers had 147,548 battery receiving sets on hand and 9548 socket powered sets; ordinary speakers, 153,091; amplifier-speaker units, 5018; B and C batteries, rated in 45 volt units, 525,441; storage A batteries, 77,148. This makes an average of twenty battery-operated receiving sets and a little over one socket power set per dealer, a healthy situation, considering that both dealers and jobbers are represented. Moving less than 150,000 battery-operated sets at this season is not an abnormal demand upon the public.

RADIO INDUSTRY STANDARDS

OUR persistent campaign for the adoption of a single set of standards for the radio industry has now come to an end because both trade organizations have, at last, agreed to work together in this one respect at least. This move, however, is only the first step in our program, which calls for complete unification of the two trade associations. The present step, respecting standards, brings this objective nearer.

The Radio Manufacturers' Association and the Radio Division of the N. E. M. A. have agreed to review all manufacturing standards pertaining to radio and will publish a single industry standard. In cases of dispute, the American Engineering Standards Committee will serve as an arbitration board. The entire industry is to be congratulated upon this outcome of the persistent campaign which a few individuals have waged quietly and persistently for many months.

THE Radio Manufactuers' Association has appointed a Patent Interchange Committee, with A. J. Carter as its chairman, which is to work out a patent pooling plan. It has obtained the consulting services of Mr. C. C. Hanch, who worked out the patent cross license system for the automobile industry. We would suggest that this worthy effort be combined with that along similar lines being made by the Policies Division of N. E. M. A. Without unification of effort, both associations are wasting time and cannot hope to accomplish anything of permanent value.

THE Radio Corporation's quarterly statement for the September quarter announces a net profit of $4,141,355, its largest net operating profit for any quarter. Its earnings per share were $2.80 and, for the same quarter a year ago, $1.53.

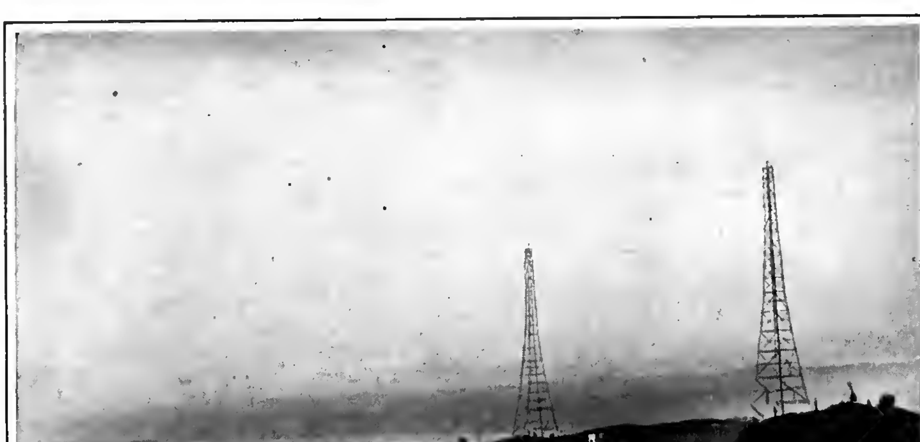
NEWS FROM ABROAD

THE writer has had the privilege of talking to Mr. J. M. Bingham, the Chief Engineer of the New Zealand Broadcasting System, who is visiting the United States in order to learn the latest in broadcasting practice from American engineers. As a matter of fact, the entire broadcasting industry of the United States might profitably visit New Zealand in order to learn how to run radio broadcasting successfully. No country has more efficient regulation.

Broadcasting has been placed in the hands of a single company by authority of the New Zealand Parliament. This monopoly is supported by an annual tax upon broadcast listeners. The purchase of every receiving set and every part that goes into a receiving set, down to the last binding post, is recorded by dealers. Government agents have access to their books at all times. No listener can escape the vigilant eyes of government inspectors. The revenue thus gained is divided between the broadcasting stations and the Government, but not in the unsatisfactory ratio which obtains in the British Isles. Eighty per cent. or more of the broadcast tax collected in New Zealand is actually spent in program talent or the erection and maintenance of broadcasting stations. No radio advertising or commercial goodwill broadcasting is allowed or necessary.

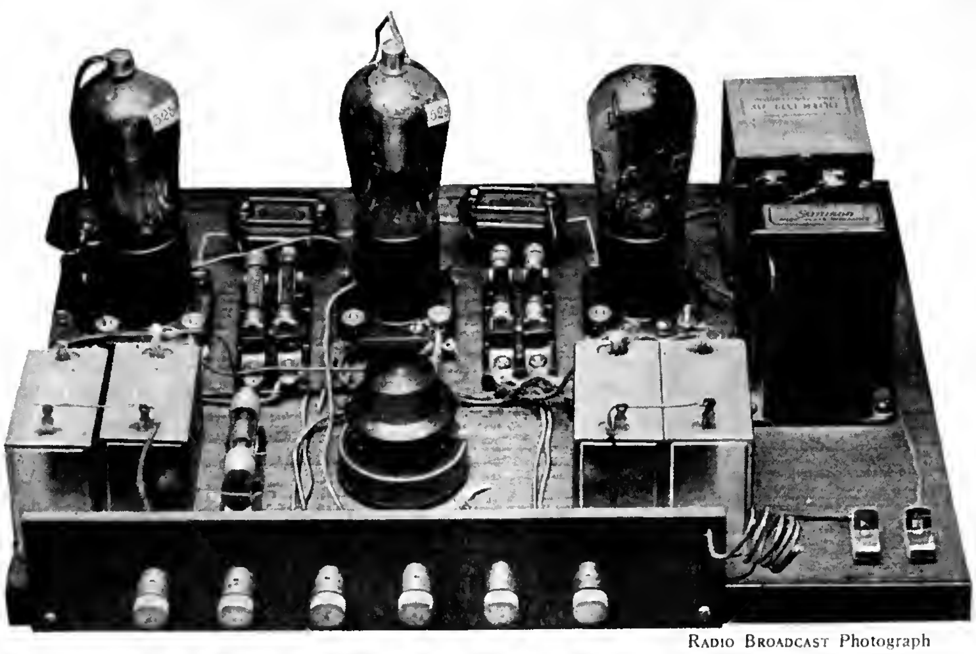
One would conclude that, under such an efficient system, with its magic wand to overcome any serious problems and vicissitudes, broadcasting would thrive and grow. Its growth has been steady but not startling. The number of licensees, in a population of one and a quarter million, is about twenty thousand. Four high power broadcasting stations cover the four-hundred-mile length of the country. There are some dead areas, but prospective changes in transmitter location will soon remedy these. Interconnecting wire circuits are being developed but, as yet, there is virtually no chain broadcasting. Naturally, with but four stations, there are no frequency allocation difficulties. There is no economic problem in meeting station maintenance cost. There is little or no evasion of listener tax. Altogether, it is the most efficient broadcasting system in the world.

A DEPARTMENT of Commerce statement advises that there are 685 broadcasters in the United States and its territories; the total in all nations, other than the United States, is 431. Of these, 196 are in Europe, 128 in North America, outside of the United States, 52 in South America, 18 in Asia, in Oceania 28, and in Africa 9. The four most powerful broadcasting stations in this country are WGY, 100,000 watts with 50,000 watts as its usual power; WEAF, 50,000 watts; KDKA, 50,000 watts; and WJZ, 35,000 watts. In Russia, there are two 40,000 watt stations and one of 20,000 watts. The total number of broadcasting stations in numerical order are: Canada 59, Cuba 47, Russia 38, Sweden 30, Australia and Germany 24 each, Argentina 22, United Kingdom 20, France and Mexico 18, Spain 15, Brazil 12, Chile 9, Finland 7, England 6. There are four each in Belgium, Czecho-Slovakia, Uruguay, India, Netherlands, East Indies and New Zealand; three in Italy, Poland, China, Japan and South Africa, and smaller numbers in other countries.



STATION 2 YA AT WELLINGTON, NEW ZEALAND

The New Zealanders have elegant scenery on which to mount their radio stations if this can be taken as typical. 2 YA has 5000 watts power and is one of four stations serving the country



RADIO BROADCAST Photograph

USING 222 TYPE TUBES IN AN AUDIO AMPLIFIER

This is the conventional resistance-coupled amplifier using two screened-grid tubes and one 171 power tube. The little cap on top of the tube is the signal grid connection. The values of resistance, etc., are given on Fig. 5

THE SCREENED-GRID TUBE

By The Laboratory Staff

THE new screened-grid tube, the UX-222 or CX-322, is designed to appeal to the more experimentally inclined of the set constructing fraternity, and while it is comparatively simple to build receivers to utilize some of the advantage of these tubes, the great task comes after the last wire is in place.

Contemporaries of RADIO BROADCAST have devoted considerable space to this new tube and, perhaps, are so keenly alive to its potentialities that they have somewhat over-exaggerated its possibilities so far as the average non-technical set builder is concerned. The screened-grid tube has been in the RADIO BROADCAST Laboratory for several months now, and for a considerable longer period of years in the research laboratories of the R.C.A. and the General Electric Company. As a result of our experiments at Garden City, we must still say that this is an experimental tube, and that hard and fast rules for quickly throwing together coils and condensers with screened-grid tubes to connect them, are not yet possible.

TABLE 1

AMPLIFICATION FACTOR	PLATE IMPEDANCE
3	2000
8	12,000
15	25,000
30	150,000
35	250,000

Tubes available in the United States differ considerably from those used in England, and in our opinion suffer somewhat in comparison. This is not due to their electrical characteristics but, rather, due to the mechanical arrangement which, in English tubes, seems to have been worked out with more thought toward ease of use.

Readers interested in the tube may find Captain H. J. Round's book, *The Shielded Four-Electrode Valve*, very helpful. It is published by Bernard Jones Publications, Ltd., 58 Fetter Lane, London, E.C.4, and the price is two shillings and sixpence (a little over sixty cents).

Considerable time has been devoted in RADIO BROADCAST Laboratory to determine how to use these tubes in radio-frequency amplifiers. Before discussing these experiments in detail, we will indicate the advantages obtained through the use of a 222 screened-grid tube instead of a 201-A type tube in a radio-frequency amplifier. This involves delving somewhat into r.f. amplifier theory to get an idea of how they work and upon what their amplification depends.

When a 201-A type tube is used in a radio-frequency amplifier circuit (see Fig. 1) in conjunction with an ordinary r.f. transformer, the amplification obtained will be a function of the number of turns in the primary coil and its coupling to the secondary coil. With either a very few or a great many primary turns the amplification will be low, but with some definite intermediate number of turns the amplification will become a maximum. Under such conditions the amplification using a 201-A tube will be about 10 at 500 meters (600 kc.) and about 15 at 200 meters (1500 kc.). In order to get even this amplification from a 201-A type tube, a carefully designed circuit is necessary, incorporating some method of neutralization to overcome the effect of the capacity between the grid and plate of the tube, which would otherwise cause the circuit to break into self oscillation.

Somewhat greater amplification can be obtained with an ordinary three-electrode tube if the electrodes are so constructed and arranged as to give the tube a higher amplification constant. Such a tube is called a "high-mu" tube and although such tubes have been used most frequently in resistance-coupled audio amplifiers, they may also be used in an r.f. amplifier. There are, however, several reasons why their use in the latter capacity is not advisable.

The amplification factor of a tube is entirely under the control of the tube engineers, and tubes can be built with little difficulty having constants anywhere from 0.5 to 500. When the amplification constant of a tube is increased in this manner, however, the plate impedance also increases and, in fact, increases approximately as the square of the amplification constant, so that the plate impedance increases much more rapidly than the amplification constant. The table on this page will give some idea of how the plate impedance varies as the amplification factor is changed.

Now, in order to obtain considerable gain from a high-mu tube when it is used as a voltage multiplier in an r.f. stage, it is necessary to have a very high impedance load in the plate circuit, so that transformer coupling with a step-up ratio may not be practical. An ordinary high resistance might be used were it not for the fact that it would be shunted by the output and input capacities of those tubes preceding and following it. These capacities across the load resistance would limit the effective impedance of the load in the plate circuit to a low figure, so that the amplification will fall to a comparatively low value. An effective way in which to obtain high gain from a high-mu tube is through the use of a tuned-plate amplifier (see Fig. 2 and compare it with Fig. 1). In such a circuit the output and

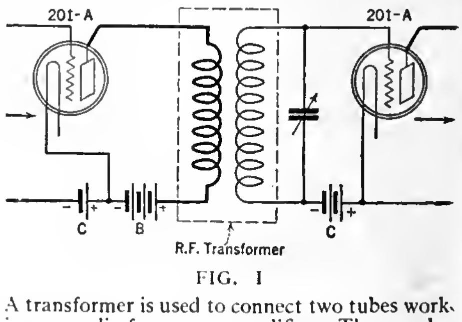


FIG. 1

A transformer is used to connect two tubes working as radio-frequency amplifiers. The number of turns on the primary for maximum amplification is controlled by the input and output impedance of the tubes used. For a given set of tubes and at a given frequency there is a number of turns which will give maximum amplification input capacities of the tube are in parallel with the condenser which tunes the circuit and have no effect other than to decrease slightly the amount of capacity necessary in the variable condenser in order to tune to any given wavelength. At resonance the effective resistance as measured across the two ends of a tuned circuit is very high and the tuned plate type of amplifier is therefore capable of producing an effective high impedance in the plate circuit—a necessity if high gain is to be obtained, as stated before. The effective resistance at resonance of even a good coil-condenser combination, when it is connected into an amplifier, is, however, probably not more than 100,000 to 200,000 ohms. When the effective resistance in the plate circuit of a tuned plate r.f. amplifier is equal to the plate impedance of the tube, the amplification obtained is one half the mu of the tube. Thus, a tuned circuit giving an effective resistance of 150,000 ohms, and used in conjunction with a tube having an amplification constant of 30 and a plate impedance of 150,000 ohms would produce an effective amplification of one half mu, or 15. It should be evident that the limiting factor preventing the attainment of much larger values of amplification, is the large increase in plate impedance that occurs when the amplification constant is increased. What we want, obviously, is a tube with a very high amplification factor and as low a plate impedance as possible. Such characteristics are not obtainable using an ordinary three-electrode tube because, as indicated previously, the plate impedance increases much more rapidly than the amplification constant. To obtain a high mu with a comparatively low plate impedance, it is necessary to introduce a fourth electrode into the tube. The effect of the fourth electrode was explained in articles on the four-electrode tube in the December, 1927, and January, 1928, issues of RADIO BROADCAST, and will not be repeated here except to point out that this fourth electrode does give a very large increase in the amplification constant without as large an increase in plate impedance as would be obtained with a three-electrode tube. Measurements in the Laboratory indicate that the amplification constant of the 222 tube is about 200, under certain conditions, and the plate impedance is about 800,000 ohms. If an ordinary three-electrode tube, such as a type 240 high-mu tube, were to be constructed to have a mu of 200, the plate impedance would be about five to seven million ohms! A high value of amplification constant with a comparatively low plate impedance is one of the major characteristics and advantages of the 222 screened-grid tube.

The amplification obtained from this tube is a function of the mutual conductance of the circuit and the impedance of the load in the plate circuit. Owing to the fact that the impedance of the tube is so high, higher than its load impedance, the mutual conductance of the circuit is practically equal to that of the tube. If the mutual conductance of the tube is assumed to be 350 micromhos the amplification with various load impedances can be obtained by multiplying the mutual conductance in mhos by the load impedance. The values have been calculated and appear in Table 2. For certain reasons, however, it is likely that we can't get more than about 200,000 ohms in a tuned circuit under operating conditions. If an effective resistance of 200,000 ohms is connected in the plate circuit of a 222 tube, then the amplification will be about 70 (see Table 2). Compare this with the amplification of 10 to 15 obtained with a 201-A type tube.

The 222 tube has another distinct advantage, also important in the construction of high-gain radio-frequency amplifiers. This second advantage is that the effective grid to plate capacity

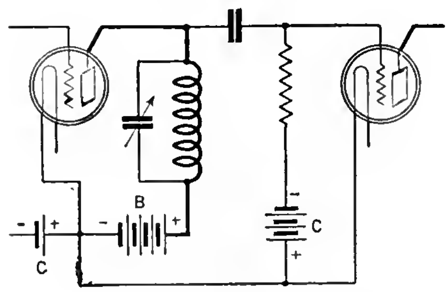


FIG. 2

If the plate impedance of the previous tube is very high the entire input coil of the following tube may be used to approach the maximum amplification possible. This is true when the screened-grid tube is used, for its plate impedance is very high indeed, of the order of one half to one megohm

of the tube is very small. It is this capacity which causes an ordinary tube to oscillate when it is used in an r.f. circuit. Theoretically, it is possible, therefore, to use this new tube in an r.f. amplifier without resorting to any scheme of neutralization to prevent the tube from oscillating.

Some experiments have been made in the Laboratory in an attempt to use these tubes in an r.f. amplifier designed for operation over the broadcast band. The circuit diagram is given here in Fig. 3. The experiments indicated more than anything else the difficulty of operating these tubes in a circuit designed to give the maximum amplification of which the tube is capable. The experiments also indicate that the tube can only be satisfactorily used in circuits containing very complete shielding and very complete filtering in the battery supply leads. This is to be expected, for such shielding and filtering is necessary in a good r.f. amplifier, using 201-A type tubes and, obviously, will be much more essential in an amplifier using these new tubes.

If the amplification of a circuit consisting of a UX-222 tube followed by a tuned circuit is measured, it be will found, with a good coil, to average about 30. The amount of gain obtained depends upon the efficiency of the coils used and increases as the coil is made better.

The first experiments were made with just one stage of r.f. amplification using the 222 tube followed by a detector, and even with very complete filtering and with both of the circuits shielded in aluminum cans the circuit would oscillate on practically all wavelengths. The coils used in the tuned circuits in this receiver were those made by Silver-Marshall, Incorporated, and it is probably true that, if poorer coils had been used, the circuit would have been found stable in operation. In fact, one ohm in series with the tuned circuit at 500 meters (600 kc.) and four ohms in series with the circuit at 200 meters (1500 kc.) was all that was necessary to make the circuit stable. This additional resistance necessary to prevent oscillation is not very great and many coils would have even higher resistances than that of the combined Silver-Marshall coils and resistances.

The same conditions of instability were, of course, also experienced when the receiver was changed over to use 222 tubes in two stages of r.f. amplification. Again, even with good filtering of the battery circuits, it was impossible to control the circuit, and it persisted in oscillating over the entire broadcast band. The circuit could be stabilized by any of the "losser" methods. In this particular receiver it is found that a resistance of about 1000 ohms connected between the grid and tuned input circuit would prevent the tubes from oscillating. Also stabilization of the amplifier is possible by tapping the plate on to a portion of the output coil rather than connecting it to the top of the tuned circuit, but this method of connection also results in a decrease of amplification. The photograph on page 284 shows

TABLE 2
Effect of Coil Resistance

Series Resistance of Coil	Effective Resistance at Resonance	Figure of Merit	Amplification Gm = 350
50	50,000	31.5	17.5
25	100,000	63.0	35
17.5	150,000	126	42.5
12.5	200,000	252	70
6.2	300,000	504	105

Conditions: Coil inductance 250 microhenries
Frequency, 1000 kc.

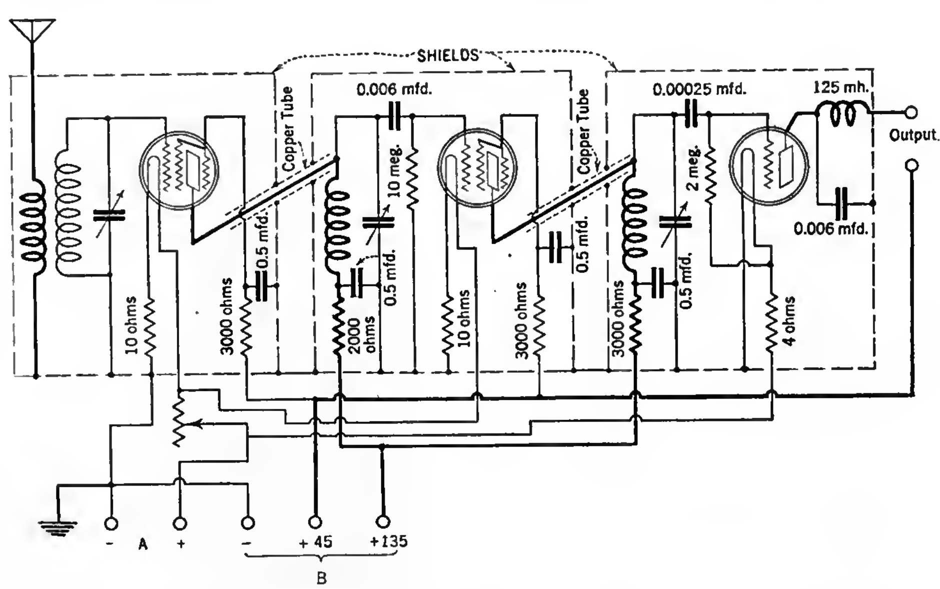


FIG. 3

Here is a two-stage screened-grid broadcast frequency amplifier hook-up. The stage shielding, and the filtering in each plate- and screen-voltage lead must be very good, and leads to the control or signal grid on top the tube must be short and often shielded. The leads connecting one stage to the next should be run in copper tubing which is grounded. Even then it may be found difficult to "hold down" the circuit how the coil was tapped. Further experiments will be conducted in the Laboratory to indicate the comparative effect of these various methods of stabilizing the circuit where they are necessary, but the use of such methods of preventing oscillation probably decrease the amplification that can be obtained and it will be preferable to design the receiver in such a manner as to give stable operation without any stabilizing devices. It may seem peculiar to the reader that so much difficulty was experienced with oscillation in the r.f. amplifier when one of the major purposes of the tube was to give freedom from instability in r.f. circuits. It should be realized, however, that the tube gives a very high amplification and it is necessary to develop new design features in receivers before these tubes can be utilized to best advantage. When it is realized that very careful design is required to produce stable high-gain radio-frequency amplifiers using 201-A's it should be clear why even greater care is necessary when a 222 tube is used, and perhaps four times the amplification per stage is obtained. It is probable that high-gain amplifiers that are perfectly stable at high radio frequencies will be constructed, but as yet we have not been able to do it in the Laboratory. This should not be construed as a statement to the effect that the possible gain is not greater than that obtainable with 201-A type tubes, for it certainly is—considerably so, but what we wish to infer is that circuits designed to operate with the tube to its best advantage are not available.

There are other problems than those connected with gain and stability. That of securing selectivity is probably even greater than that of maintaining stability over a wide frequency band. Owing to the greater amplification of all signals, the apparent selectivity is poor. When one has a two-stage broadcast frequency amplifier using screened-grid tubes giving three times, to be conservative, the gain per stage of 201-A tubes, the problem of selectivity becomes serious. The solution may be to decrease the gain per stage or to use some type of filter circuit at the input of the receiver capable of increasing the selectivity.

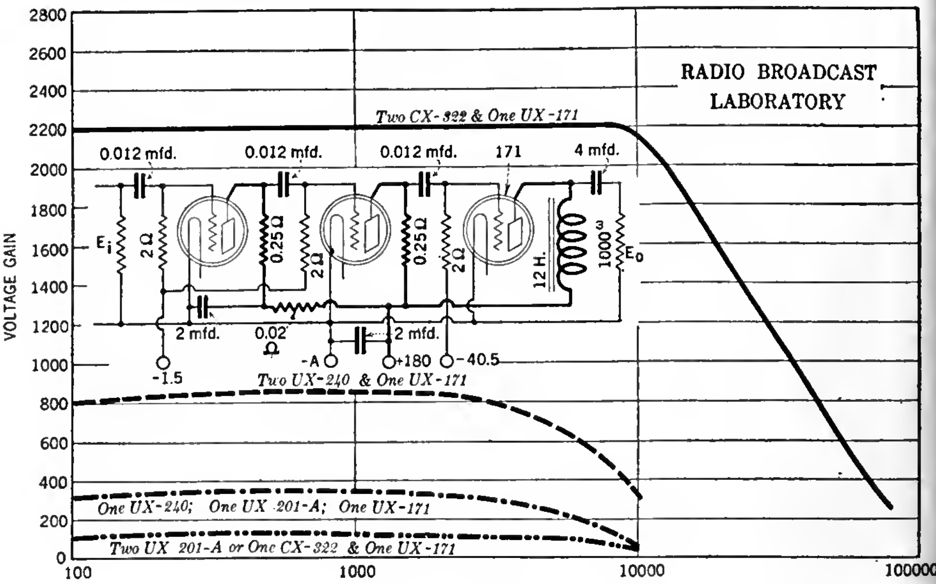


FIG. 4

When the total a.c. voltage appearing in the plate circuit of the last tube is divided by the input voltage to the first tube, this kind of curve results. In each case the final tube was a 171, and various combinations of high-mu tubes, screened grid tubes, and standard 201-A tubes were measured and the results plotted as shown

USE IN AUDIO AMPLIFIERS

In AUDIO-frequency amplifiers the difficulties are not so great, due to the fact that what grid-plate capacity exists in the tube (it is of the order of 0.025 mmfd.) cannot feed back such a large voltage into the input as it can at higher frequencies.

The two uses of this tube have been pointed out in previous articles. It may be used as a screened-grid tube in which the grid-plate capacity has been almost eliminated, or as a tube in which the grids are reversed and one is used mainly to reduce the space charge of the tube so that we have a tube whose values of amplification factor and impedance are much greater than the best of our high-mu tubes, the plate-grid capacity still being appreciable.

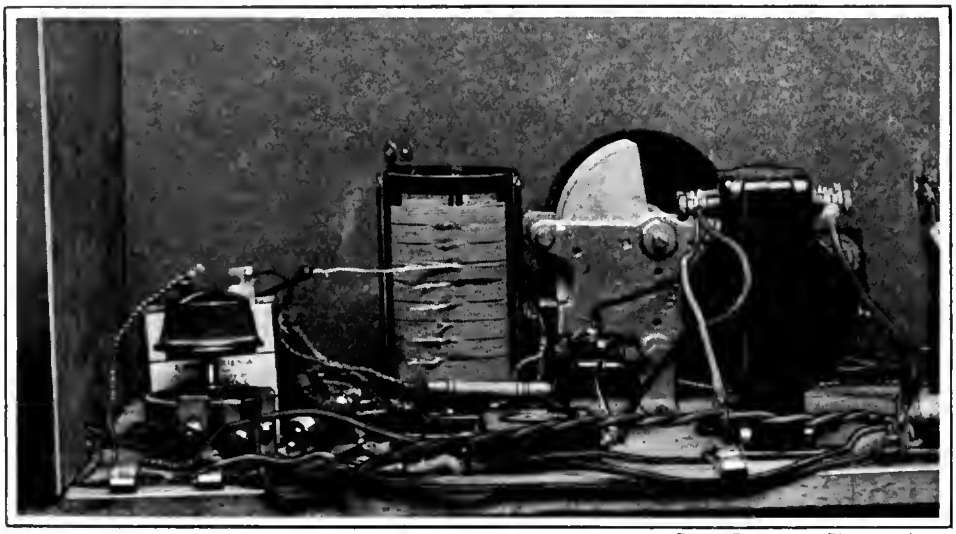
Experiments in the Laboratory indicate that the space-charge application of the tube is a good talking point but not much good in practice. If one wants to use this new tube in a low-frequency amplifier, which is where the space-charge tube would be important, all that is necessary is to use the screened-grid tube with proper values of resistances, capacities, and voltages. A photograph on page 282 shows a conventional three-stage resistance amplifier used in the Laboratory to obtain the data given in Fig. 4. Using screened-grid tubes with 180 volts to the 0.25-megohm resistors and 45 volts on the screen, a flat characteristic was obtained from 60 to 10,000 cycles. The total voltage appearing in the plate circuit, roughly three times that across the 1000-ohm resistance in its output, divided by the input voltage, gave a ratio of 2200, which is almost three times that obtainable when UX-240 high-mu tubes were used. Six volts were obtained across the output resistance when the input voltage was roughly five millivolts.

There is no catch in this amplifier, and for anyone who wants a voltage gain of 2200, and can use it, we recommend converting his old resistance amplifier into one using the new tubes.

While the curve in Fig. 4 shows that some amplification may be obtained at low radio frequencies with resistance coupling, much greater voltage step-up will be secured if tuned plate circuits are used, just as we use them at broadcast frequencies. Here the voltage gain possible is a function of but two factors, the mutual conductance of the circuit and the load impedance. The mutual conductance of the circuit is practically constant and equal to the static mutual conductance of the tube. Neither of these statements is true of ordinary tubes in ordinary circuits.

Multiplying the two factors together gives the maximum voltage gain to be expected, which is approached but not reached in practice. With a mutual conductance of 300 and a tuned circuit with an effective impedance of 250,000 ohms, a voltage step-up of 75 should be secured, and with air-core coils, amplification as high as 200 in the intermediate-frequency band has been recorded. When resistance coupling is used, the familiar drop in amplification at high frequencies is noted, due to the stray shunting capacities as well as the output and input capacities which tend to lower the effective impedance in the plate circuit.

In the amplifier of Fig. 4 a voltage gain of 2200 was indicated when 222 type tubes were used in the first and second stages. This is the total a.c. voltage in the plate circuit of the last tube divided by the input voltage. Figuring that the power tube, a 171, contributes a voltage amplification of 3, the two screened-grid tubes



Radio Broadcast Photograph

AN AUTO-TRANSFORMER MAY BE USED

In place of the conventional two-winding transformer between tubes, an auto-transformer may be used. This photograph shows how the proper place to tap the coil is determined in the Laboratory. The amplification at each tap is measured and the best number of primary turns found

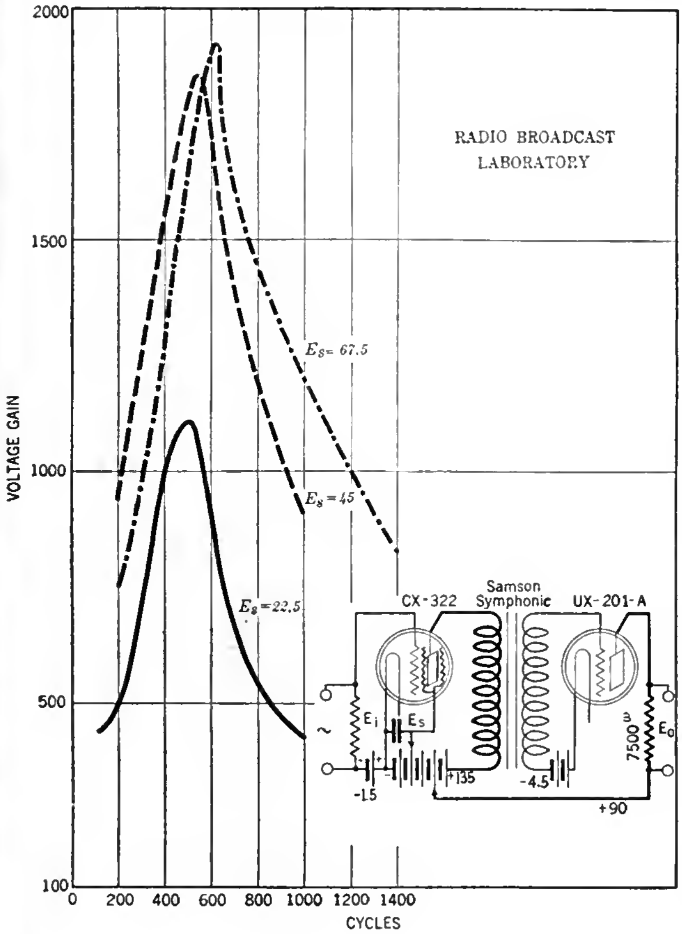


FIG. 5

There is often some advantage in a highly peaked amplifier. These curves were made with a Samson "Symphonic" transformer when used with a screened-grid tube

contribute about 27 each. In the Laboratory a single CX-322 (UX-222) fed into a UX-171 gave a voltage stepup of 120, corresponding to what may be expected from a three-stage resistance amplifier when two 201-A tubes with a 171 are used.

Off hand a voltage amplification of over 3000 with three tubes seems tremendous, but let us consider two transformer-coupled stages plus a final 171 amplifier. If the transformers have a 3:1 turn ratio, and the tubes have a mu of 8, the total voltage amplification from plate circuit of the last tube to input will be $(3 \times 8)^2 \times 3$, which gives 1730.

When transformers are used with the screened-grid tube, the effect of a low primary inductance transformer used with a low-impedance tube is obtained. In other words, a good transformer with a low-impedance tube gives a good characteristic; a high-ratio transformer (low primary inductance) with a high-impedance tube gives a peaked characteristic; a good transformer with a high-impedance tube also gives more amplification about the middle of the audio band than it does at the two ends. Curves of a Samson "Symphonic" transformer, which gives flat amplification with a 12,000-ohm tube, are shown in Fig. 5 and may indicate to code listeners how they can confine the amplification to a rather narrow band of audio frequencies. This transformer naturally resonates at a rather low frequency, and if the amateur or code listener desires his amplifier to peak at a higher frequency he should use a transformer with lower primary inductance, say a 5-1 transformer. These curves show a discrimination of two to one in voltage amplification between 200 and 500 cycles, and a total amplification of nearly 2000 under certain conditions. In other words, across 7500 ohms in the output of a 201-A type tube, 8.85 volts were obtained with an input of 3.5 millivolts. This is vastly greater amplification than amateurs use to-day, and probably far greater than they need. The average short-wave receiver with one stage of audio, and fair coupling to the antenna, goes down to the noise level, if the audio gain is about 30 to 50. The advantage of using more audio amplification lies in the fact that looser coupling to the antenna may be utilized, with consequent decreased radiation—with the usual type of receiver—and the fact that in good locations, where the noise is far down compared to weak signals, this amplifier will enable the listener to hear practically any radio-frequency disturbance in the ether, whether it is caused by signals or otherwise. The diagram of connections for this amplifier are given in Fig. 5. If still greater discrimination in favor of a certain small band of audio frequencies is desired the screened-grid tube might be connected to the detector output by means of a low-inductance choke, say of two or three henries, as shown in Fig. 6. This will be practically a short-circuit on the low frequencies, and will lower the voltage gain at all frequencies, but there will be plenty left. The average telephone receiver peaks very sharply between 700 and 1200 cycles and, combined with such a circuit as has been used in the Laboratory, should enable the listener to work through low-frequency static noises. There is some question among amateurs whether it is desirable to tune their audio amplifiers, since so many "hams" use low-frequency sources of plate supply for their power tubes, many using raw a.c. and others using self-rectifying circuits in which the tone is rather low. It is probable that it is the higher audio tones which should be eliminated from a code amplifier by proper bypassing, for it is these tones due to tube noise and other sources that supply nothing to the amateur but, on the other hand, tax his nervous energy.

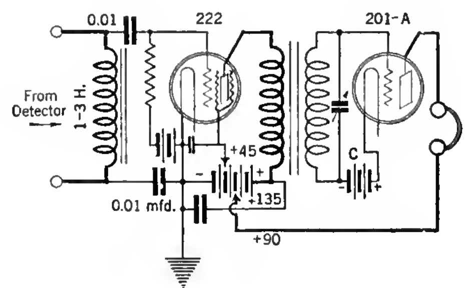
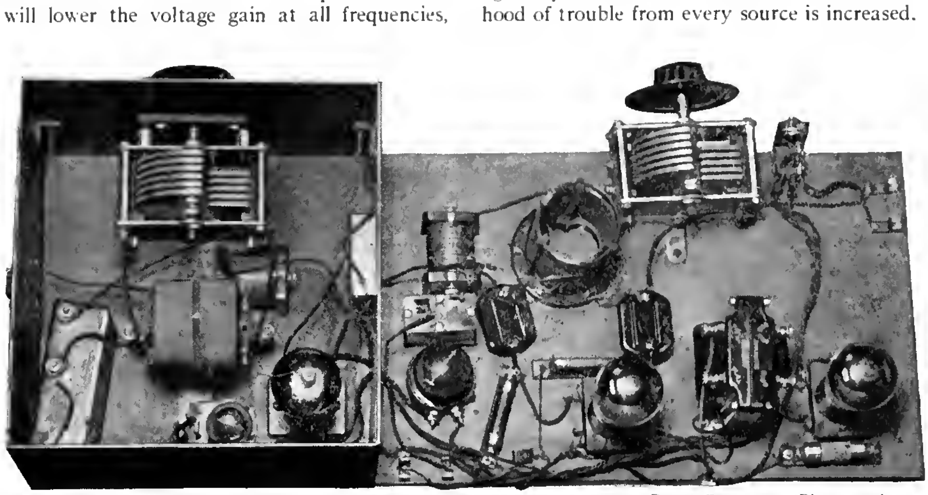


FIG. 6

If still greater discrimination against unwanted audio signals is desired, this manner of connecting the detector to the audio stage might be useful. The low-impedance choke in the input short circuits the low frequencies. The bypass condenser across the audio transformer secondary shunts out the higher audio tones and leaves only a narrow band around 1000 cycles

The screened-grid tubes which have been tested in the Laboratory are microphonic, and in the transformer-coupled system shown in Fig. 6, some trouble was encountered in keeping the amplifier from singing at the frequency where it amplifies greatest, which was near the mechanical resonant frequency of the elements of the tube. In the resistance amplifier less trouble was encountered, but it must be remembered that we are dealing with a large voltage amplification, which means that the likelihood of trouble from every source is increased.



Radio Broadcast Photograph

AN EXPERIMENTAL SET-UP

This is the Laboratory's "brass box" receiver—one r.f. stage using a screened-grid tube, with accessory apparatus, a detector, and a single stage of transformer-coupled audio amplification, are included. Arrangements are made for using a 201-A type tube in place of the 222 type so that the increase in amplification due to the new tube may be directly measured. The detector is calibrated and used as a vacuum-tube voltmeter while the audio stage enables the experimenter to monitor what is going on in the system

RADIO FOLK YOU SHOULD KNOW

WALTER VAN B. ROBERTS

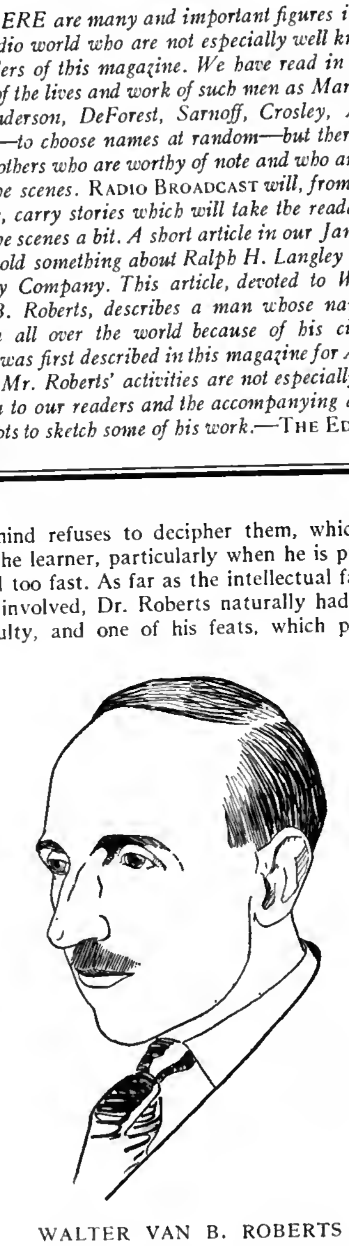
Drawing by Franklyn F. Stratford

THERE are many and important figures in the radio world who are not especially well known to readers of this magazine. We have read in great detail of the lives and work of such men as Marconi, Alexanderson, DeForest, Sarnoff, Crosley, Armstrong—to choose names at random—but there are many others who are worthy of note and who are behind the scenes. RADIO BROADCAST *will, from time to time, carry stories which will take the reader behind the scenes a bit. A short article in our January issue told something about Ralph H. Langley of the Crosley Company. This article, devoted to Walter Van B. Roberts, describes a man whose name is known all over the world because of his circuit, which was first described in this magazine for April, 1924. Mr. Roberts' activities are not especially well known to our readers and the accompanying article attempts to sketch some of his work.*—THE EDITOR.

MR. ROBERTS is well known to readers of RADIO BROADCAST as a frequent contributor to the magazine, and as the author of the comprehensive and lucid "How Radio Receivers Work" (Doubleday, Page & Co.). He is the inventor of the Roberts receivers, combining cascade radio-frequency amplification and regeneration. Since 1924 he has been on the engineering staff of the Radio Corporation of America, as a receiver and patent specialist. Mr. Roberts was an instructor in Physics and Electrical Engineering at Princeton before assuming his present position.

With some exceptions, among which the Roberts receiver is noteworthy, new receiving circuits christened with the name of the inventor have been lacking both in originality and technical merit. The reason has generally been too much publicity urge and not enough engineering qualifications on the part of the begetter of the great idea. Mr. Roberts is utterly lacking in publicity itch, and very strong in engineering background. From Princeton he has the following degrees: B. S., A. M., E. E., and Ph. D., but he is so modest about them that few people know he has them. The same applies to his scholastic honors in mathematics and physics—membership in Phi Beta Kappa, a medal for electrical research, and several fellowships and scholarships. A characteristic touch is the footnote appended to the bibliography at the end of his excellent little book, "How Radio Receivers Work": "This Bibliography is recommended to radio experimenters who really desire to increase their technical knowledge." The book itself is a very good summary, even under the handicap of some degree of popularization, of technical knowledge in the radio receiver field, but this fact the author apparently declines to recognize.

In May, 1917, Mr. Roberts enlisted in the Signal Corps as a Master Signal Electrician, "a high-sounding title ranking along with some of the higher grades of sergeants, if I remember correctly," as he puts it. He soon returned to Princeton to organize and run the Department of Signalling and Wireless in the School of Military Aviation, an army ground school for aviators. The object of the course was to inculcate the several thousand men who took it with an elementary knowledge of radio theory and practice on the spark-set-and-crystal-detector level, and to teach them to receive and send Morse at low speed. The code students were taught to print each letter separately as received, and cautioned not to look at letters already recorded for fear that they would be influenced in copying what was to follow. "To this day," testifies Dr. Roberts, "I copy code by writing letters separately and get all 'balled up' if I try to see what the message is about before it is all finished." Evidently he found learning the code a very painful process at first, as it is for most people. A monograph could be written about the agonized thoughts, amounting almost to hallucinations, the disturbances of breathing, the involuntary lapses of attention during which the code characters are heard while, in a sort of paralysis, the mind refuses to decipher them, which afflict the learner, particularly when he is pushed ahead too fast. As far as the intellectual factors were involved, Dr. Roberts naturally had little difficulty, and one of his feats, which proved useful in convincing the men that their memory of the code characters would improve with practice, was an ability to receive at ten words a minute any new code made up of four-element combinations of dots and dashes, after four minutes of study.



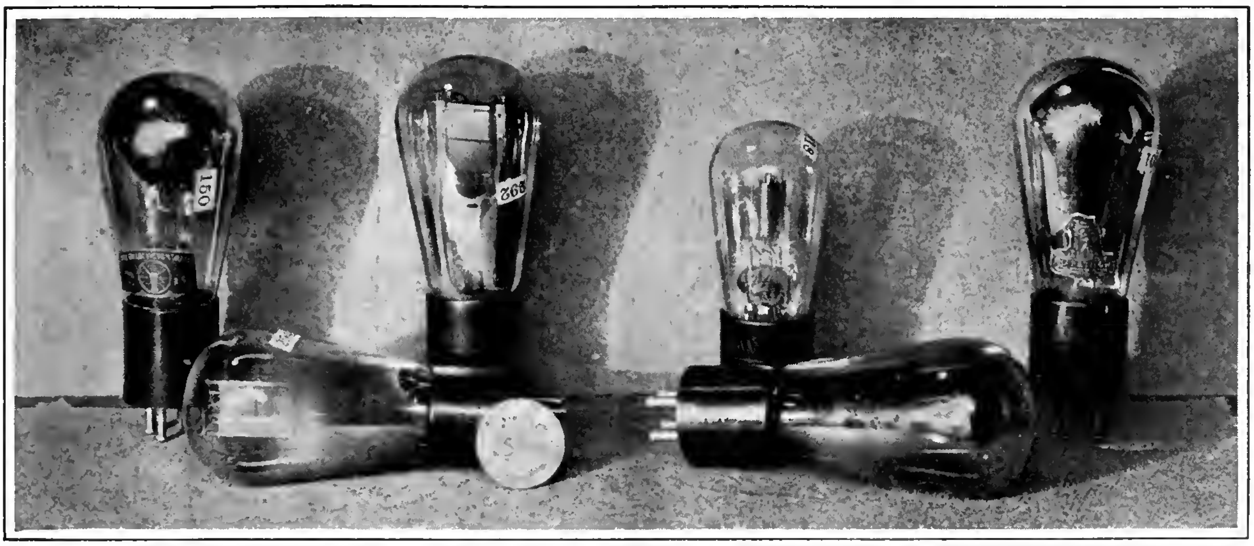
WALTER VAN B. ROBERTS

Early in 1918, Mr. Roberts obtained a commission as First Lieutenant in the Signal Corps, and soon after he was transferred to the 29th Engineers Sound-Ranging Service. In this branch of artillery practice microphones are placed at about half-mile intervals in convenient or possible places, depending on the terrain and the nature of the gun fire as well as on the technical requirements of the method. A pair of wires runs from each transmitter to a central station. When an enemy gun fires, the sound, traveling at only about 1200 feet per second, is received first by the microphone nearest to it, and, after an appreciable interval, by the next microphone, and so on. These times are automatically recorded at the central station, and the location of the gun follows after a few minutes of calculation. The big job is keeping the lines intact; Mr. Roberts states that half the personnel of a sound-ranging group is required for this purpose, over a hundred breaks in the lines during a night of heavy shelling being not uncommon. He thinks that a small radio transmitter associated with each microphone might be better than the wire links.

Mr. Roberts was a technical officer in the sound-ranging dugouts from June to October, 1918, when he was retired to hospital "with an excuse for getting a wound stripe," as he is pleased to phrase it. However, valuable technical officers were not sent back for bruised finger nails, and we may surmise that Mr. Roberts did not find his way to the rear alone, or under his own means of locomotion. He did go to the front alone, however, and by almost as painful a route. It seems that he sailed for France as a casual officer in charge of one hundred and twenty crates of sound-ranging equipment, including storage batteries, carboys of acid, wire, and special microphones responsive only to low-frequency sounds. His first job was to keep his one hundred and twenty crates together in the unloading process. He succeeded, presumably by exerting the forcefulness of a brigadier general, which is difficult without the silver star. With all the stuff in a freight car, Roberts added his baggage and a can of corned beef, and finally himself. He thus traveled in state to the freight yards outside of Paris, where he remained two days. He did not leave his freight car, because no one knew when it would pull out, and he wished urgently to be with it at that time. After a week in the freight car, he finally got close enough to the front to permit the equipment to be transferred to three trucks, which moved it into the trenches under cover of darkness.

Before the war Dr. Roberts had one other job—he worked on acoustic problems for the Western Electric Company, at $12 per week. But he says that this sum was more than he was worth.

Mr. Roberts is married, has two children, and lives in Princeton, New Jersey.



Radio Broadcast Photograph

HERE ARE THE NECESSARY TUBES FOR THE UNIT DESCRIBED IN THIS ARTICLE

The metal disc is the size of a half dollar, and is shown to give some idea of the size of the tubes

An A. C. Push-Pull Amplifier and B Supply

By J. E. Coombes

THE introduction of a.c. tubes has greatly simplified the construction of complete receivers which derive all of their power directly from the electric light mains. For those of us who now have a tuner unit or a complete receiver with an out-of-date audio amplifier, the a.c. tube is a logical means whereby we can construct a completely a.c. operated audio amplifier that can be hitched on to the output of the detector tube or to which we can connect an electrical pick-up when we want to play phonograph records. And, incidentally, we can design our amplifier also to supply plate voltage to the detector and r.f. tubes of the radio receiver proper. Such a combination amplifier and B supply device is illustrated in this article.

The device illustrated herewith includes a two-stage transformer-coupled amplifier using a type 227 a.c. tube in the first stage, followed by two type 210 tubes in a push-pull arrangement. Plate potential for these tubes is obtained from two 216–B or 281 type tubes operating in a full-wave rectifier circuit. Filament current for the two 210's is obtained from a filament winding on the power transformer (T_1 in Fig. 1) and filament current for the 227 a.c. tube is obtained from a separate filament transformer, T_2. The latter transformer also contains a winding which can be utilized to supply one or more r.f. tubes in the radio receiver proper, thereby making the entire set operate directly from the power mains. We are assuming that 226 type a.c. tubes will be used in the r.f. amplifier, and a 227 type tube for the detector. The latter will be supplied by the same transformer winding as the first audio stage. The B power part of the amplifier contains a glow tube to maintain the output voltages constant independent of the load drawn by the radio receiver.

Some readers may merely want to construct the push-pull circuit and B supply rather than a complete two-stage amplifier. For this reason the circuit diagram has been divided into two parts by a dotted line, the push-pull amplifier and B supply being located to the left and the first stage of audio amplification to the right. Neglect the right-hand side of the diagram if only the push-pull amplifier and B supply are to be constructed, and connect the output of the receiver proper to the terminals marked X-Y, the new input posts. This latter unit (the push-pull amplifier) will operate without any appreciable hum although a slight amount of hum is noticeable during the silent periods in a pro-

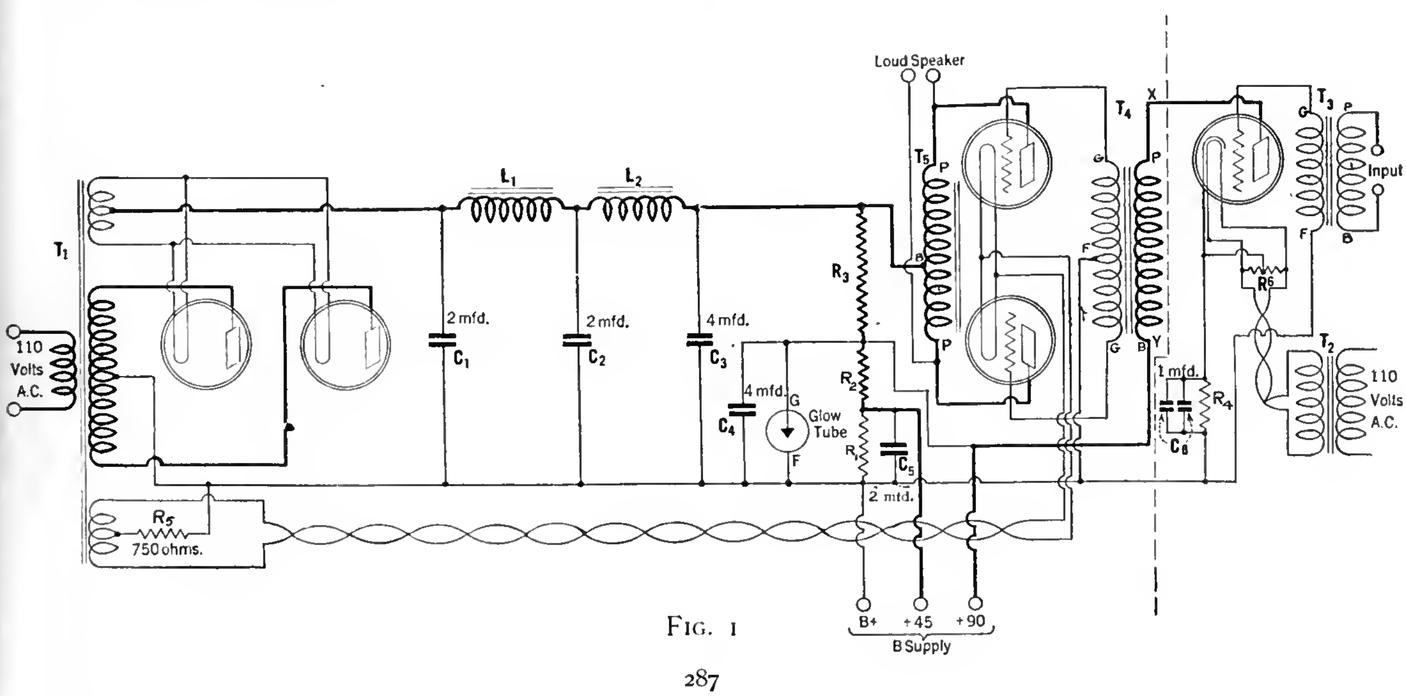


Fig. 1

gram when using the complete two-stage amplifier.

Naturally this amplifier can handle considerable volume. Volume, however, is not the main objective any more than an 80-mile-per-hour automobile is expected to travel at top speed through traffic. Like the automobile, however, this heavy-duty power amplifier has the liberal fund of reserve power essential to prevent overloading and thereby reproduce a radio program with the least possible distortion.

The power transformer, T_1, contains three separate windings. One winding provides 550 volts either side of the center tap to supply a full-wave rectifier system using two 216-B or 281 type tubes. The latter tube, because of its greater rating, will generally have somewhat longer life than a 216-B tube and will also give a slightly greater output voltage. In addition to the center-tapped high-voltage secondary, the transformer also contains two 7½-volt windings to supply filament current to the rectifiers and the 210 power amplifier tubes. The output of the rectifier is fed into a filter system containing two filter chokes, L1 and L2, and three condenser banks, C_1, C_2, C_3. The high-voltage output, (about 450 volts under load) of the filter is fed directly to the plates of the UX-210 (CX-310) tubes.

All of the resistances necessary in the construction are contained in the Ward-Leonard Vitrohm resistor kit, type No. 507-47. R_1 and R_2 in the diagram are two 5000-ohm resistances contained in the kit. R_3 is composed of a combination of resistors. By using different values of resistance at this point the amount of current drawn by the glow tube is varied. Generally, it will be satisfactory to have R_3 consist of the 3500-ohm and 1500-ohm resistances in series, to give a total resistance of 5000 ohms. However, when the tuner unit consists of only a couple of tubes, say a detector and one stage of r.f., this resistance may be increased by connecting the 3000-ohm resistance in series with the two mentioned above. This combination will give a total resistance of 8000 ohms and this additional resistance will decrease, somewhat, the current drain on the filter system and the maximum possible voltage is thereby delivered to the plate of the power tube.

The C bias for the 227 type tube is obtained from the voltage drop across the 1500-ohm resistance, R_4. This resistance is bypassed with a 2-mfd. condenser. C bias for the 210 tubes is obtained from the 750-ohm resistance, R_5, connected to the center tap of the filament winding supplying these tubes. A bypass across this resistance is not necessary because there are no audio-frequency currents flowing through it.

The following table shows how the total output voltage of the rectifier-filter system varies with current drawn from it:

D. C. Current, mA.	D. C. Volts
60	537.5
70	515.0
80	487.5
90	462.5
100	440.0
110	427.5
120	417.5

In normal operation the 210's take about 20 mA. each, the glow tube a maximum of 40 mA., the first audio stage requires a maximum of 5 mA., and if the detector and r.f. tubes take a total of 10 mA., then the total load on the B supply unit will be 95 mA. At these current drains the output is about 450 volts and subtracting about 30 or 35 volts which is lost in the C bias resistance, there is left an effective voltage of about 415 volts on the plates of the 210 tubes.

The complete amplifier, as the illustration shows, was constructed on a baseboard, measuring 9 x 24 inches, and most of the wiring can be done under the baseboard by drilling holes through the board directly beneath the terminals on the various units and threading the leads through. The filament leads to the 210's and 227 should be twisted. No special kinks are necessary in the construction and the circuit diagram and illustration in this article should supply all the necessary constructional hints.

To assemble the complete amplifier and B supply exactly as illustrated, the following parts are necessary:

T_1—Thordarson Power Transformer, T-2098
L_1, L_2—Thordarson Double Filter Choke, T-2099
T_2—Thordarson Filament Transformer, T-2445
T_3—Thordarson R-200 Audio Transformer
T_4—Thordarson Push-Pull Input Transformer, T-2408
T_5—Thordarson Push-Pull Output Choke, T-2420
C_1, C_2—Acme Parvolt Filter Condensers, Series B, 2-Mfd.
C_3—Acme Parvolt Filter Condenser, Series B, 4-Mfd.
C_4—Acme Parvolt Filter Condenser, Series A, 4-Mfd.
C_5—Two Acme 1-Mfd. Parvolt Filter Condensers, Series A
C_6—Acme Parvolt Filter Condensers, Series A, 1-Mfd.
R_1—5000 Ohms
R_2—5000 Ohms
R_3—5000 to 8000 Ohms (See Text)
R_4—1500 Ohms
R_5—750 Ohms
(All these resistances are contained in the Ward Leonard Vitrohm Resistor Kit, No. 507-47)
R_6—General Radio Center Tapped Resistance
Five Benjamin Sockets, 4-Prong, No. 9040
One Benjamin Socket, 5-Prong, No. 9036
Seven Eby Binding Posts

The Requisite Tubes

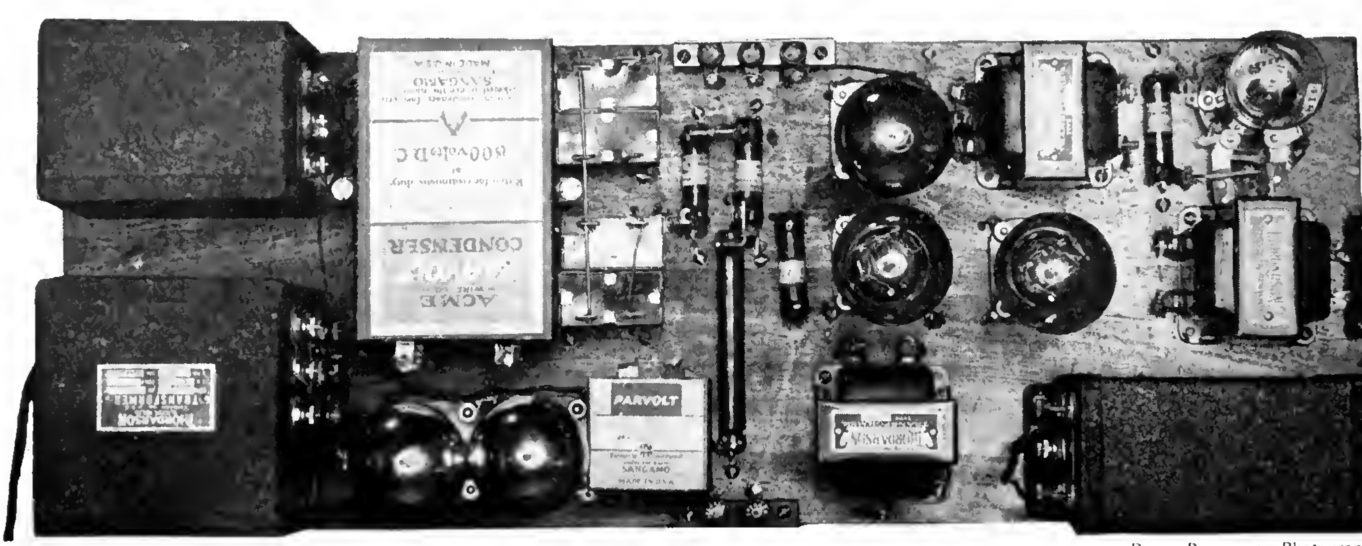
Two UX-210 Power Tubes
One UX-874 Glow Tube
Two UX-216-B Rectifier Tubes
One UX-227 A.C. Heater Type Tube

The power lead from T_1 can be plugged into an extra receptacle which is in the end of the filament transformer, leaving one lead to be plugged into the regular light socket. In operation, the resistances will get quite warm and the regulator tube should glow with a bluish or pinkish glow. The input terminal connecting to the P post of the input transformer should connect to the plate of the detector tube and the other input lead should connect to the B + 45-volt terminal on the B supply. If one side of the A battery is not grounded, it should be.

It will be noted that R.C.A. terminology has been resorted to throughout this article when referring to tube types. Tubes exactly similar to those bearing the R.C.A. stamp are supplied by Cunningham. The following table shows the parallel types:

R. C. A.	Cunningham
UX—226	CX—326
UX—227	CX—327
UX—210	CX—310
UX—216-B	CX—316-B
UX—281	CX—381
UX—874	CX—374

Many independent manufacturers are also supplying tubes the characteristics of which are similar to or approximate very closely those of the tubes specified in this article.



Radio Broadcast Photograph

THE COMPLETE PUSH-PULL AMPLIFIER AND B SUPPLY

New Recordings by Radio Favorites

FAMOUS SYMPHONY CONDUCTORS

THE insert at the top, shows Nikolai Sokoloff, conductor of the Cleveland Symphony, shown in the large oval. Many records have been made for Brunswick by the Cleveland orchestra. Henri Verbrugghen is shown in the left-hand insert of the lower group of three conductors, the center one being Willem Mengelberg, and the right-hand one Walter Damrosch. Verbrugghen is conductor of the Minneapolis Symphony, heard over WCCO; Mengelberg now conducts the New York Philharmonic, heard over WOR; Walter Damrosch, conducting a large group of New York Symphony men, is heard over WJZ and chain each Saturday night. The Cleveland orchestra broadcasts through WEAR

Recent Symphony Orchestra Recordings

A FEW records which have been recently issued deserve special attention, particularly because they are noteworthy achievements in recording. If you are not aware of the vast improvement that has been made in this art by the development of electrical recording, play a record of the old method and compare it with one of the new method. You will observe the extended tone range of the latter, in which you will hear high and low notes which were lost by the old system of recording. Of course that is taking for granted that your own reproducing apparatus is adequate. If you are still making use of one of the pioneer phonographs, or an antediluvian horn as your loud speaker, all records will sound equally bad. But with good equipment it won't require much imagination to believe that you are in the hall with the orchestra itself instead of in your own home listening to canned music.

One of the new records which would be particularly successful for this demonstration which we suggest is the "1812" *Overture* of Tschaikowsky (Brunswick), in which the composer has plumbed the musical depths with the resounding tones of the tympani, then in the next breath climbed to ecstatic heights with the strings. The full orchestra is brought into play and not an iota of color is lost by the recording of this magnificent overture, which has been played in masterly fashion by the Cleveland Orchestra under the direction of Nikolai Sokoloff.

Nor are any of the delicate shadings lost in the exquisite *Dernier Sommeil de la Vierge* of Massenet, as played for Brunswick by the Minneapolis Symphony under the baton of Henri Verbrugghen. This lovely ecclesiastical music contrasts strangely with the robust *Coppelia Ballet* which appears on the reverse side of the record. This delightful composition by Delibes has as much swing to it as any present day dance number you can think of and a melody as simple as any jazz strain—and furthermore it is many times as soul-satisfying.

Two more classical dance numbers are Johann Strauss's *Artist's Life* and *Tales From the Vienna Woods* (Brunswick). The interpretation of these oft-heard waltzes by Willem Mengelberg, conducting the New York Philharmonic Orchestra, is to their usual rendition as a production of Midsummer Night's Dream by Max Reinhardt is to a high-school performance of the same comedy.

Perhaps the most famous musical selection in the world is the *Wedding March* from Lohengrin. Certain it is that a great many people, be they married or single, know it and love to hear it played. Certain it also is that most of them have never heard it more beautifully interpreted, if as beautifully, as it has been by the Cleveland Orchestra under the direction of Nikolai Sokoloff, for Brunswick. This makes the usual rendition, cloaked in romance and sentiment though it be, seem stale by comparison. And the same may also be said about the Prelude to Act 3 of *Lohengrin*, which selection is on the opposite side of the *Wedding March* (Brunswick).

Another familiar number is the *Song of India* by Rimsky-Korsakow. We once thought that we never wanted to hear this again. That was because a neighbor of ours—oh, years ago—had just invested in a phonograph and a few records, very few! One of them was the *Song of India* popularly recorded. The thrill of having a phonograph was evidently great, for the machine was never silent. It was Spring and all windows were open. Need we say more? But we find that this record by the Cleveland Orchestra is something else again. We can hear it with as much delight as if it were entirely new to us. This same orchestra's version of Tschaikowsky's *Sleeping Beauty* waltz is full of color and feeling and contrasts vividly with the usual performance of this favorite by hotel orchestras and bands, whose treatment of it is seldom more than an adequate reading of the notes (Brunswick).

On the next page we give a list of recent electrically recorded symphony records.

Recent Popular Records

HAVING on various occasions thrown stones in no uncertain fashion at popular music it behooves us to explain ourselves before we proceed to review some of the popular records. While we still contend that it wearies us in bulk, we admit that we thoroughly enjoy it in small doses. A little of it over the radio is an excellent thing; and the same applies to the phonograph.

But the dose must be moderate and we want it palatable.

Though we can t seem to get away from the stumbling block of a limited number of current songs which we are forced to hear over and over again, the better orchestras do their best to vary the music as much as possible by the addition of frills in studied orchestration. Those who orchestrate well can make good music out of mediocre. Take for instance *Good News* and *Lucky in Love* as played for Brunswick by Ben Selvin and His Orchestra. Yes, those are the same selections which we frowned on so severely last month. But you would never know they were the same! That is what Selvin orchestration does for a piece. A little trimming here and there by a steel guitar—and the trick is done. The result: a simply grand dance record!

This orchestra is versatile, too. In *I Could Waltz On Forever* it makes the most of the strings, the sax, and the piano. Even that moss-grown favorite, *Cheerie-Beerie-Bee*, on the reverse, takes on new life under Selvin treatment (Brunswick).

Play-ground in the Sky from "Sidewalks of New York," being a particularly good number to start with, doesn't need much doctoring and it has very wisely been simply treated by this same orchestra. Incidentally, why haven't we heard this selection oftener? It is swell! *Wherever You Are* from the same show isn't as good but the most has been made of it (Columbia).

The fourth record by this outfit is *I Call You Sugar* and *Yes She Do* (Brunswick). Again trick orchestration. Selvin does this instrumental ornamentation extremely well, making it fit into the general scheme of things instead of letting it stand out like the ball on the Paramount Building, as a lesser light would be apt to do. The result is that the records are not ruined for dancing but are improved.

Our old favorite, Ernie Golden, is a past master at this art of orchestration. He rings the bell again with *All By My Ownsome* and *A Night In June*, in which he introduces a steam caliope effect which is grand! We suggest that he get it patented and use it as a musical trade mark (Brunswick).

Don Voorhees has made four recordings on three different discs for Columbia. These four are: *Rain, Baby's Blue, Highways Are Happy Ways*, and *When the Morning Glories Wake Up In The Morning*. There is a sort of smooth placidity about this orchestra by which you can always identify it. It never gets excited, it is uniformly good and yet it never seems to climb quite to the topmost heights. However, it has personality and that is a lot in these days. We have named the records in the order in which we rate them, the first being by far the best. Listen to the saxophone.

On the opposite side of *Baby's Blue* is *The Calinda* by the Radiolites. It is a very good number with an irresistible swing. Not the least attractive feature of the record is the vocal chorus by Scrappy Lambert, of cough drop fame. (Columbia).

The Radiolites are responsible for another good dance record, *There's A Cradle in Caroline* and *Everybody Loves My Girl*. Neither selection is inspired but each moves along with a smooth rhythm (Columbia).

A record that stands out from the rest is *Charmaine* and *Did You Mean It?* by Abe Lyman's California Orchestra. Both numbers are played with a restraint not often displayed by a dance orchestra. Soft pedals and plaintively insinuating rhythms are a relief after robust, vigorous jazz (Brunswick).

If you have once heard Phil Ohman and Victor Arden stroke, jingle, bang, and otherwise urge on the ivories, you will look forward eagerly to hearing them again. We have and did, and were disappointed by their record for Brunswick, *There's Everything Nice About You* and *Mine*. Oh, yes, they are good numbers, well played, but there is too much of the orchestra and too little piano. You can always hear good orchestras but there is only one Ohman and Arden.

Two more disappointments were records by Ben Bernie and His Hotel Roosevelt Orchestra and by Vincent Lopez and His Casa Lopez Orchestra. By rights one can expect the best from these two bands. But they both play as if pay day were at least a month away. The records are *Miss Annabelle Lee* and *Swanee Shore* by the first outfit and *Someday You'll Say "O. K."* and *Just a Memory* by the second. Both are Brunswick.

Only moderately good are the rest: *A Night in June* and *Are You Happy* by the Ipana Troubadours (Columbia); *Feelin' No Pain* and *Ida Sweet as Apple Cider* by Red Nichols and His Five Pennies (Brunswick); *Manhattan Mary* and *Broadway*, both numbers from "Manhattan Mary," by Cass Hagan and His Park Central Hotel Orchestra (Columbia); *Like the Wandering Minstrel* and *Molly Malone*, from "The Merry Malones," played by The Cavaliers (Columbia); and *No Wonder I'm Happy* and *Sing Me a Baby Song* by the George H. Green Trio (Columbia).

Taken all in all all these dance records that we have reviewed form a good collection. Not one of them is really poor.

If you are a devotee of Roxy you will welcome three records played in the Roxy Theatre by Lew White, the organist, *Broken Hearted* and *Just Like a Butterfly, When Day is Done* and *Forgive Me, Underneath The Weeping Willow* and *At Sundown* (Brunswick all). It is all typical movie organ music. Many people object to that sort of thing but we like it when it is well done, as this is. Our preference is for *Underneath the Weeping Willow* and second choice is *Broken Hearted*. Neither of these has a vocal chorus and the rest have. Does a vocal chorus go with organ music?

The male counterpart of Vaughn De Leath seems to be Vernon Dalhart. He isn't as gushy, for which let us be truly thankful, but the idea is the same. He offers *My Mother's Old Red Shawl* and *Down On The Farm* on a Brunswick record.

Billy Jones and Ernie Hare, the Happiness Boys, again present us with a little vulgar singing of a nice sort. Well, you know they aren't exactly refined but they are *good*. This time they have recorded *You Can't Walk Back From An Aeroplane* and *Who's That Pretty Baby?* for Columbia.

Art Gillham, the Whispering Pianist, hands out the typical vaudeville sob stuff, piano and recitative, in *Just Before You Broke My Heart* (Columbia). On the other side is *I Love You But I Don't Know Why* which is moderate.

About the only thing to say about *Roam On My Little Gypsy Sweetheart* and *There's A Cradle in Caroline* as sung by the Goodrich Silvertown Quartet is that they have been in better shows than this (Columbia).

The same might be said of the Anglo-Persians who play *Call of the Desert* on a Brunswick record. But they redeem themselves by the selection on the reverse side, *Down South*. We end on a note of praise for the carpet riders.

New Electrical Symphony Orchestra Recordings

New York Philharmonic Orchestra	Victory Ball—Fantasy. Parts 1 and 2	(Schelling)	1127	*Victor*
	Victory Ball—Fantasy. Parts 3 and 4	(Schelling)	1128	*Victor*
	Artist's Life	(Strauss)	50096	*Brunswick*
	Tales from the Vienna Woods	(Strauss)	"	"
	Marche Slave, Parts 1 and 2	(Tschaikowsky)	50072	*Brunswick*
	Midsummer Night's Dream—Scherzo	(Mendelssohn)	50074	*Brunswick*
	Midsummer Night's Dream—Nocturne	(Mendelssohn)	"	"
Chicago Symphony Orchestra	Wine, Woman and Song	(Strauss)	6647	*Victor*
	Southern Roses	(Strauss)	"	"
	Carnival Overture, Parts 1 and 2 (Op. 92)	(Dvorak)	6560	*Victor*
	In Springtime—Overture, Parts 1 and 2, Op. 36	(Goldmark)	6576	*Victor*
	(1.) Serenade (Volkmann, Op. 63.) (2.) Flight of Bee	(Rimsky-Korsakow)	6579	*Victor*
	Valse Triste	(Sibelius)	"	"
	To a Water Lily	(MacDowell)	1152	*Victor*
	To a Wild Rose	(MacDowell)	"	"
St. Louis Symphony Orchestra	Country Dance, No. 1	(German)	9009	*Victor*
	Pastoral Dance, No. 2—Merrymaker's Dance, No. 3	(German)	"	"
	Fingal's Cave—Overture, Parts 1 and 2	(Mendelssohn)	9013	*Victor*
Cleveland Symphony Orchestra	Blue Danube Waltz	(Strauss)	50052	*Brunswick*
	Tales From Vienna Woods	(Strauss)	"	"
	Danse Macabre	(Saint-Saëns)	50089	*Brunswick*
	Merry Wives of Windsor Overture	(Nicolai)	"	"
	Finlandia	(Sibelius)	50053	*Brunswick*
	Symphony No. 2	(Brahms)	"	"
	Hungarian Dance, No. 5, G Minor	(Brahms)	15092	*Brunswick*
	Valse Triste (Op. 44)	(Sibelius)	"	"
	Slavonic Dance No. 3	(Dvorak)	15091	*Brunswick*
	Traumerei	(Schumann)	"	"
	1812 Overture—Parts 1 and 2	(Tschaikowsky)	50090	*Brunswick*
	Lohengrin: Prelude to Act 3	(Wagner)	15121	*Brunswick*
	Lohengrin: Wedding Music	(Wagner)	"	"
	Sleeping Beauty Waltz	Tschaikowsky	15120	*Brunswick*
	Song Of India	(Rimsky-Korsakow)	"	"
Minneapolis Symphony Orchestra	Coppelia Ballet—Prelude and Mazurka	(Delibes)	50087	*Brunswick*
	Dernier Sommeil de la Vierge	(Massenet)	"	"
	Der Freischutz, Overture, Parts 1 and 2	(Weber)	50088	*Brunswick*
	Melodrama from "Piccilino"	(Guiraud)	15117	*Brunswick*
	Waiata Poi	(Hill)	"	"

"Our Readers Suggest—"

"Our Readers Suggest. . ." is a regular feature of Radio Broadcast, *made up of contributions from our readers dealing with their experiences in the use of manufactured radio apparatus. Little "kinks," the result of experience, which give improved operation, will be described here. Regular space rates will be paid for contributions accepted, and these should be addressed to "The Complete Set Editor,"* Radio Broadcast, *Garden City, New York. A special award of $10 will be paid each month for the best contribution published. The prize this month goes to Conrad Ederle, New York City for his suggestion entitled "Extending Loud Speaker Leads."*

—The Editor.

Extending Loud Speaker Leads

It is often very desirable to place a loud speaker some distance from the set in conjunction with which it is operating. The long leads, however, are somewhat bulky, and are especially conspicuous when run along the wood molding.

It was recently the writer's job to install a loud speaker diametrically across the living room from the receiver in such a manner as to merit the approval of several discriminating family critics. The method used to accomplish this task may be of general assistance.

In the first place one of the two long leads generally necessary was dispensed with. There are two available grounds in our living room, a radiator by the receiver, which is used for the set ground, and gas logs in a fireplace, on the mantel over which the loud speaker is mounted. A connection from the loud speaker to the logs was used as one wire, the other loud speaker terminal being connected to the receiver as shown by the dotted lines in Fig. 1. As a matter of experiment, the resistance of the ground circuit (*i. e.,* the matter between the set ground and the loud speaker ground) was determined, and its value found to be 28 ohms. This is not, indeed, very low, but, on the other hand, not high enough to occasion an appreciable loss in signal strength.

A No. 26 single white cotton-covered wire was used as the conductor from the loud speaker to the set. This wire was run inconspicuously along the cream colored molding. However, the last six feet, from the molding across the wall to the loud speaker cord, was necessarily exposed. The visibility of the exposed portion was reduced materially by running the single wire down a corner and gluing the wire in place rather than using tacks. A drop of LePage's glue was placed at one foot intervals along the wire. This was allowed to become tacky before being pressed against the wall. Talcum powder was blown from the palm of the hand, while the glue was still moist, effectively hiding the brown color, and blending successfully with the buff tone of the walls.

Conrad Ederle,
New York City.

STAFF COMMENT

As Mr. Ederle observes, it is often desirable to operate a loud speaker at some distance from the receiver. The desirability of this arrangement may be dictated by esthetic or technical considerations. Some receivers, notably those operating from loop antennas, function best in a definite section of a room.

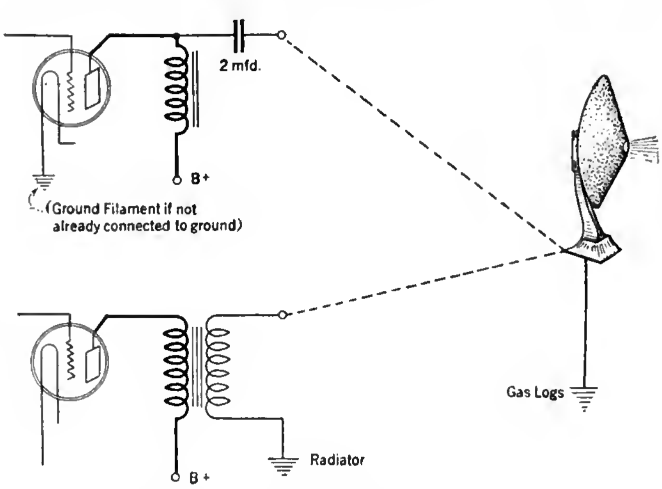


FIG. 1

Showing how a single lead to the set, plus a ground connection, can be used with either transformer or choke coil output device to operate a loud speaker at some distance from the receiver

The same holds true with loud speakers when careful consideration is given to acoustic effects.

Belden has produced a flat two-wire extension cord which may be laid under a rug, providing a very convenient form of inconspicuous wiring. While the Belden arrangement was designed ordinarily with the requirements of the 110-volt power line in mind, there is no reason why it should not be adapted to a loud speaker output circuit.

In using the ground return suggested by Mr. Ederle, it is quite essential that an output device be employed—either a choke coil arrangement or a transformer. Unless one of these is used, the high voltage to the plate of the output tube will, in many cases, be shorted 'over' to ground. Both circuit arrangements are shown in Fig. 1.

The Cartridge Type Charger

Many fans have the connections from the storage A battery to the charger arranged as shown in Fig. 2A, merely closing the 110 volts a. c. circuit whenever the battery needs charging. This scheme is entirely satisfactory when a bulb type charger is used, for the path between the plate and the filament of the tube becomes non-conducting when the filament heating current is cut off and, therefore, no discharge path through the charger is presented to the A battery current.

When the cartridge type charger which has recently appeared on the market is used, however, this scheme is no longer satisfactory. An investigation made to learn why a battery connected to the charger as shown in Fig. 2B seemed to lose its charge in a few days disclosed the reason. An ammeter introduced into the circuit to indicate the rate of charge showed a slight negative reading when the a. c. power was cut off. Further investigation disclosed a reverse current of approximately 180 milliamperes passing continuously when the transformer was disconnected from the power line.

A double-pole double-throw switch was included in the circuit as shown in Fig. 2C. The battery now retains its charge as long as it did before the type of charger was changed.

Herbert J. Harries,
Pittsburgh, Pennsylvania

STAFF COMMENT

Measurements in the Laboratory on the new type National full-wave charger, which employs two cartridge recti-

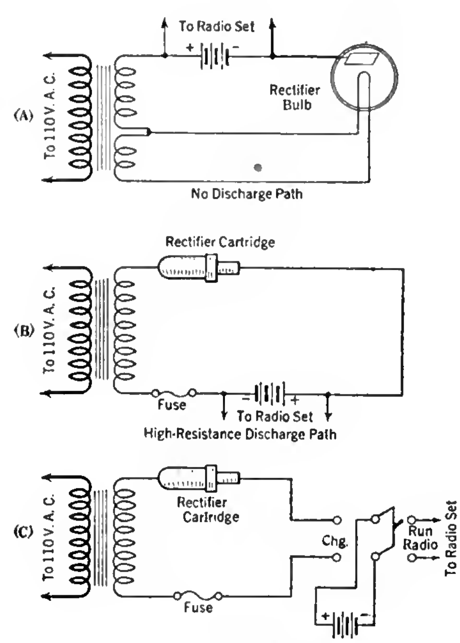


FIG. 2

Various methods of A battery charger connections. C shows a system of connections for a cartridge rectifier fiers, indicate that practically *no* current will flow if the arrangement in Fig. 2B is employed, suggesting that the switching is unnecessary. We believe that the current Mr. Harries noted was due to a defective cartridge. In such a case the switching arrangement might very well be resorted to since a cartridge that is only slightly defective will still give many hours service. The switching arrangement shown in Fig. 2C may be slightly improved by using a three-blade switch, the extra contacts being used to control the 110-volt line to the charger. When the switch is in the right-hand or charge position, the charger will automatically be turned on.

The Glow Tube

THE use of the glow or regulator tube, such as the UX-874 (CX-374) or the Raytheon type R, effects a general improvement in socket power circuits. The stability of the r. f. circuit is sometimes improved, while the tendency to "motorboat," and oscillation in the audio-frequency amplifier is considerably reduced by its use. The glow tube is connected between the ninety-volt tap and the negative binding post on the power supply unit and is so designed that a practically constant potential is maintained across these posts regardless of the current load.

The regulator tube was specified or furnished

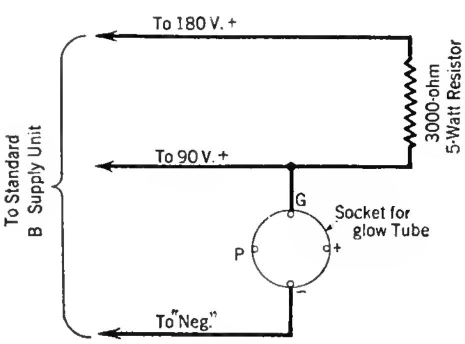


FIG. 3

How to add a glow tube to any B supply device. The addition of the glow tube will increase the stability and all-around efficiency of the circuit.

with very few B supply devices, homebuilt or ready made, previous to the present radio season. The benefits of the glow tube can be obtained with such power sources by connecting the tube externally. The addition of the tube is a matter of a few simple connections. Briefly, the glow tube is connected between the ninety-volt tap and negative, and an additional resistor, having a value of three thousand ohms, is wired between the high-voltage tap and the ninety-volt tap. The regulator tube plugs into a standard UX socket, the grid post on the socket being the anode terminal of the tube and the negative filament terminal the cathode. The anode should always be wired to the ninety-volt post. The diagram of connections is shown in Fig. 3.

HENRY LANDON,
Chicago, Illinois.

STAFF COMMENT

A REGULATOR tube should never be added to any socket power set until it is determined whether the device will supply an additional drain of 30 milliamperes without an excessive voltage drop.

Output Transformer Connections

WHEN connecting up an output transformer it may be noticed that the instrument is usable for either the straight transformer form of output or as a choke with condenser bypass type (Fig. 4). The idea, when I tried it out, proved to be quite successful and showed some possible advantages for the arrangement.

The tone quality, from the two jacks, was different. The transformer coupling was more mellow and softer and the impedance coupling more brilliant in tone with the particular in-

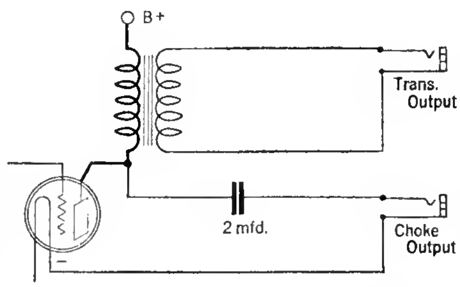


FIG. 4

An output arrangement making it possible to use the transformer as a choke if desired

struments that I used. General tone fidelity was good in both cases so one could select the arrangement most pleasing at the time, or match the reproduction from different loud speakers to some extent.

The double output suggested the simultaneous use of two reproducers and was tried using Sparton and Baldwin loud speakers. Both worked perfectly alone or together in either position and neither reproducer seemed in any case to reduce the volume obtained from the other one alone.

J. B. HOFFMAN
Kewanee, Illinois.

STAFF COMMENT

MR. HOFFMAN suggests a simple and practical method of connecting two loud speakers with different characteristics to secure a tonal combination more pleasing to the ear than the more usual series connections—always providing, of course, that the loud speakers used have impedances adapted to this particular arrangement. The choke connection will, in some cases, provide more pleasing reproduction than the transformer system. Mr. Hoffman's arrangement may be used in conjunction with the resistor controls suggested for tandem speaker operation in this department last month.

The volume from the individual loud speakers is necessarily reduced when two or more of them are used but the total volume from the receiver may be increased.

A Simple Vernier Condenser

WITH the present-day congestion of radio traffic, any device that may facilitate tuning is worthy of consideration. The writer found that the construction of a simple vernier condenser along the lines to be described improved reception on his tuned r. f. receiver. The vernier is connected across the main tuning condensers in the receiver, and is employed in securing that delicate adjustment so often essential to quality reception.

The mechanical details of the device are illustrated in the drawing, Fig. 5.

The base consists of a piece of spare panel material, $2\frac{1}{2}$ inches long by 2 inches wide. The plates are cut from stiff copper sheets with a $1\frac{1}{4}$-inch radius. The peak of the stator plate is cut away for the shaft of the rotor. The fixed plate is fastened to the base by small screws threaded to the panel, or with nuts.

A long brass screw (See Fig. 5) provides the shaft to the rotor, which is clamped between a nut and the screw head. A shim or several washers between the rotor plate and the panel, space the two plates of the condenser from $\frac{1}{8}$ to $\frac{1}{4}$ of an inch, depending upon the amount of tuning desired.

The closer the plates are arranged together the greater will be the variation. A lock-nut and washer on the other side of the small panel holds the shaft at the desired tension. A hard rubber top of a binding post is used as a knob. In the author's receiver the vernier condenser is mounted on the main tuning panel, as shown in the sketch.

L. B. ROBBINS,
Harwich, Massachusetts

STAFF COMMENT

THERE are many uses for a small variable condenser of this type. Its possibilities as a short-wave vernier, as a compensating condenser across the main tuning capacities in a gang condenser, and as a neutralizing condenser in capacity stabilized circuits, are immediately suggested. With the exception of such instances where the vernier condenser is actually employed for tuning, in which case constant adjustment is necessary, it will be desirable to mount this capacity adjuster on the sub-panel of the receiver.

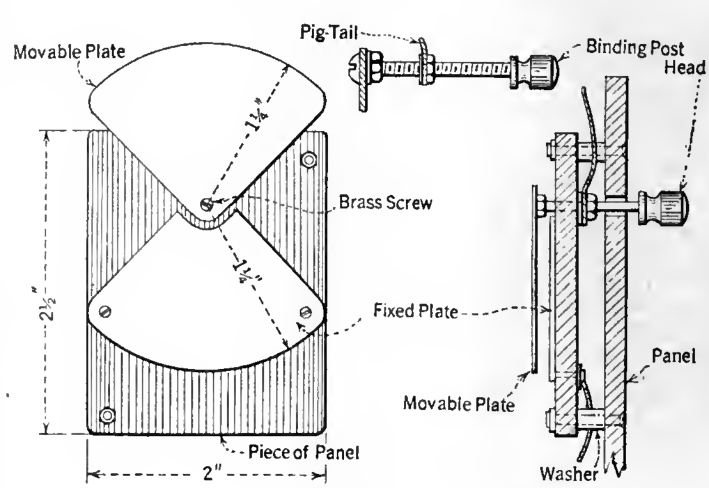


FIG. 5

Constructional details of a useful vernier condenser

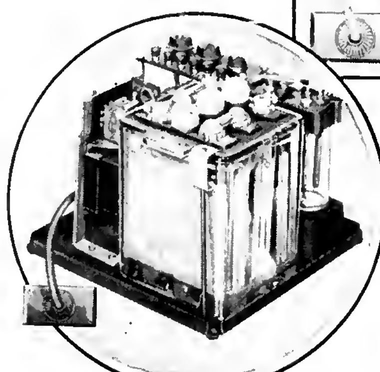
Some Reliable Radio Power-Supply Accessories

AN AUTOMATIC CONTROL

The purpose of this switch is to automatically connect the a. c. power source to either the A battery charger or the B socket-power device, depending upon whether the set is switched off or on. It is a product of U-S-L Radio, Incorporated, Niagara Falls, New York. Price, $3.75

A AND B POWER

THIS Vesta power unit combines a source of A current with one of B current. Features are: A Westinghouse rectifier is used; built-in hydrometer; side windows enable the state of charge and liquid level to be viewed; there is an automatic relay incorporated. The B supply is 180 volts at either 40 or 60 mils. Price, 40 mils, $72.00; 60 mils, $77.00. The lower picture shows the unit with case removed



AN "ALL AMERICAN" B DEVICE

THERE are four B taps on this unit—45 volts, 67 volts, 90 volts, and power tap. In addition, the two knobs which may be seen on the front panel are for adjusting the 45-volt and 67-volt outputs to any desired amount for most satisfactory operation. There is also a "Hi-Lo" switch for increasing or decreasing the voltage output in accordance with the milliampere drain. The price of this unit, in the 110 v., 50-60 cycle model, is $31.50, less tube

TOWER OF BOSTON

IS responsible for this ruggedly constructed B device. The output is rated at 65 milliamperes, 180 volts. There are five positive B taps—detector, 67 volts, 90 volts, 135 volts, and 180 volts. An automatic power control switch is built in the unit. If a trickle charger is used, this latter control switch automatically switches it in or out of circuit. Price, $32.50

A NEW A-SUPPLY DEVICE, BY GRIGSBY-GRUNOW-HINDS

IT IS here shown with the popular "Majestic" Super-B, in combination with which it is particularly adaptable. This new "Majestic" A unit is completely dry in construction, and uses no acids or liquids whatever. The manufacturers claim that there is absolutely no hum in operation. The maximum output of the "Majestic" A unit is 2½ amperes at 60 volts, and it lists at $39.50. The Super-B unit, incidentally, lists at $29.50 with tube. The complete "Majestic" A-B supply therefore sells for $69.00

AN INEXPENSIVE B UNIT

BY Modern, of Toledo. The maximum voltage output at 25 mils. is 185 volts, and at 30 mils., 175 volts. The Modero B Compact lists at $26.50 without Raytheon tube. The voltage at the power tube tap may be reduced by inserting a fixed resistor in the fuse clips provided within the case

RADIO BROADCAST Photograph

Why the Output Device?

By Keith Henney

Director of the Laborotory

IN SPITE of its apparent simplicity (it consists of a core of iron, windings of copper wire, and perhaps a paper condenser), an "output device" performs several useful purposes, aside from being the connecting link between one's loud speaker and a power amplifier. In the first place it keeps the d.c. plate current of the last amplifier tube from circulating through the windings of the loud speaker and, secondly, it may adjust matters when a loud speaker and a tube are used whose respective impedances do not "jibe."

From the standpoint of keeping d.c. from the loud speaker, the output device is only necessary when power tubes are used—when the plate current is greater than ten milliamperes. From the standpoint of fidelity the device is necessary when the loud speaker impedance differs considerably from that of the tube out of which it works. In the latter case, only one kind of output device, the output transformer, does any good, the choke-condenser type serving no useful purpose from the standpoint of fidelity unless the choke has taps on it, when it becomes an auto transformer, and not, strictly speaking, a choke.

What does it matter if the d. c. plate current of the last tube in one's amplifier goes through the loud speaker?

There are several effects. The power which the loud speaker winding must dissipate as heat may be found by multiplying the resistance of the winding by the current squared through it. If the loud speaker has a resistance of 1500 ohms and the final power tube is a 171 with a plate current of 20 milliamperes (0.02 amps.), the power lost is 0.6 watts, which may or may not be too great for the winding to dissipate in heat, depending upon whether the winding was made with this thought in view. If the winding will not satisfactorily dissipate this heat (such will eventually become evident by a burnt-out winding) the use of an output device, of suitable electrical dimensions, may be resorted to as a safety measure.

One fiftieth of an ampere (20 mils.) flowing through the loud speaker which has a resistance of 1500 ohms represents a voltage drop, obtained by multiplying these two values together, of 30 volts, which must be subtracted from the terminal voltage of the plate supply source to calculate what voltage is actually on the plate of the final tube. If the B battery consists of four standard blocks we should have 180 volts and accordingly we place a C bias on the 171 type tube of 40.5, but since there are 30 volts drop in the loud speaker winding, the actual plate voltage is only 150, and 40.5 volts C bias is, therefore, too great. The use of an output device in which the voltage drop is lower than through the loud speaker is to be recommended in such a case.

When d.c. flows through the winding of the loud speaker, the armature, the little lever that moves in accordance with voice-frequency currents and imparts its message to the loud speaker diaphragm, is pulled from its neutral position with respect to the winding, and is much more liable to strike the pole pieces of the magnet under strong signals. In other words, the armature is working under a permanent bias which is neither necessary nor desirable; it forces the armature to work under a hardship that is easily removed by means of the output device.

Some types of output devices have the additional advantage that they remove d.c. plate voltages from the loud speaker tips with the result that these tips or any part of the loud speaker mechanism or the output jack or terminals may be touched while the "juice" is on without danger of shock. No output device, however, will protect one from being shocked by the loud speaker voltages produced by strong signals. What one hears as kettle drums—or static—is the result of very strong sudden voltages across the loud speaker after they have been translated into sound by the loud speaker diaphragm.

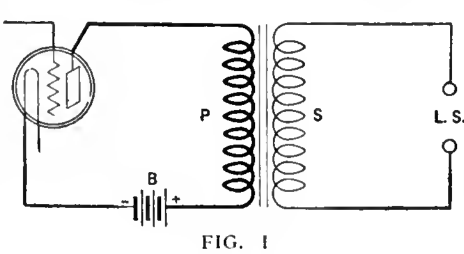


FIG. 1

Output devices, then, are used to:

(1.) Keep d.c. from the loud speaker winding.
(2.) Prevent serious loss in plate voltage.
(3.) Prevent heating of the loud speaker winding due to power loss there.
(4.) Prevent placing a mechanical bias on the loud speaker armature.
(5.) Adjust serious impedance differences and, therefore, improve fidelity.

AND SOME OUTPUT DEVICES:

(6.) Keep the loud speaker terminals at low d.c. potentials preventing shock or burn.

As mentioned previously, there are two types of output devices, or loud speaker filters, as they are sometimes called. There is the true transformer, with two windings, of copper wire insulated from each other and wound on an iron core which is insulated from the windings; and there is the choke and condenser combination. The transformer, by its very nature, keeps the d.c. from the loud speaker and d.c. voltages from the terminals. It has the added advantage that, by proper design, differences in impedance which may exist between the loud speaker and the power tube may be adjusted.

The choke-condenser combination consists of a high-inductance copper coil of many turns on an iron core—and the condenser. If the choke is tapped, impedance differences may be adjusted, but for purposes of discussion, it then becomes a transformer, although the two windings are not insulated from each other but possess a certain part of the copper wire in common. This combination of a coil and a condenser may be connected into the power tube circuit in two ways, one of which is better than the other. The transformer may be connected in only one way, which corresponds to the poorer of the condenser-choke connections.

The output transformer is illustrated in Fig. 1. The d.c. resistance of the primary should be low so that little plate voltage is lost; the a.c. impedances of both windings should be high so that most of the a.c. voltage developed by incoming signals will appear across the loud speaker winding and not be lost on the tube's impedance. The d.c. voltage lost is again the product of the current and the resistance, so that every time one milliampere flows through 100 ohms, a tenth of a volt is prevented from reaching the plate. If the tube requires 20 milliamperes and the resistance is 500 ohms (a typical case) we have lost 10 volts.

The transformer has one disadvantage in that all of the voice-frequency currents must return to the filament of the last tube through the common impedance of the plate supply apparatus, as shown in Fig. 1. Unless this impedance is small, either inherently or unless it be reduced by proper bypassing, the amplifier is liable to "sing," or to cause poor reproduction from otherwise good apparatus, due to audio-frequency regeneration.

Two condenser-choke combinations are illustrated in Fig. 2. The resistance of the choke must be small, for the same reason that it must be small in any case—to prevent plate-voltage loss; the inductance must be high at rather large values of d.c. current, and the condenser must

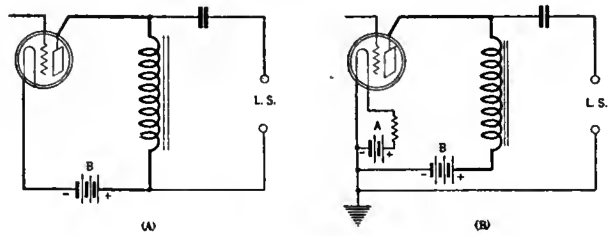


FIG. 2

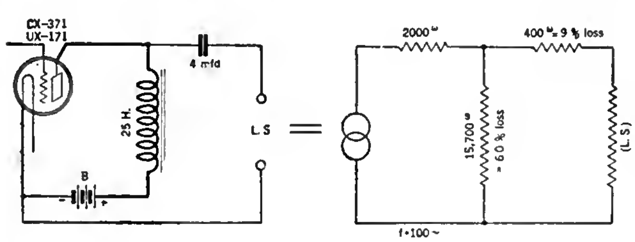


FIG. 3

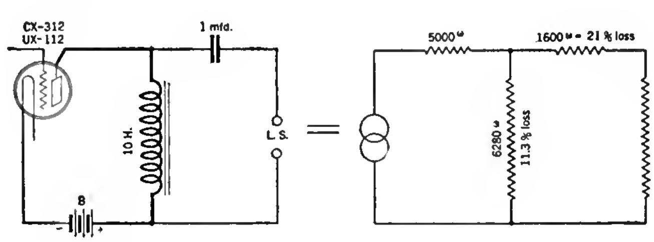


FIG. 4

be large. The equivalent circuit is shown in Fig. 3. Here is a source of voltage, a series impedance representing the plate resistance of the tube, a shunt impedance representing the choke, and a series impedance representing the condenser, and another impedance representing the loud speaker. The shunt impedance is a bypass for the audio frequencies and naturally must be large compared to the remainder of the circuit, *i.e.*, the series impedance of the loud speaker and the condenser.

Let us take a definite example. We shall consider a 171 type tube with an internal impedance of 2000 ohms, a shunt choke of 25 henries, a condenser of 4 mfd., and a 2000-ohm loud speaker. This latter figure represents the impedance of the loud speaker at some audio frequency, say 100 cycles, and has little to do with its d.c. resistance. At this frequency the choke has an impedance of 15,700 ohms, representing a loss of 6.0 per cent., and the condenser has an impedance of 400 ohms representing a loss of 9.0 per cent., with the result that all but 15 per cent. of the voice-frequency currents flow through the loud speaker, compared to the case in which neither condenser or choke were used when there is no loss. The 15 per cent. loss will be hardly detectable to the human ear. The impedances of the condenser and choke are most important at low frequencies.

Let us consider another case, this time choosing a loud speaker which has an impedance of 1000 ohms at 100 cycles, a tube with an output impedance of 5000 ohms, a choke of 10 henries, and a 1.0-mfd. condenser series impedance. Fig. 4 shows the result, 32 per cent. of the current which should flow through the loud speaker being lost. The condenser which is in series with the loud speaker must take its share of the voice currents which are circulating in this circuit, and for that reason its impedance, compared to that of the loud speaker, must be small.

METHODS OF CONNECTION

IF THE condenser-choke arrangement is connected as in B Fig. 2, all of the a.c. currents in the plate circuit of the last tube return to the filament directly. This connection has the added advantage that neither of the loud speaker terminals are at high d.c. potential with respect to ground. One side connects directly to A minus, which is at ground potential, while the other connects to the condenser and is insulated from the high potential. If the condenser breaks down the B-battery voltage will be put across the loud speaker, therefore a good condenser must be used—one capable of withstanding not only the voltage of the plate supply without puncturing but the added voltages produced across it by the audio frequencies, which, however, will be small if its capacity is large. In A of Fig. 2 one of the loud speaker terminals is "hot" since it is connected to the positive side of the plate supply, which is high above ground potential. In this case nothing happens if the condenser breaks down except that the plate current will divide between the loud speaker and the choke, most of it still going through the latter because of its lower d.c. resistance. The voltages across the condenser in this case are lower than in B of Fig. 2 since there is no steady voltage due to the plate supply but only the audio-frequency voltages, and these will be small owing to the low impedance of the condenser.

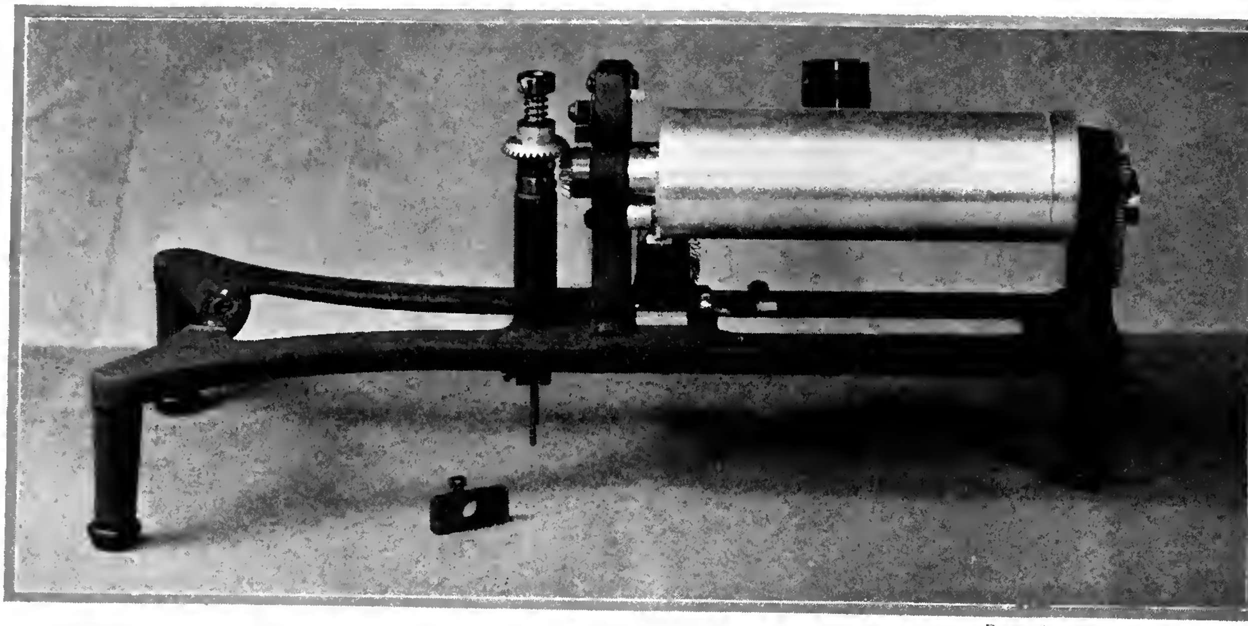
The absolute values of the inductance and the capacity may be varied within certain limits depending upon the tubes and the loud speaker used. With a 2000-ohm tube and a 4000-ohm loud speaker, 20 henries is plenty and a capacity of 4.0 mfd. is correct.

Since the effect on audio frequencies of both the choke and the condenser may be neglected, if proper values of each are used, the loud speaker looks directly into the plate circuit of the power tube, and as far as a.c. currents go, might just as well be connected there. This is perfectly proper provided the impedances of the tube and loud speaker do not differ too widely. For example, a 2000-ohm or a 5000-ohm tube may be used without impedance adjustment with a 4000-ohm, or even higher impedance, loud speaker. But if two 5000-ohm tubes are used in a push-pull circuit so that the resultant impedance is doubled to 10,000 ohms, and one considers a loud speaker whose impedance at 100 cycles is 1000 ohms, trouble will occur.

Here we need a transformer. If the primary and secondary individual impedances are high compared with the impedances of the tube and loud speaker, and provided a good core with good coupling is used, there will be little voltage loss, and practically the entire a.c. voltage on the plate of the last tube will be transferred to the loud speaker, the magnitude depending upon the turn ratio of the transformer, of course.

The trouble mentioned above will not be loss of power due to improper impedance matching so much as distortion due to another cause. All tubes have a plate current plate voltage characteristic that is somewhat curved. This curve produces additional frequencies when incoming signals produce large values of a.c. plate current. If, however, a large impedance is placed in the plate circuit, changes in grid voltage, due to large signals, produce a smaller proportionate change in a.c. plate current, and the characteristic is straightened out. Mathematics shows that when the impedance of the load is twice that of the tube, the greatest amount of undistorted power will be secured from the tube. At low frequencies the impedance of most loud speakers is very low, so that the tube's characteristic is curved, and loud low-frequency signals produce a rattle or rumble that is objectionable. For this reason, the loud speaker should not match the tube in impedance, but should have a greater impedance, and if this is not possible, a transformer must be used which makes the loud speaker look like a higher impedance to the tube. This may be done by using a step-up transformer, looking from the loud speaker to the tube, so that the impedance of the former is stepped-up or increased as far as the latter is concerned.

Such is the story of loud speaker filters, or output devices. With power tubes in the plate circuit, when there are over ten milliamperes flowing, they are useful in protecting the loud speaker; when low-impedance speakers are used with high-impedance tube circuits, they are desirable. Unless the plate current is such that the loud-speaker armature is sadly biassed and rattling against the pole pieces of the magnets, it is doubtful if the average listener can tell the actual difference in fidelity whether the device is used or not. If a condenser-choke combination is used the loud speaker should be connected to the negative filament lead or the center tap of an a.c. operated power tube. Connected thus, the owner of the loud speaker will be protected from d.c. shocks, although he can get a severe jolt by holding to the speaker terminals when a kettle drum operator gives his instrument a good "whack."



Radio Broadcast Photograph

THE RAYFOTO RECORDER

This photograph illustrates a final model of the recorder. The pictures are recorded on a piece of photographic paper wrapped around the drum. This unit is designed to fit over the turntable of any standard phonograph

Operating Your Rayfoto Picture Receiver

By Austin G. Cooley

THERE are several details concerning the Rayfoto printer and Rayfoto recorder which were not discussed in the article in the December Radio Broadcast; a knowledge of these is not necessary in order to construct the printer although necessary to obtain most satisfactory results. In this article we will use several terms that have not been used in preceding articles but which will serve to differentiate between the various units of the Rayfoto apparatus. A description of these terms, with a brief explanation of the function of the various parts which they define, will be found in the table of definitions on this page.

Readers of this series of articles will recall the description given in the November article of the Rayfoto relay and its function. This relay is operated by the plate-current increase produced in the amplifier tube of the printer by the synchronizing signal. There is a natural tendency, however, for the relay contacts to vibrate for a very short time after they first close. This causes irregular operation of the trip magnet which the relay controls, and the irregular operation in turn produces uneven synchronizing which causes jagged effects in the received picture.

To prevent this irregular action of the relay it was necessary to arrange the circuit so that when the relay contacts closed they would lock tightly together. The most important part of this locking circuit is a resistance, R_2 in the circuit diagram published on page 297.

When the relay, R_4, closes, due to the synchronizing impulse, it causes current to flow through the trip magnet coil and hence through resistance R_2 to minus B. The current through R_2 produces a voltage drop across the resistance of such polarity as to decrease the negative bias on the grid of the amplifier tube. This causes the plate current to increase a comparatively large amount, and this plate current, flowing through the coils of the relay, R_4, makes it lock fast and prevents the contacts from vibrating. As soon as the armature on the trip magnet releases the drum, the contacts on the trip magnet close and thereby short-circuit the relay so that it is out of the circuit while the drum is making a revolution.

The locking resistance should be adjusted so that the plate current of the amplifier tube, as read at jack J_2, is about 15 milliamperes when the relay and trip magnet contacts are closed.

There is always a certain amount of sparking at the contacts but this causes no harm unless the spark is sufficiently intense to cause an arc after the contacts have opened. This is remedied by increasing the gap between contacts when they are open.

The contacts should be kept clean although there is nothing to be gained by excessive filing and cleaning. Cleaning the contacts about once a month with a piece of cloth is all that is necessary.

Reliable operation of the synchronizing system is impossible if there are excessive set noises. Such noises can often be traced to noisy batteries or poor connections. Make no attempt to receive Rayfoto pictures until such noises are cleared out. This does not imply that perfect receptive conditions are necessary for picture reception but considerable extraneous noise is not conducive to success.

The photographic paper that has been found most satisfactory is Azo No. 2 semi-matt or semi-gloss, singleweight, size 5 x 7 inches. The room in which the pictures are received must be somewhat darkened and a test can be made to determine if the room is dark enough by placing a piece of paper on the drum, allowing it to remain there about five minutes, and then developing it. If, in the developer solution, it turns gray or black in about 30 seconds there is too much light in the room, and the room will have to be darkened in some way. Of course, in the evening, no difficulties will be experienced and it will generally be found safe to operate the Rayfoto receiver without any shading at a distance of about ten feet or more from a forty-watt electric light.

In wrapping the piece of photographic paper around the drum for this test be sure that the emulsion side is on the outside. The side of the paper with the emulsion on can be determined by biting a piece of the paper with your front teeth. That side of the paper with the

Table of Definitions

Printer: A two-tube unit consisting of a one-stage audio-frequency amplifier and an oscillator. The Rayfoto signals from the radio receiver are amplified in the audio amplifier the output of which is impressed on the Rayfoto modulation transformer which, in turn, modulates the oscillator. The output of the oscillator produces the corona discharge which prints the picture.

Recorder: The mechanical unit for attachment to a phonograph turntable, and consisting of a drum on which a piece of photographic paper is wrapped, a clutch system, and a trip magnet for use in obtaining synchronism.

Relay: This relay is operated by the synchronizing impulse and when the contacts on the relay close, the trip magnet operates and releases the drum on the Rayfoto recorder.

Lap: The interval between the time that the drum on the Rayfoto recorder completes a revolution and the time that the synchronizing impulse is received. The recorder lap was explained fully in the November, 1927, Radio Broadcast.

Static Slip: The operation of the Rayfoto relay by a static impulse instead of by the regular synchronizing impulse.

emulsion will take the impression of the teeth or will stick to the teeth.

After experience has been gained in the operation of the system, No. 4 Azo paper can be used and it will be found that this paper can stand more light without being affected. When No. 4 paper is used a greater discharge of corona is necessary than with No. 2. If the signal strength is low so that not much corona is available, it will be best to use No. 1 paper, which is more sensitive.

In making preliminary tests it is a good idea to let the printer operate on broadcast signals and, after a run has been made, to develop the paper for about thirty seconds and determine if the corona discharge from the strong signals is sufficient to print out black.

Be sure to wrap the paper around the drum in the right direction, which is opposite to the direction of rotation of the drum. If the paper is wrapped in the wrong direction the corona needle will catch under the edge of the paper and pull it up.

The speed of the drum at the transmitter has been standardized at 100 revolutions per minute and, therefore, the speed of the drum on the Rayfoto recorder should be near 106 revolutions per minute in order to obtain the correct lap. Adjust the speed of the drum to this value by letting the drum revolve for a minute with the trip magnet armature down, counting the number of revolutions.

If the Rayfoto recorder unit is examined it will be found that the arm which carries the corona needle will slide along the machined shaft located at the rear of the device. If the arm does not move along the shaft very easily, it should be oiled. At no time should the shaft be touched with emery paper or sandpaper. The shaft may be cleaned if necessary by mixing a little Gold Dust powder with some lubricating oil and wiping off the shaft.

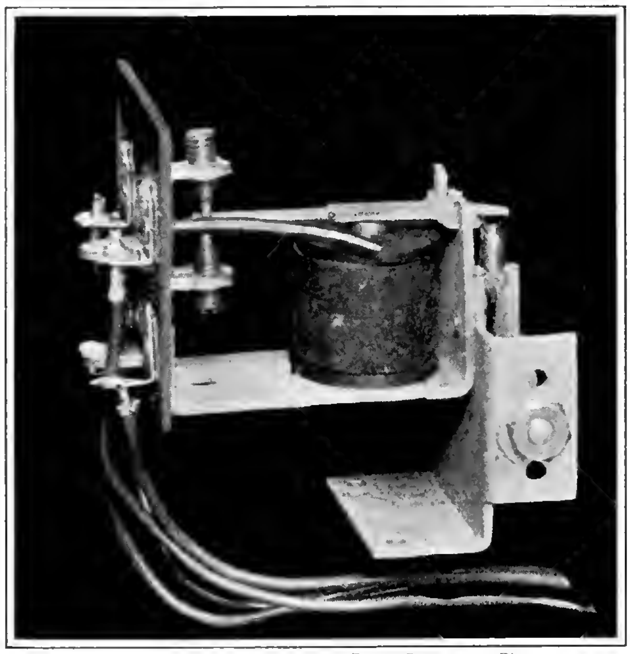
To adjust the Rayfoto receiver to operate through static, it is necessary to first adjust the relay and corona discharge. Tune exactly to the station transmitting the pictures. Reduce the signal in the printer by the gain control to a point where the relay just ceases to operate on the synchronizing impulse. Determine whether there is sufficient corona by examining the discharge from the needle point. There should be quite a noticeable discharge. A piece of Azo paper should, of course, be on the drum when any test of corona discharge is being made and if there is not sufficient corona for making a fairly black mark from the strong signals, increase the spring tension on the relay, then boost up the gain until the relay just starts to operate. Check again to see if the corona discharge is sufficient. If not, repeat until a fair discharge is obtained. When working through static, it may be necessary to work with a discharge much lower than normal. Consequently, the print will be weaker, unless a more sensitive paper, such as Azo No. 1 is substituted for that generally used, to make up for the reduced corona.

In making the above adjustment, the drum may be held in such a position that the stop-shoe does not strike the push rod by revolving the drum half a turn. The discharge made by the synchronizing signal may then be observed.

If it is difficult to obtain sufficient control of the relay by the spring adjustment, the gap between the armature and pole tip may be increased by adjusting the contacts.

After these adjustments have been made, tune the radio receiver to a frequency about fifteen kc. above or below the frequency of the picture transmitting station. If the relay operates more than once a second from the static noises, the experimenter might as well turn in and give up the idea of picture reception for the rest of that night. If the relay does not operate from static noises, the gain should be increased to a point where it just commences to operate; then reduce the gain a small amount. Thus you find the critical point of maximum permissible gain without static tripping the synchronizing relay. After this has been done, tune back to the picture signal and check to see that the gain has not been increased too much.

The next thing to do is to adjust the speed of the recorder. The speed should be such that the recorder lap is as small as is consistent with regular operation of the trip magnet.



Radio Broadcast Photograph

THE RAYFOTO RELAY

A close-up of the relay. It is this relay, actuated by the synchronizing signal, that causes the drum of the recorder to be released, every revolution, at exactly the correct moment

CHECKING PERFORMANCE OF THE EQUIPMENT

THE November Radio Broadcast gives some of the essential information on the subject of blurring and detail. It may be well to mention here one or two things the experimenter may check if he experiences trouble. In many cases, the following simple checks will solve the difficulty.

First, be certain of the connections to the modulation transformer, making sure that the proper terminals are used, because this has an important bearing on the operation of the entire system. The primary terminals are No. 1 and No. 2. No. 1 should go to the plate of the input amplifier tube and No. 2 to the meter jack and then to the battery supply. No. 3 of the secondary should be connected to the plate of the oscillator through the r. f. choke and No. 4 goes to the meter jack and then to the booster voltage supply. Also the connections to the primary of the audio transformer in the printer should be reversed to determine which arrangement gives most satisfactory operation.

If there is a large recorder lap, that is, if the receiving drum has sufficient lead to arrive at the end of the revolution considerably ahead of the convertor drum, the relay will be connected in the circuit for a longer period than necessary. Should some static of strong intensity be received during the lap, the drum will be released ahead of the synchronizing impulse. Such jumps, due to static operation of the relay, are known as *static slips*.

The possibility of these static slips decreases

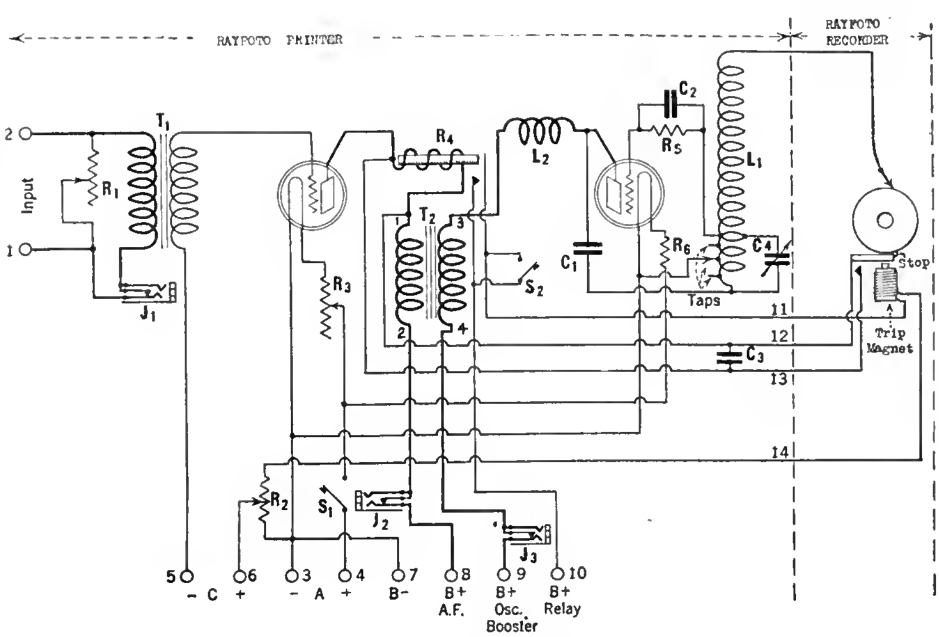


FIG. 1

The circuit diagram of the Rayfoto printer unit. The connections between this unit and the Rayfoto recorder are indicated. Constructional information on the printer was given in the December issue of Radio Broadcast. The Recorder unit cannot be home constructed but may be purchased as a complete unit as the lap is reduced. Careful adjustment of phonograph motor speed is suggested to maintain a minimum lap. If, however, the speed is matched too closely, there is no lap. The trip magnet then operates as the stop shoe strikes the push rod. Such operation is very unstable and produces very jagged pictures.

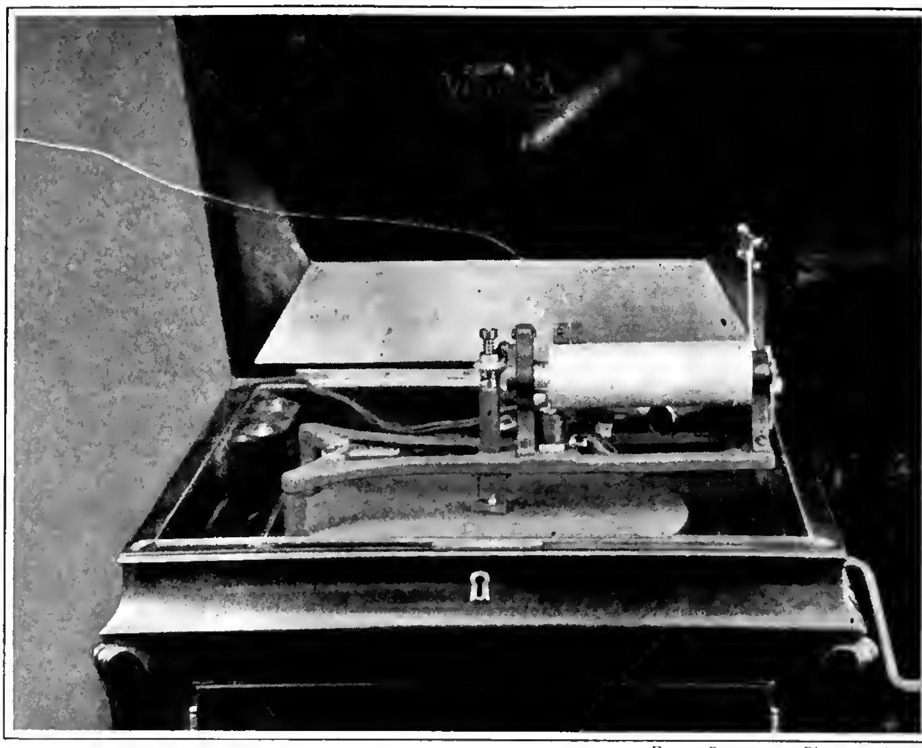
If the recorder speed is reduced so that it is slightly slower than that of the convertor, the recorder drum will not reach the end of the revolution in time to receive the synchronizing impulse. The relay will then operate on the impulse of the next revolution, or, if there are strong picture signals, during the revolution, and the result will be no picture at all or one that is very badly distorted.

After a little experience, the experimenter will be able to tell from the sound of the recorder whether the lap is correct. Sometimes streaks occur in the Rayfoto pictures because the oscillator tube ceases to function for a moment. Such a streak appears in the Rayfoto picture printed on page 216 of the January RADIO BROADCAST. This frequently occurs when the oscillator is tuned to give the maximum amount of corona. To avoid these streaks, detune slightly with the variable condenser across the oscillator coil. A higher resistance in the grid circuit also tends to reduce the possibilities of streaks.

Streaks are also caused by poor connections and by detuning of the radio receiver by hand or body capacity. For this reason, it is desirable to have a well-shielded receiver.

At present, pictures with fairly strong contrast are being transmitted so that good Rayfoto prints may be made with the average haphazard adjustment of the printer. Some may find that they are getting a little too much corona on the minimum signals and that the intermediate shades are produced as blacks. Correction for the minimum signal can be best accomplished by reducing the booster voltage. The difference between the intermediate shades and blacks can easily be increased by reducing the gain and then allowing a little more time for development of the picture. When reducing the gain, it may be necessary to reduce the spring tension on the relay.

From the foregoing it should be obvious that some skill is required to secure the best possible results. Poor pictures are a matter of poor adjustment of motor speed, amplifier gain, stop-start mechanism. Good pictures are a credit to the experimenter who receives them. In picture reception, the amateur has one advantage over the fan who contents himself with mere audio reception. He obtains permanent and irrefutable evidence of his success—a catalogue of his progress throughout the development of what will some day be a widely practised science and art—the reception of high-grade pictures in the home.



RADIO BROADCAST Photograph

THE RECORDER IN PLACE

The photograph illustrates how the Rayfoto recorder is mounted over the turntable of a phonograph

PARTS FOR A RAYFOTO PICTURE RECEIVER

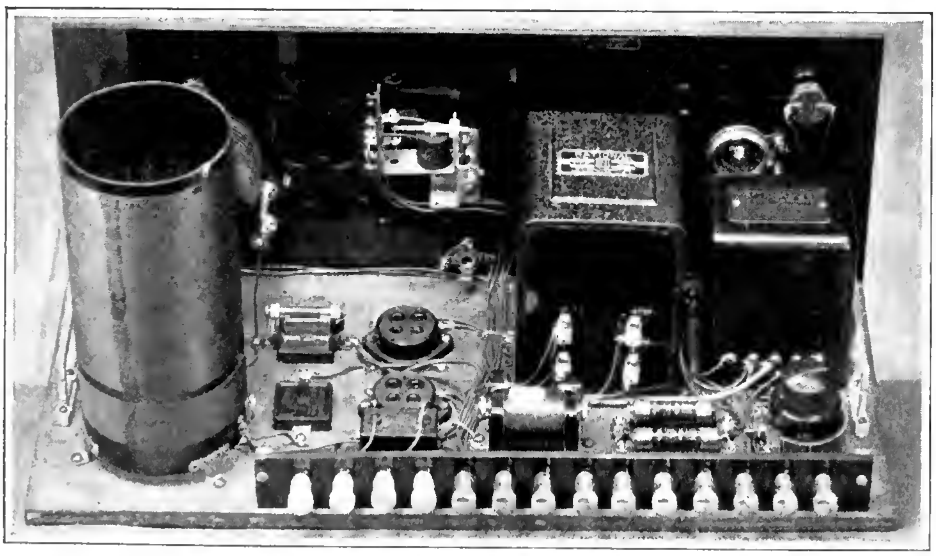
CERTAIN parts for use in a Rayfoto receiver have been especially designed for the purpose and therefore possess the essential characteristics for good results. They have been designed to take care of the present requirements of the system and will also be satisfactory for use as the system may be gradually developed. These special parts, made under the Rayfoto trade mark, are listed below:

L_1—Rayfoto Corona Coil
T_1—Rayfoto Amplifying Transformer
T_2—Rayfoto Modulation Transformer
R_4—Rayfoto Relay
Rayfoto Printer Unit

The remainder of the parts necessary to construct a picture receiver are given below. Any standard parts conforming with the specifications given below may be satisfactorily used.

R_1—Variable Resistance for Gain Control
R_2—200-Ohm Variable Resistance Capable of Carrying 100 Mils.
R_3—12-Ohm Filament Rheostat, 0.5-Ampere Capacity
C_3—0.1-Mfd. Fixed Condenser
R_5—0.01-Megohm Grid Leak and Mounting
C_1, C_2—0.0005-Mfd. Fixed Condensers
C_4—0.0005-Mfd. Variable Condenser
L_2—Radio-Frequency Choke Coil
S_1—Filament Switch
S_2—Push Button Switch
J_1, J_2, J_3—Double-Contact Short-Circuiting Jacks
R_4—4-Ohm Filament Ballast Resistance
Telephone Plug
Milliammeter, 0-25 Milliampere Scale
Two Sockets
Fourteen Binding Posts
Panel
Panel Brackets

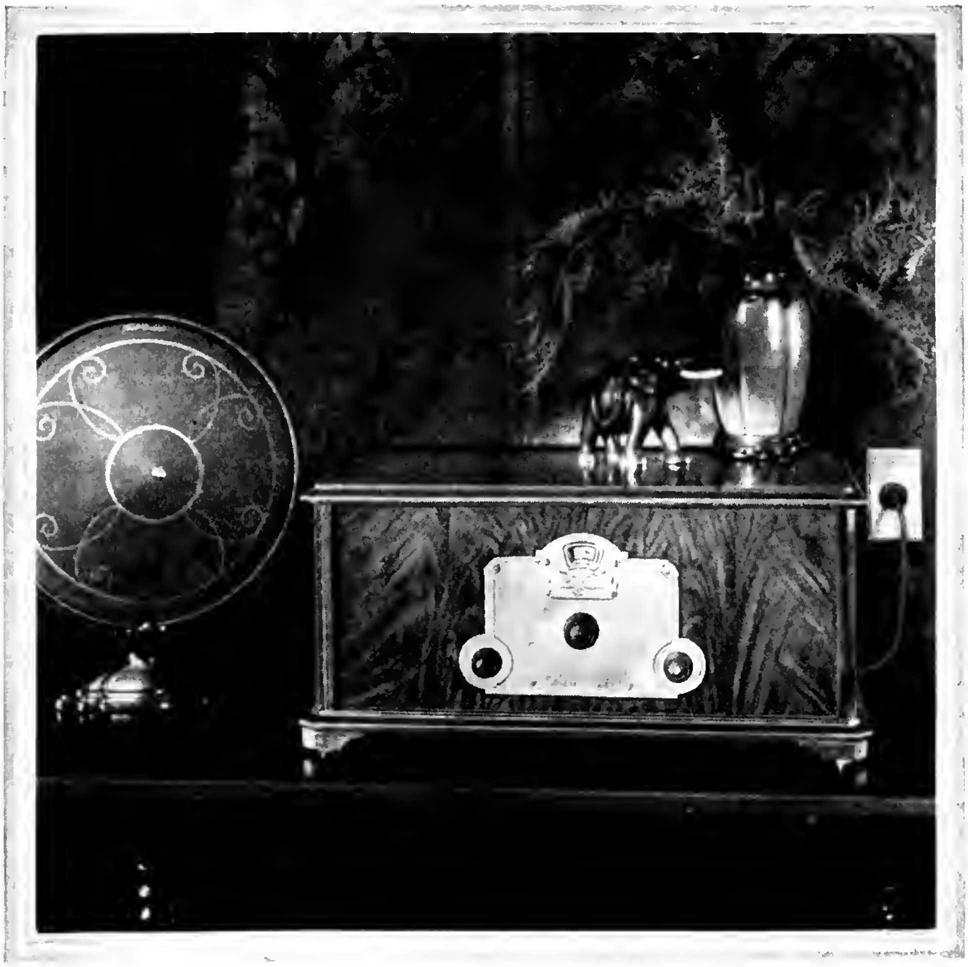
The designating letters preceding the parts given in the above list refer to the lettering on the circuit diagram given on page 297 of this article. Readers interested in constructing a Rayfoto picture receiver and desiring further information regarding the necessary parts may obtain this data by writing to RADIO BROADCAST magazine.



RADIO BROADCAST Photograph

THE RAYFOTO PRINTER UNIT

The parts for the unit, containing the amplifier and oscillator circuits, can be purchased and then wired together as indicated in the photograph. The circuit diagram is given in Fig. 1. At the left is the Rayfoto corona coil. The transformer at the extreme right is the Rayfoto amplifying transformer and at its left is the Rayfoto modulation transformer. The Rayfoto relay can be seen mounted on the panel



THE FREED-EISEMANN "NR-60" ELECTRIC RECEIVER

How the "NR-60" was Engineered

By John F. Rider

GENTLEMEN, we need a new electric receiver, designed for a.c. tubes and equipped with B supply. The receiver must be a single-control set to retail at $150.

The above is the sum and substance of a message delivered to the engineering department of the Freed Eisemann Corporation and is the reason for the birth of the "NR-60 receiver."

The electrical development of this receiver will prove of intense interest to the radio fraternity at large, because it covers a subject very much in the public eye at present.

One can readily see that the problem placed before the engineering department of this organization differs greatly from that usually confronting the average research staff. The request was not for a d.c. receiver, but one designed for use with tubes utilizing raw a.c. upon the filaments and also a B supply unit. Hence we have four requirements. First is the receiver circuit itself, which constitutes a problem replete with many obstacles, particularly so in this day of competition. Secondly, the use of a.c. tubes means the provision in the design of the receiver for the elimination of the 60-cycle hum in the filament supply. Thirdly, the design of the power transformer which will supply all the filament voltages and the a.c. for the plate voltage, later to be rectified by the rectifying tube, is a problem not to be scoffed at. Fourth, is the coördination of all the parts to produce a satisfactory all-electric receiver. The latter is more easily said than done, as can be attested by many fans.

Let us follow in the order mentioned above and watch the progress of the electrical development. Six tubes are to be used in the receiver. The receiver is to be operated with an outdoor antenna. A certain amount of selectivity is therefore necessary. Considering the status of broadcasting at the present, and the possibility of increased power at the transmitters, provision for satisfactory selectivity must be incorporated in the event that more stations go on the air, station wavelengths are reallocated, or transmitter power is increased. This necessitates that at least three tuned stages be used. Furthermore, the manufacturer specifies a certain antenna length, which, however, is not always obtainable. To assure satisfactory sensitivity in the event that a short antenna is used, three stages of tuned radio-frequency amplification are decided upon. Such decision, however, can be made only after the gain or amplification per stage has been determined mathematically and checked empirically.

In order to permit this determination, a large number of different types of tuned radio-frequency transformers must be first designed on paper and then constructed for experimental purposes. This experimental work is of paramount importance during the development of a radio receiver. The variance in types of the different experimental tuned radio-frequency transformers is found in the type of wire used, the diameters of the winding form, the spacing of the individual turns, the placement of the primary with respect to the secondary, the ratio of inductance to capacity on different wavelengths, the length of the winding form, and many other intricate details. Comparison in a mathematical manner is not sufficient, because phenomena encountered in practice can not be included in the calculations. Hence both mathematical and experimental determinations are necessary.

The actual experimental work of measuring the gain per stage for various radio-frequency amplifying systems is a tedious, detailed procedure. The tuned radio-frequency transformer to be measured is coupled to a tube. A known radio-frequency voltage is fed into the input circuit of this tube. The output of the tuned radio-frequency transformer is then measured at various broadcast wavelengths by means of a vacuum-tube voltmeter. A comparison of the output voltage values of the various radio-frequency transformers is a direct indication of their merit.

After a large number of tests of various forms of inductances, and with the realization that a special system of neutralization was available in addition to the fact that individual shielding was permissible, the staff decided to utilize what is considered to be the most efficient form of inductance, the single-layer solenoid with spaced winding. With this decision the design of the three tuned stages was complete, but what about the antenna system? Should this be untuned, and of the conventional system? The consensus of opinion was to deviate from the conventional and to utilize a tuned antenna circuit. The sensitivity of the complete system would be greater, the receiver output would be greater and, in addition, the frequency response characteristic of the complete r.f. system would be better. Last but not least, the tuned antenna system could be designed so that single-control would be satisfactory, regardless of the length of the antenna employed.

This started another series of investigations, and after a period of time, the variometer tuned type of input was selected. This arrangement possessed several salient features. First, it permits unicontrol. Second it provides greater gain or amplification as the wavelength is increased. This property is inherent in inductively tuned circuits and is diametrically opposite to the phenomena in capacitatively tuned circuits. This is due to the increase of impedance of inductively tuned circuits with increase in wavelength. The action of the variometer-tuned antenna-input circuit by increasing the gain on the upper wavelengths of the normal broadcast spectrum would tend to compensate the falling characteristic of the other stages. This type of tuned antenna input circuit affords a much greater signal voltage to the grid filament circuit of the first r.f. tube. As a matter of fact the difference between such a tuned system, Fig. 1A, and the conventional untuned antenna, Fig. 1B, is of the order of 3 to 1 in favor of the former arrangement (system A).

By the use of a small series capacity, connected between the antenna and the grid input terminal of the first tube, the variance in antenna capacity when different lengths of antenna are used, is practically nullified, and the tuned system is to all intents and purposes, isolated. This means that the setting of the variometer dial will remain constant regardless of the length or type of antenna used.

Stability of the radio-frequency system was the next point of interest. Being in possession of a Hazeltine license, neutralization of this form for the radio-frequency stages was an immediate decision. Having designed the inductances and knowing the operating characteristics, the conventional Hazeltine system was selected. This system utilizes a voltage transfer of reversed phase from one grid circuit to the preceding grid circuit. The value of the feed-back voltage is governed by the design of the secondary of the tuned radio-frequency transformer and is the voltage across a certain portion of this

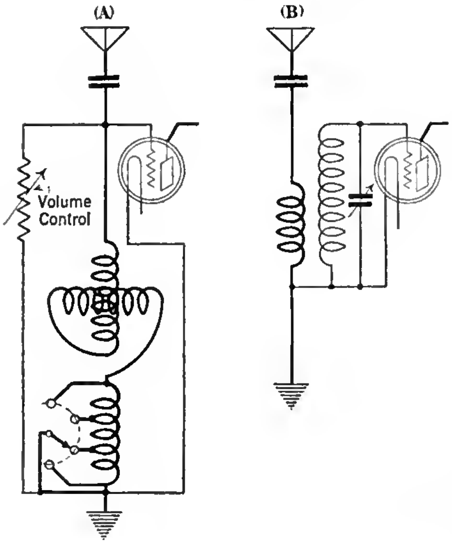


FIG. 1

winding. The voltage is obtained by tapping the secondary winding at a predetermined point.

With respect to shielding, the decision to shield individual stages by enclosing the tube, coil, and condenser in a can, was immediate. The choice, however, of the shielding material, required some consideration. Electrical conductivity and economy are the two important factors. After considering these two points the selection was aluminum.

The experimental work carried out upon the tuned radio-frequency transformers influenced the selection of the type of winding. Now arose the problem of producing "matched" inductances. Accuracy is very important in all single-control units. To overcome slight discrepancies, such as would be occasioned by one or two turns more or less on the coils, each tuned radio-frequency transformer is equipped with a copper vane located at one end of the main inductance. Manipulation of these vanes permits accurate variation of the inductance of the windings, thus facilitating "matching" of the condenser-inductance combinations, and the tuned circuits.

Summarizing the radio-frequency amplifying system we have the following: A tuned antenna input, complete individual shielding, three stages of tuned radio-frequency amplification, complete neutralization, and single tuning control. The maximum capacity values of each tuning condenser is 0.00032 mfd. The shape of the tuning condenser plates affords a modified straight frequency-line variation.

DETECTOR AND AUDIO SYSTEMS

NOW for the detector and audio systems. Utmost sensitivity is desired, hence the grid leak-condenser system of detection is employed.

As to the audio system, the choice must be made consistent with three factors, economy, results, and knowledge. Only two tubes are available for audio amplification. The best way of obtaining sufficient volume is by means of transformer coupling, and since extensive research work has been carried on to design and produce an excellent audio-frequency transformer, the decision to use transformer coupling was natural. That the research work along this line was of high calibre is shown by reference to Fig. 2. This curve shows the operating characteristic of the audio transformer. It is a 3 to 1 coupling unit, without a pronounced peak on the higher audio frequencies, a characteristic seldom found with the average audio-frequency transformer. The elimination of a sharp peak at some frequency between 3000 and 10,000 cycles is due to scientific coil design and minimization of leakage reactance.

The next problem was the selection of a means of coupling the output tube to the loud speaker. Some coupling medium is necessary because of the heavy output plate current occasioned by the necessity of using a power tube in the output stage. Passing the heavy plate current through the loud speaker windings would injure them, in addition to the possibility of reducing the magnetic strength of the magnets in the event that the polarity of the loud speaker is reversed with respect to the polarity of the plate battery. The design of a coupling unit was imperative. A transformer of very good design was developed, and its frequency operating characteristic when used with a 171 type tube is shown in the accompanying curve, Fig. 3, at the bottom of this page.

Now arose the problem of volume control. Much work was done along this line; as a matter of fact, this work could not be avoided, since the method of controlling receiver signal output with a d.c. receiver is not wholly satisfactory when applied to a.c. receivers. After an extended period the system shown in the wiring diagram on page 301 was selected as being most effective. This is a variable high resistance shunting the tuned input circuit

This arrangement provides a means of adjusting the receiver output by controlling the signal voltage passing into the first radio-frequency amplifier. This arrangement proved satisfactory because it does not display an effect upon the sideband characteristics of the radio-frequency amplifier, nor does it manifest any variation in the degree of neutralization. Yet the control of volume is perfect.

THE TUBES USED

UNDER the existing circumstances, the tubes selected were the RCA 226 and 227, with a 171 in the output, or the equivalent Cunningham 326 and 327 with a 371 in the output. The operating characteristics of these tubes are practically identical to that of the regular d.c. filament tubes, hence the design of the associ-

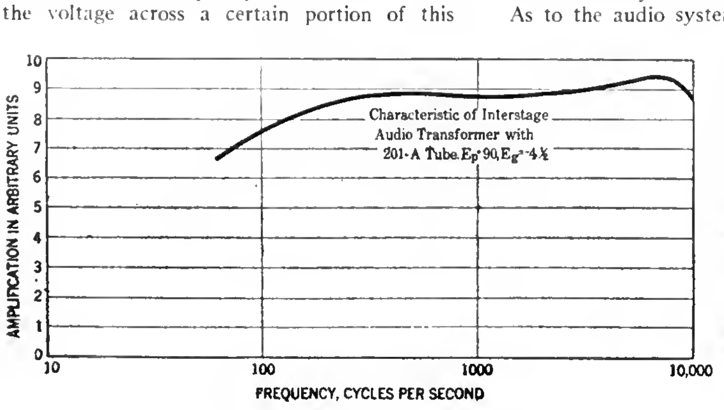


FIG. 2

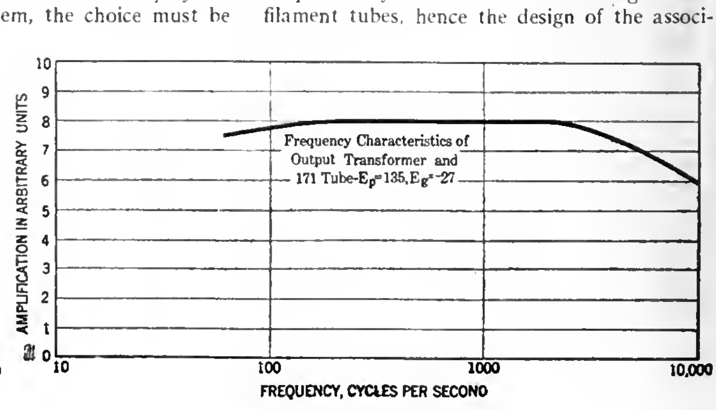
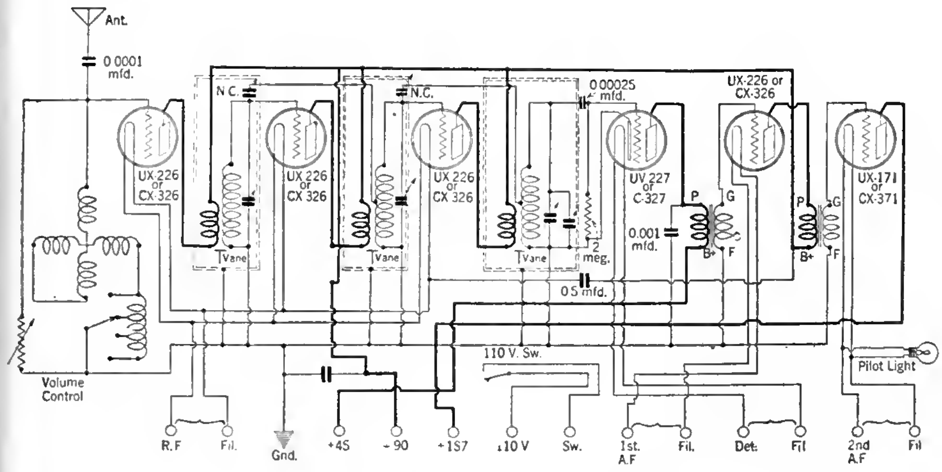


FIG. 3



CIRCUIT DIAGRAM OF THE "NR-60"

ated apparatus did not require special precautions. The 226 type of tube was selected for the three stages of radio-frequency amplification and for the first audio stage. The 227 heater type of tube was selected for the non-regenerative detector and the 171 was used as the output tube. A precaution required in the receiver was that twisted cables be used and that they be isolated so that transfer of the 60-cycle hum was minimized. That the arrangement was effective is demonstrated by the satisfactory operation of the receiver, despite the fact that the audio-frequency transformers have satisfactory response on 60 cycles. Were the filament wiring in a position to cause hum due to induction, this hum would be heard with regularity in the loud speaker.

The use of a.c. tubes necessitates a mid-tap for each amplifying system. Experience proved that a variable potentiometer shunting each tube filament circuit was a better means of obtaining an accurate electrical balance than the use of a mid-tapped transformer winding. The use of such a mid-tap requires a separate grid bias for each amplifying system. This grid bias is obtained from the B supply.

The design of the B supply unit and the A supply unit was an interesting problem. Let us consider the power unit as a whole. The power pack supplies all the voltages required for filaments, grids, and plates. It is complete in itself encompassing the B device, the A supply, and the output transformer. A study of the wiring diagram of the power supply on this page shows an arrangement which can be followed to excellent advantage by many manufacturers of power transformers and by others interested in a.c. tubes of the type mentioned herein. The 226 tubes are rated at 1.5 volts and 1.05 amperes and the 227 is rated at 2.5 volts and 1.75 amperes. The voltage is low and the current is high. If a large number of these tubes are fed through one cable and from one source of supply, that is, from one winding, the total amount of current will reach a fairly high value and any small resistance in the circuit will cause an appreciable voltage drop. To minimize this effect each system of amplification is equipped with a separate filament winding, supplying energy to the tubes in that system. This arrangement also eliminates the necessity of inserting various values of resistances to supply the correct voltages, were one single winding used. For example, the maximum filament winding voltage is 5 volts, for the 171 tube. The 227 requires 2.5 volts and the 226 requires 1.5 volts. All of these voltages could be supplied from one 5-volt winding of proper capacity. But the insertion of the necessary resistances for reducing the 5 volts to the correct value for the other tubes would increase the cost of manufacture and would be less efficient. The method used was found much more efficient and, therefore, adopted. An accurate mid-tap is made possible for the radio-frequency and the first audio-frequency tubes by the use of a potentiometer. Furthermore, each filament circuit consists of a pair of twisted cables. The 227 detector tube receives a plate voltage of 45 volts from the B unit. By employing filament windings which provide the required filament voltages, all filament controls are eliminated.

The design of the B device was cause for considerable thought. Should it be a half-wave rectifier or a full-wave rectifier? Each possessed certain advantages. The half-wave rectifier is simpler, but the full-wave rectifier affords certain technical and practical advantages. In the first place the frequency of the charging voltage applied to the condensers of the filter system is 120 cycles with a full-wave rectifier and as such the action of the condenser is better; the reactance of the condensers is lower. The filtering action improves as the frequency of the hum to be eliminated increases. In addition, the current capacity of the unit is doubled. Where a half-wave rectifier would permit 65 mils., a full-wave rectifier would permit 130 mils. at the same voltage. Hence, by using the full-wave rectifier, sufficient current is provided at high voltages.

To eliminate any possible hum due to induction from the power device to the receiver, the complete unit is housed in a shield. The condensers used in the B device are, in turn, housed in an individual can within the main can. Both cans are grounded to the common ground terminal and the main can is at ground potential.

One side of the main line is connected to ground through a 0.1-mfd. condenser, thus bypassing to ground any radio-frequency energy in the power line.

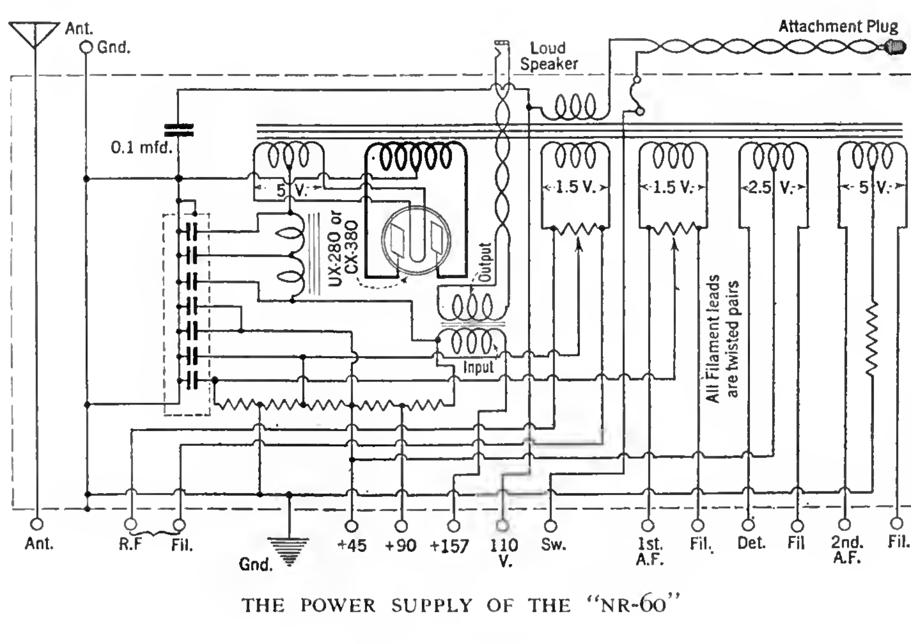
The design of a receiver is not limited solely to the choice and pattern of the individual components of the receiver. Complete test of the combined parts may show that they are not satisfactory when used together.

The method of testing the radio-frequency transformers applies to the method of testing the gain or amplifying power of the complete radio-frequency amplifier.

The audio-frequency transformers are also tested with vacuum-tube voltmeters. Each transformer is tested on three frequencies and a definite output must be obtained before the transformer is passed.

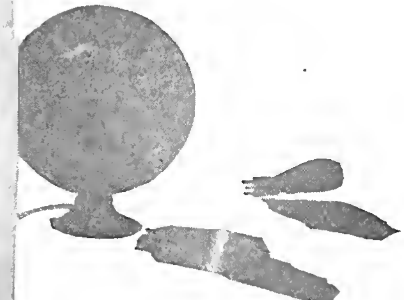
A vacuum-tube voltmeter is employed when balancing out the hum in the receiver and by means of the meter reading the value of the existing ripple is ascertained.

After the receiver is assembled ready for the first complete test, it is placed into a test rack. The source of energy supply for this test comes from a crystal-controlled master oscillator circuit tuned to a fixed frequency of 600 kilocycles. This type of oscillator also supplies testing frequencies which are multiples of the fixed frequency. These multiple frequencies are the harmonics generated by the crystal-controlled tube. The tuned circuits in the receiver are adjusted to 600 kilocycles and are brought to resonance by means of the copper vanes associated with the inductances. Then the receiver is tuned to the second harmonic of 600 kilocycles, which is 1200 kilocycles, approximately 250 meters. It is then adjusted to perfect resonance by means of balancing condensers on the shortest wavelength within the broadcast band.



THE POWER SUPPLY OF THE "NR-60"

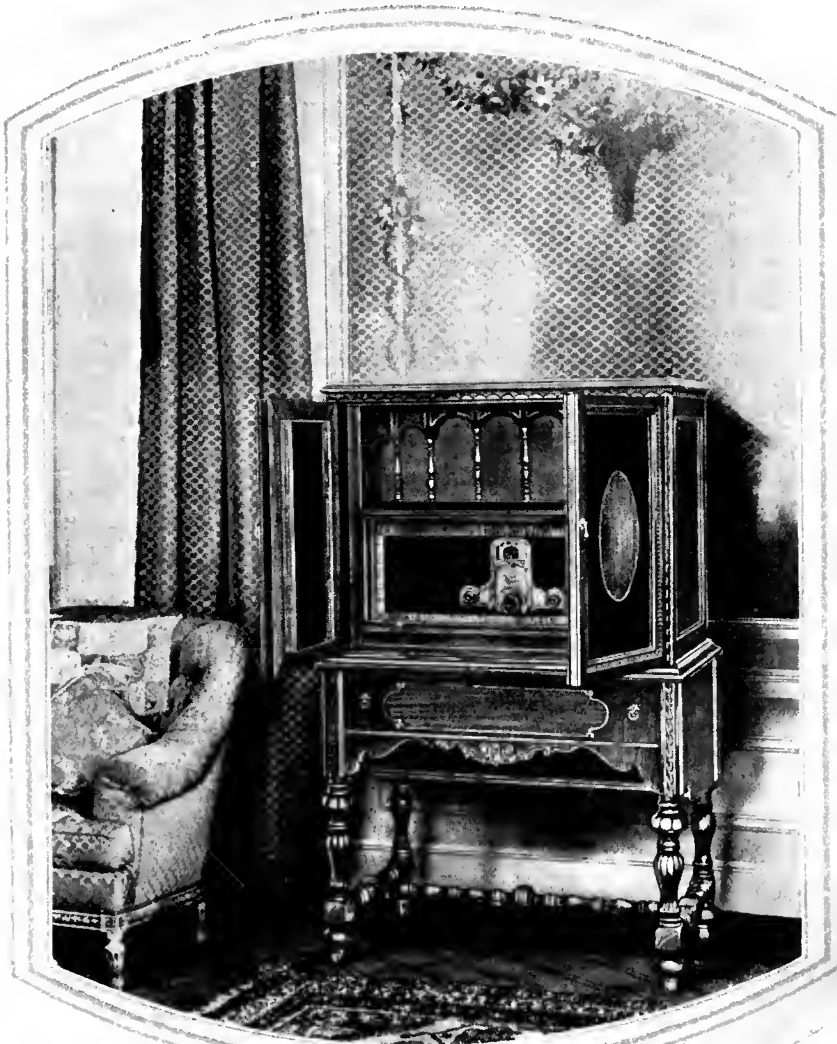
RADIO RECEIVERS REPRESENTING A WIDE PRICE RANGE



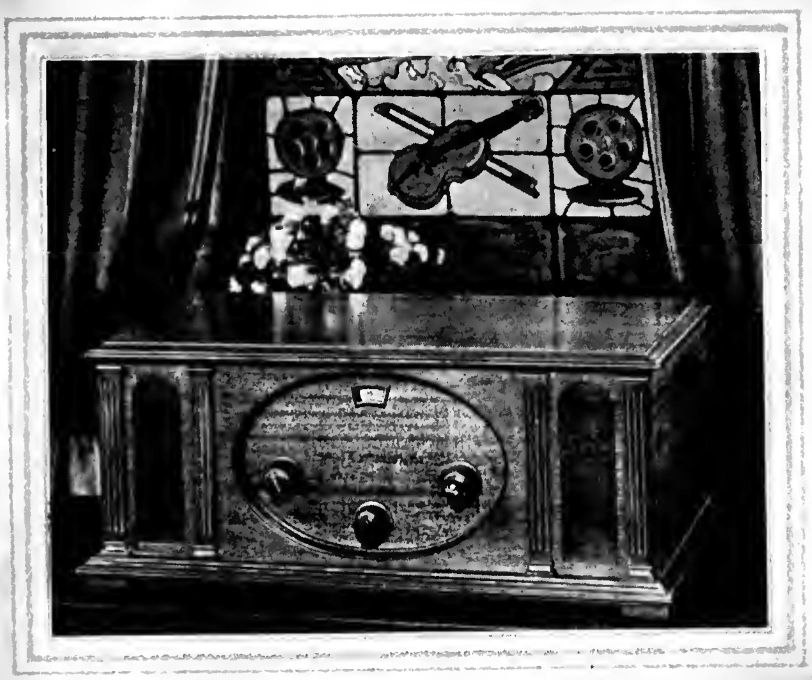
SPLITDORF'S "BUCKINGHAM"
Designed to blend in with the surroundings of a home decorated in the English style, the period of this cabinet work dates back some four hundred years. The "Buckingham" is a six-tube receiver employing three r.f. stages, tuning being accomplished by an attractive rose shaped knob which may be seen in the center of the receiver. A complete A, B, C power unit is housed within the cabinet. Behind the cane center panel in the upper part of the chest is the "Maestro Cone Tone" reproducer. The list price of the "Buckingham" is $800.00 complete

THE FERGUSON "HOMER"
Compactness is expressed in this new receiver by J. B. Ferguson. Housed within an exceptionally attractive little cabinet is this seven-tube receiver, employing four r.f. stages, two only of which are tuned, and two audio stages. A single illuminated dial accomplishes the tuning, and there is also a volume-control handle on the panel. Control of volume is obtained by means of variable plate coupling. The audio channel makes use of General Radio transformers. The "Homer" lists at $95.00 as illustrated. Chassis only, $80.00

THE advent of the more expensive, more luxurious, receiver, is not to be heralded as something new, although developments along this line have been very marked of late. Ever since its swaddling clothes days radio has been represented in a surprisingly wide range of prices. That a certain manufacturer charges ten times as much for one receiver as for another using the same circuit and number of tubes, need not deter the man of modest means from investing in the least expensive model. Frequently the chassis in both models is identical, the extra cost being due to refinements of cabinet work, the inclusion of a complete power-supply unit and also, perhaps, a built-in loud speaker



A LOOP RECEIVER
This is the "Ortho-sonic" F40 receiver, by Federal of Buffalo. The circuit makes use of seven tubes in a carefully balanced and shielded circuit. The loud speaker, which is built in and concealed by a silk screen and hand-carved grille, is said to be capable of beautiful tone. The loop may be seen mounted upon the inside panel of the left-hand door. There is ample space for installing the necessary power equipment. The cabinet is of walnut with vermilion inlay and hand carving. Price, without tubes or accessories, $450.00



THE "CRUSADER"
By King, also of Buffalo. Many interesting features distinguish this receiver. Special attention, for example, has been paid to its design that the use of a B-supply device will not complicate matters. There are two r.f. stages and three audio stages, the latter employing a combination of transformer and double-impedance coupling. The three variable tuning condensers are adjusted by means of a single knob, but there is an auxiliary knob for the first stage so that exact resonance may be obtained. The "Crusader" is completely shielded. The cabinet will fit in with either mahogany or walnut home furnishings particularly well. Price, without accessories, $115.00

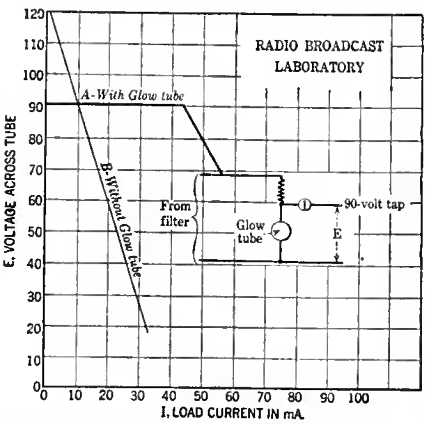
No. 129 Radio Broadcast Laboratory Information Sheet **October, 1927**

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.



A "NUT-SHELL" EXPLANATION OF GLOW TUBE OPERATION

The functions of a well-known type of regulator tube were fully described on Laboratory Sheet No. 129, which is reprinted above. The principles underlying the performance of the Raytheon R tube, illustrated below, are somewhat different to those of the 874 type tube

Constant B Device Output

By G. F. Lampkin

THE most obvious problem in the construction of a B device is that of filtering—of reducing the hum to a negligible value. In some power units, especially those made during the last few years, so much attention was paid to this problem that another problem, not so apparent, but fully as important, was somewhat neglected. This latter problem is one of voltage regulation—the changing of the B device output voltage when the output current is varied. A cut and dried definition states that voltage regulation of an electrical device is the rise in voltage when full load is thrown off the device, expressed as a percentage of the full-load voltage. The regulation of ordinary electrical apparatus is seldom greater than ten per cent. The regulation of some B power units runs above 100 per cent.

If a 90-volt set of B batteries be connected to a receiver, it may be known with reasonable certainty that the voltage applied to the receiver is 90, whether there are one or six tubes being supplied. If a B device is connected to a receiver and the device has poor regulation, the voltage

GLOW TUBE CONSTRUCTION

The use of a glow tube in B power units is becoming increasingly popular. The Raytheon one here shown is very efficient. It was described at length in the October, 1927, Radio Broadcast

may be 150 when supplying one tube but less than half that figure when supplying six. If the experimenter has available a high-resistance voltmeter suitable for the measurement of the output voltages of a B power unit, the voltages may be checked while the power unit is connected to the receiver to make certain that the voltages supplied to the set are correct. Some power units are equipped with variable resistance units so that the correct voltage may be obtained by the proper adjustment of them. Without a high-resistance voltmeter it is difficult to adjust accurately the voltages of a B supply unit, containing variable resistances to control the voltage. However, if the variable resistances are loosened so that the resistance is as high as possible and are then gradually tightened until the receiver operates satisfactorily, it is possible to adjust the voltages with fair accuracy. There is a danger of shortening the lives of the tubes in the receiver if the resistances are tightened beyond that point which gives satisfactory reception.

Under some circumstances the variation of the d.c. voltage with the load current introduces another disadvantage in that it tends to cause audio distortion. When the loud speaker is connected as indicated in Fig. 1, the plate current delivered by the power unit supplying the entire receiver may have a swing of ten milliamperes when a loud low note is being amplified. A receiver that would give such a signal might draw a total load of about thirty milliamperes and the plate current swing will, therefore, form an ap-

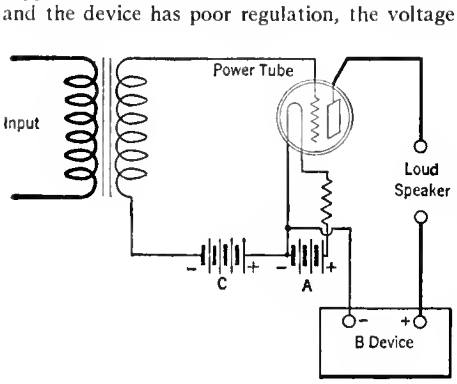


FIG. 1

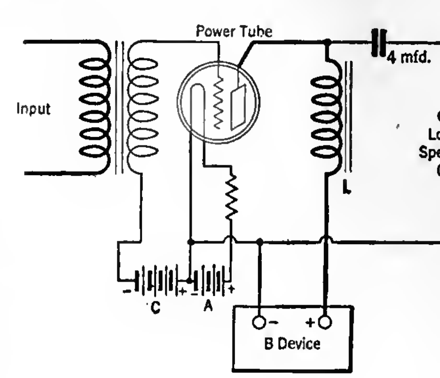


FIG. 2

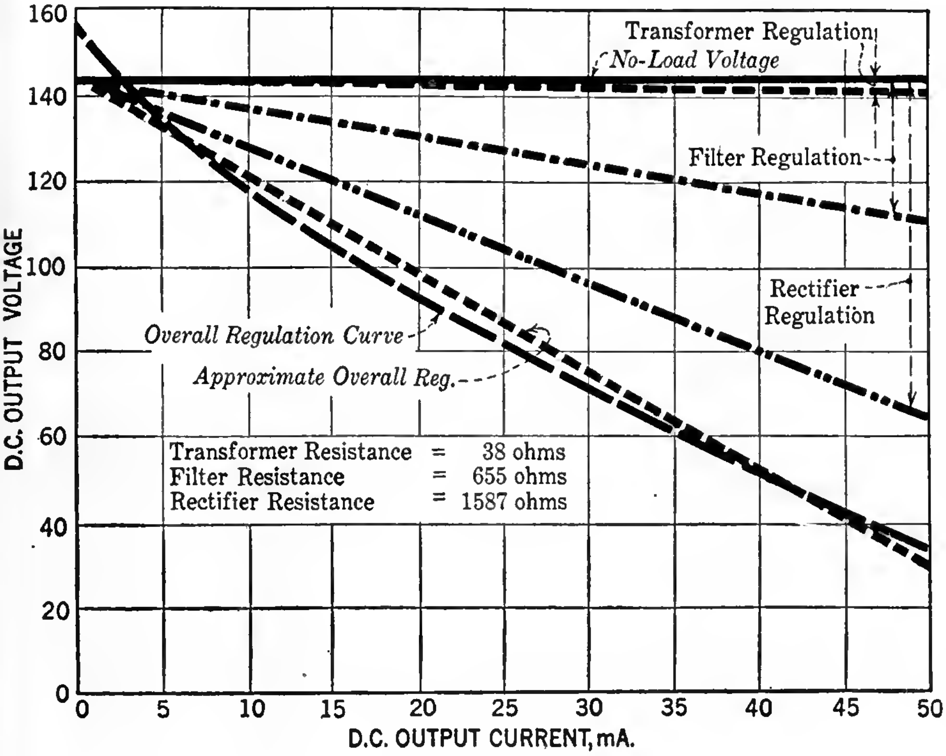


FIG. 3

preciable part of the total load so that the B device voltage will also vary. When the plate current increases, due to the signal, the B device voltage drops and tends to nullify the change; similarly, when the plate current decreases the voltage goes up and again tends to nullify the change. The regulation of the device would thus tend to cut off both the positive and negative peaks of the signal. The filter condenser at the output of the B device can take care of the plate current swings to some extent by charging and discharging on the negative and positive swings respectively. The effect of the condenser in this function is dependent on the frequency, however, and at low frequencies it does not exercise control to any great extent over the output voltage.

When the loud speaker is connected as in Fig. 2, distortion due to a variable load on the power unit is prevented because all the a.c. currents must flow around through the loud speaker and back to the filament and hence do not go through the power supply. As a result, the current drawn through the choke L from the power supply is practically constant and the load on the power unit does not vary appreciably with the signal.

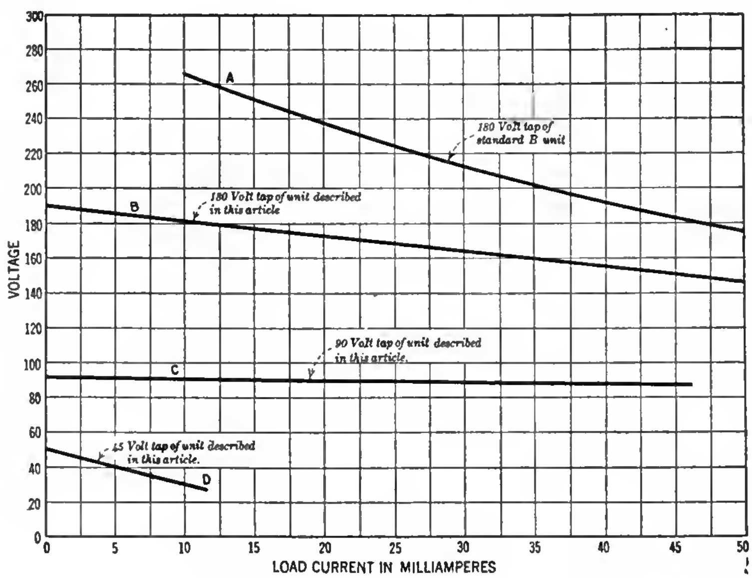


FIG. 5

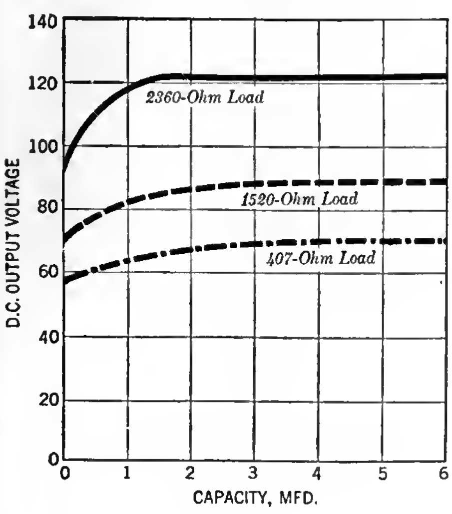


FIG. 4

The regulation of a B device is caused by the internal impedances of the three units that make up the device—the transformer, the rectifier, and the filter. As the current drawn from the device increases, the internal voltage drops also increase and the result is that the output voltage becomes less. A graph of the output voltage of a typical B device for different values of current is shown in Fig. 3. Such a graph is called a regulation curve. It is nearly a straight line and for purposes of simplification it may be replaced by one such as the lowest straight line of the group. The vertical distance between this line and the upper horizontal line, which represents the no-load voltage, is the internal voltage drop for any given current value. The drop at 50 milliamperes load is 144-30, or 114 volts. Dividing voltage by current, $\frac{114}{.050}$, gives the value of total internal resistance as 2280 ohms. This resistance is partly hypothetical, for it represents the overall value from a.c. input to d.c. output. It might be called the "equivalent" internal resistance.

That part of the regulation which is due to the transformer is comparatively negligible. The secondary voltage of the transformer dropped from 116 to 114.5 when the output current was changed from 0 to 50 milliamperes; this corresponds to a regulation of 1.3 per cent., and an equivalent internal resistance of 38 ohms. The regulation due to the filter is dependent chiefly on the resistance of the filter chokes, and on the capacity of the first filter condenser, *i.e.*, the one immediately after the rectifier. The curves of Fig. 4 show what effect the size of the first condenser has on the output voltage. At light loads, high-resistance, the voltage goes up sharply, then flattens out, as the capacity is increased. For any load, the voltage curve is flat at a value of 4 microfarads. This is a more or less standard value, so the contribution of the first condenser to the filter regulation may be neglected, and only the resistance of the chokes considered. This resistance can be measured with d.c., and was in this case 655 ohms. The equivalent resistance of the rectifier, is, by subtraction, 2280 — (655 + 38) = 1587 ohms. Thus, for this particular B device, the rectifier constituted the major cause of regulation. The individual curves of transformer, rectifier, and filter regulation shown give a good idea as to how the voltage drops are distributed. The total of the distances from the no-load-voltage line to these three curves gives the approximate overall regulation curve.

The problem of producing power units with good regulation is important. As a result several methods are at present in vogue whereby power units can be constructed with comparatively good regulation. The use of a glow tube in the output circuit of a power unit will cause the regulation of the unit to be excellent over the entire range of useful load. A group of curves taken on a power unit utilizing a glow tube are given in Fig. 5. Also it has been found that by decreasing the total resistance across the output of the power unit the regulation can be improved. When the total resistance R, Fig. 6, is reduced, the currents circulating through it, which represent a loss, are increased, but if the power unit has available sufficient capacity, this loss of current is advisable because it improves the regulation of the entire unit.

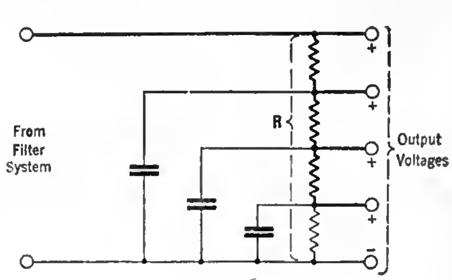


FIG. 6

The Listeners' Point of View

A FANTASY ON SPONSORED PROGRAMS

By JOHN WALLACE

THIS is station KWOK broadcasting on a wavelength of four yards and six inches by authority of the Federal Boxing Commission. Station KWOK is loaned and saturated by the McSwif Stomach Pump Company and the Quebec Liquor Commission, Chicago Branch, and is situated on top of the Division Street gas holder, holder of high-grade gas. Every Wednesday evening at this time a program of detrimental music is brought to you by buggy from New York through the courtesy of Hamstein, Hoffstein, Snickelby, and Snootch, manufacturers of taxi cabs, doll cabs, bottle caps, and cogs, KWOK, Where Everybody's Sappy. Please stand by for the Eastern pronouncer.

This is WOOP, New York, broadcasting by special license of the city pound with a frequency that is positively dismaying. Every Monday evening at this time our facilities are engaged by the Hoffstein, Hammerstein, Snigelby and Scrooch Company, manufacturers of high grade taxi caps, doll cats, bottle cogs and coops, presenting the "Hof-hac-snack-co Hour" through WOOP together with 43 other stations, four precincts, three wards, and the juice of one lime. Stand by please while your local station idemnifies itself.

This is KWOK, Chica-

This is WOOP New Yo- (just to give the boys in the switch yard a chance to do their stuff.)

This is KWOK

'Taint, it's WOOP

'Tis

'Taint

'Tis (O dear, this could go on forever, but at this point both stations join hands in a circle and the girls choose partners.)

You're on your back in the studios of WOOP the key station of the Duodecimal System. I will now tip the microphone over on Mr. Gregory Swallop advertising manager for the Hatstein, Hemstein, Hockelby and Pooch Company who will renounce the program. Mr. Swallop.

Good evening folks. Well once again the "Hic-haec-hoc-co Hour" is with you and I know how happy you are to hear from us and I just know you are going to enjoy our program. I also know the color of your eyes—yes I do, take those handies down!—and how high up is, and the date of the second coming, and oh lots of other things. Seven days is an awfully long time to wait, isn't it, my ducks? Why of the 17,586,864,203 letters we received during the week 117 were from listeners who died because they couldn't wait. Ha, ha, they must have had jobs in a cafeteria! Ha, ha. Well, I will have my little joke. Well I know you are anxious to hear the program so I will not delay you any longer except to divulge to you that this hour of entertainment is donated to you gratis as a Christmas present, free, through the munificence of Messers —shhh! Come over closer—HINKLESTEIN, HOCKELSTEIN, SNOOPELBY and SNATCH. Don't tell! This high grade firm was foundered in 1898 and has been engaged for forty years in the manufacture of high grade taxi backs, doll craps, bottled cats, and bogs. Our taxi backs are equipped within and without with equillibrated non-actinic colloidal stradilators and sometimes with metaspheroid double-trussed oscillators—a reassuring thing to know, my doves, in case of eggs. Hinc-hoc-sno-co Brand Bottled Cats may be obtained at any grocery store, your money back if the color frays. Our bogs are shipped direct to you from the boggery, untouched by human hand.

Were you Mr. Listener, and you Mrs. Listener too, ever caught in the rain without a taxi cab? You got soaked didn't you? And if you'd of hired a cab you'd of got soaked too, wouldn't you? You should own your own. So I will now present to you the Old Soak who with his White Mule will spirit you away this evening to the Never-never Lands, there to hear lovely strains of music of foreign crimes, rendered for you by the Lard-Werks orchestra. Here take it you bum!

Hello folksch, thisich me. An afore we gawan wisha program thorchestra sgonna play for you our musical trade mark the Funeral March so that whenevah you heah it, wherevah you may be, you may remembah the lovely, "Hing-hang-snig-co Hours" and recall that one of our bogs in your back yard means immediate death for your neighbors' chickens.

Orchestra plays Chopin's Funeral March

. . . and as the last strains softly strain o'er the distant strains we vault lightly from the saddle of good old Black Beauty while the carriage boy informs us that we bring to you tonight a pogrom of Hebrew heirs collected for you by our research department in the picturesque pathways of Palestine and Palisades Park. And now if you will extinguish your lights, turn off that damned radio, relax, returning to the squatting position at the count of five, we will enter the tonneau of the Brox Bros. Travelling Crane and —wissht!— We find ourselves on a sunny slope in Spain whilst from the half open door of a little tepee in the very shadow of Popocatapetl we hear the gentle warble of the Swiss Marine Band crooning plaintively to its young that lovely lullaby "On the Road to Mandalay-hay."

Orchestra plays the Prelude in C Sharp Minor.

Boom! Boom! Boom! Three crashing chords on the piccolos followed by some thin tweedling sounds, four policemen and a cat.

This is WOOP—We Own Our Pants—broadcasting the Himpstein, Hinchbein, Snogerty and Snike program. Stand by please for your local anaesthetic.

This is KWOK broadcasting on a wa— (WOOP's switchman wins this chukker by seventeen words, receiving in award two kewpie dolls and a ham.)

This is WOOP my dears, Old Soak speaking. Our sturdy steed seems to have gone back to pasture and rubbing our eyes we find ourselves on a Kansas farm! Well I swan! And so now the boys are going to play for you a new derangement of that lovely piece by Saahnt Saahns called "The Swan." This is the first time to our knowledge that a female child under the age of fourteen has ever been choked to death over the radio and is presented to you by special arrangement with the composer. Saahnt Saahns was born in Moravia in 1792. He was the son of a sea cook and a bridge keeper's daughter. His great grandfather on the maternal side invented the poodle by interbreeding dachshunds and cotton batting so it is not surprising that the age of three found the gifted young Saahnt conducting his own works in the Ruhr district. There were no bond houses in that day so he decided to become a musician. He never got around to this, however, and in 1632 his unclad body was found in the Thames. Morticians discovered three measures of rye in his stomach and nineteen measures of music tatooed on the elevation nearest London Bridge. Thus was this immoral melody given to the world, which will now be played for you by Gilles de Rais on the flute. Mr. de Rais is the greatest living flautist. He was the first man to flaut across the English Channel. For your interest, his flute is a genuine Strad and is valued at $17.98 an inch except in leap year one cent more. Mr. de Rais will be accompanied by Miss Elva Orkney on the night boat. The Swan. . . .

LESTER PALMER

Chief announcer and program director of station WOW, at Omaha

BOB HALL OF KOIL

Mr. Hall is chief announcer, studio director, baritone soloist, "Uncle Josh" and director "Little White Church on the Hill" at this middle western station

Orchestra plays Tschaikowsky's Nutcracker Suite.

... and as this lovely Air for the G String concludes we discover that our old faithful White Mule has stumbled over the last bar and must be shot. (Three sobs followed by a cannon shot and screams of protest from the loud speaker). But hopping blithely on the bullet we find ourselves suddenly conveyed to Alsatia. "I'll Say She Does" will be the next number by the dance orchestra.

Orchestra plays Tschaikowsky's Nutcracker Suite.

And now folks, before this "Squawk-squack-co Hour" comes to a close we want to tell you about the elegant booklet we have prepared just for you. It is printed on décolleté vellum in an edition strictly limited to four million copies, each one signed in six places by the authors, Hipstein, Hopstein, Spiggoty and Speck, manufacturers of waxey tacks, boot jacks, model gats and fogs. It contains not only a copy of the Constitution, multiplication tables up to ten, a list of contributors to the Yale alumni fund of 1876, the population of the principal cities of Denmark and the Lives of the Saints, but also such valuable information as "Eighty-nine Appetizing Ways to Serve Coddled Bats," "How to Re-cog Your Baby," and "How To Make Attractive Lamp Shades, Bird Baths, and Pen Wipers Out of Old Taxi Backs." Write us and tell us how much you enjoyed our program and how it has brought cheer into your life —or leave out all that but anyway give us your name and address and the addresses of twenty of your friends who you think would also be interested in high-grade blueing. And now we conclude our program with the "Squawk-squack-co March."

Orchestra plays Tschaikowsky's Nutcracker Suite

This is WOOP. The program you have just heard was handed to you on a silver platter as the joint offering of Santa Claus, the Celestial Powers, and Hamstein, Hoffstein, Snickelby and Snootch, manufacturers of . . . hey, Joe, what the hell do those buzzards make anyhow?

The Possibilities of the Radio "Talk"

WE WERE pretty nearly won back to radio "talks" the other night after having at one time sworn off them for life. We happened to tune-in WJZ at 6 P.M. Central Time on a Tuesday and heard a Mr. Frank Dole holding forth on the Airedale. Mr. Dole's weekly dog talk, it seems, has been a regular WJZ feature for many years. He is known as an expert on dog life and is kennel editor of the New York *Herald-Tribune.*

However, we didn't know all this when we accidentally stumbled across his program and it had to survive or be tuned-out on its own merits. Our speaker was violating all the rules in the little hand book on elocution. He was dropping the "g's" on words ending in "ing" and mispronouncing some others. His speech could certainly not be described as fluent and was decidedly lacking in that first requisite of elocution —polish. Furthermore, he occasionally got tangled up in his words and would have to start a sentence over again. Some times, even, he paused—an infamous procedure in radio delivery, wasting the station's good time like that! And along toward the end of his dissertation he waxed sentimental—an oratorical device we heartily abhor. But that's not all: to cap the climax he terminated his talk with some personal messages to friends of his in the old home town in Maine!

Certainly a sufficiently lengthy catalogue of faults to damn any speaker—in the face of which we stoutly maintain that the talk was one of the best we have ever heard on the radio.

Mr. Dole succeeded in that oft talked of, but seldom demonstrated, stunt, to wit: putting across personality. He spoke exactly as he would have if you had cornered him on the street and asked him to tell you something about Airedales. Each one of the "faults" enumerated above contributed to this impression of informality and the net effect was convincing—he sounded as if he *did* know something about Airedales. Your average radio speaker, given the same material, would have made it sound as if he had just looked up the subject in the Encyclopedia Britannica.

Which last remark sums up the general run of radio talks. Almost invariably they give the impression of having been dug out of some book for the occasion. The listener's reaction to such a delivery is invariably this—"why not look it up in a book myself? it's easier to read than to listen to," click!, and the would-be talker is switched off. The speaker has to add something to the words if they're to mean any more than the same stuff printed. Mr. Dole's addition to his mere subject matter was his indubitable love for dogs, which stuck out all through his dissertation. His was no speech performed for the sole purpose of filling out a fifteen minute radio program. He likes dogs, likes to talk about them and wants other people to like them. His interest in his subject was contagious and we suspect that he may even number non-dog owners in his audience.

FRANK DOLE
Kennel Editor of the New York *Herald-Tribune* who is regularly heard through WJZ speaking on dogs, a subject which he handles remarkably well

Given other speakers with similar qualities of delivery and we don't know but that we would alter our opinions concerning the merits of the radio talk. If we could be assured that enough untutored speakers could be obtained, who would talk naturally and not dress their material up for the microphone, we would suggest an admirable series of radio talks—let some metropolitan station schedule a series of weekly ten minute talks, promising a new speaker, an authority on his subject, each week. Then as speakers get head waiters, bakers, subway guards, mounted policemen, customs inspectors, window demonstrators, flag pole painters, information clerks, pan handlers, bell hops, ribbon clerks, bootleggers—or any others of the numerous people whose work gives them a unique slant on humanity, and with whom the average man doesn't ordinarily have an opportunity to be clubby. Let them tell the inside dope on their business in their own words.

Of course it would first be necessary for the director of that program to interview the prospective speakers to ascertain whether or no their garrulities would be interesting. He could question them in the course of an hour's interview about entertaining and intimate sidelights on their trade. During the course of the conversation he could keep a topical record of the interesting things that came up. Then the speaker could be furnished with this brief list of reminders, perhaps only five or ten sentences long, and told to go ahead and talk until his ten minutes were up.

The series would succeed or fail according to its convincingness. Absolutely no editing, other than by the method suggested above, could be indulged in, and the speaker would have to be encouraged to talk in his every day language. Any faking of material, or permission of exaggerations for the purpose of putting "punch" in the talk, would defeat its own end. The listeners —a suspicious lot—would immediately decide that the "confessions" were faked in their entirety and delivered by some actor-announcer.

But if the thing were honestly done it would be honestly convincing. Suppose a window washer, inexperienced at formulating his ideas, got "microphone fright" before his speech was two minutes under way, and the program had to be filled out with piano music—the catastrophe would only serve to build up the prestige of the whole series.

INTERESTING news from France, translated by ourself at the cost of much labor and consulting of dictionaries, for your delectation:

Acting upon the Radio Broadcasting decree issued on December 31, 1926, the constitution of a new organization, the "Radio-Diffusion Française," is being prepared by the qualified representatives of literary and artistic groups, of radio manufacturers and dealers, of the press, and of various associations interested in the development of radio.

The "Radio-Diffusion Française" proposes to act upon the suggestions and orders of the statute established by the government by bringing about broadcasts of such quality and interest as will be worthy of French thought, technique, and art.

Under the auspices of the "Radio-Diffusion Française," a complete broadcast of the performance of "La Traviata" at the National Opera House was transmitted by station Radio-Paris, with full power, on January 26, 1927. The opera was offered to the listeners by the "Grands Magasins du Printemps." (The which, as you know, is a department store in Paris).

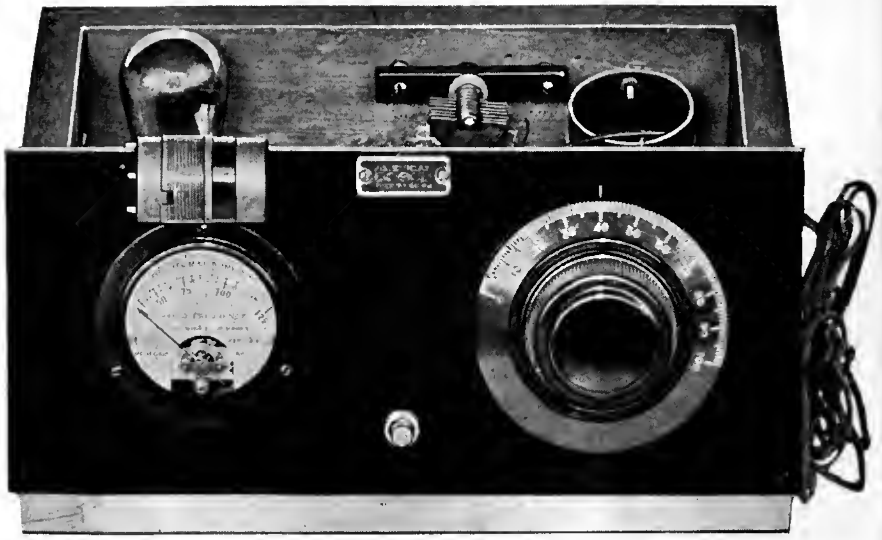
A NEW day time schedule has been inaugurated by WJR. It is called the Musical Matinee program and lasts from 12:45 to 2 o'clock every day except Sunday. Dance music is alternated with concert music, and occasionally a solist is added. Dance music is by Charles Fitzgerald and his Rhythm Kings, and light concert numbers by Jean Goldkette's Petite Symphony Orchestra.

MATCHING R. F. COILS

By

F. J. FOX and R. F. SHEA

Engineering Dept., American Bosch Magneto Corporation



THE CRYSTAL-CONTROLLED MASTER OSCILLATOR
See Fig. 2 for the circuit diagram

THE trend toward simplicity of operation as manifest in the design of radio receivers during the last few years has rendered necessary a rapid development in the technique of production testing. During the time when single-control receivers were unknown, there was less necessity for precision test methods. It was desirable that the coils and tuning condensers be identical in order that the dials might read alike, but considerable tolerance could be allowed without affecting the efficiency of the receiver. It is quite evident that this cannot be permitted with modern receivers, where as many as five or six tuned circuits are coupled together and controlled from one central drive. In this case any appreciable departure from uniformity will reduce the efficiency of the receiver and, consequently, it becomes very necessary to develop and maintain elaborate inspection equipment in order to insure absolute uniformity of all the component parts of the tuned circuits. In this article it is our purpose to analyze the various means of testing and matching radio-frequency inductances.

Most of the methods of testing inductances at radio frequencies involve some variation of the well-known resonant circuit, wherein the coil to be tested is used in combination with a calibrated condenser as a wave trap. This wave trap may be attached to some sort of detector circuit or else it may be incorporated in an oscillator circuit. If the former is used, an oscillator must be used to supply power, so, as a rule, it is more economical to make the tuned circuit part of the oscillator circuit.

The type of apparatus to be designed for this purpose is determined by several considerations. If the test set-up is to be used for matching coils, its frequency must be fixed and the tuning of the wave trap condenser must not change the power or the frequency of the oscillator. The apparatus must be designed for all possible accuracy consistent with quantity production, and, above all, it must be reliable and fool-proof. The accuracy required depends on whether the coils are to be sorted and then matched, or whether they are to be passed or rejected. If a small receiver using not more than three coils is being built, it is advisable to match coils. If, however, a large set is being manufactured, it is too expensive an operation to match five or six coils. In this case it will be found more advisable to hold the coils within a certain percentage variation from a standard, this allowable variation being as much as can be tolerated without serious loss in receiver performance.

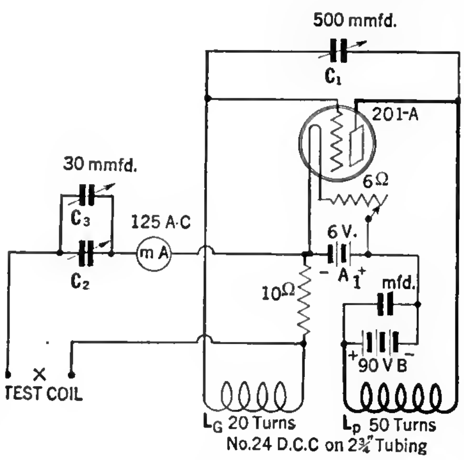


FIG. 1
A setup developed for matching coils

In Fig. 1 is shown a coil test set-up which was developed for the purpose of matching coils. This set-up utilizes a Hartley oscillator in connection with a wave trap circuit. L_g and L_p are the grid and plate coils respectively and C_1 is the main tuning condenser. The oscillator may be set at a frequency of about 1000 kc. A resistance of ten ohms is placed in series with the grid coil and the wave trap circuit is shunted across this resistance. The wave trap consists of a thermo-galvanometer in series with the coil to be tested, and a variable condenser, C_2, of such a size that it will tune the coil to 1000 kc. Across the condenser is a vernier, C_3, of approximately 30 mmfd. capacity, and this vernier will indicate the amount that the test coil deviates from standard. The variable condenser, C_2, is so adjusted that the galvanometer will give a maximum reading when the vernier is set at 15 mmfd. or, let us say, a dial reading of 50, the standard coil being connected at X. If, now, a coil to be tested is placed across X it will usually necessitate a readjustment of the vernier in order to obtain a maximum galvanometer deflection. The amount of this deviation is an indication of the deviation of the coil's inductance from standard. Coils which give vernier readings between 40 and 60 on the dial may be passed since the deviation is, roughly, only plus or minus 1 per cent. By passing all coils coming within the limits and rejecting any which fall outside we can hold coils to as great a degree of uniformity as desired. Or if the coils are to be matched, they are labeled with the reading of the vernier and sorted, all coils bearing the same number being identical.

MATCHING THE TESTING DEVICE

WHILE the above system is extremely useful when small quantities of coils are being tested, it has several disadvantages when applied to quantity production. Chief among these is the difficulty of exactly duplicating two such testing devices. If coil matching is desired, we cannot match coils tested on one set-up with those tested on another set-up.

To overcome this disadvantage, a coil-testing method has been worked out with which it is possible to duplicate measuring set-ups and in this way handle a large volume with a minimum of expense and a maximum of efficiency.

This improved system employs a constant-frequency master oscillator and a number of auxiliary oscillators. The last-mentioned oscillators incorporate the test circuits. The master oscillator maintains the test frequency of 1000 kc. and all the other oscillators are adjusted to this frequency by means of a detector loosely coupled to each oscillator.

Fig. 2 shows a wiring diagram of the master oscillator using a quartz crystal for frequency control. The crystal is connected between the grid and filament of a vacuum tube and is shunted by a grid leak. The plate circuit is tuned by means of a coil and condenser in parallel, and the circuit will oscillate when the natural period

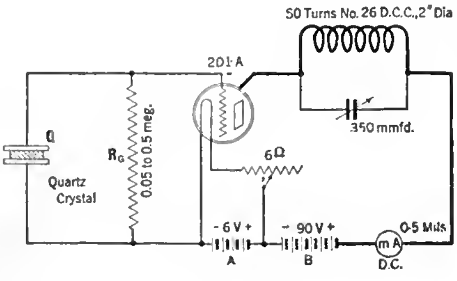


FIG. 2
The master oscillator circuit with quartz crystal control

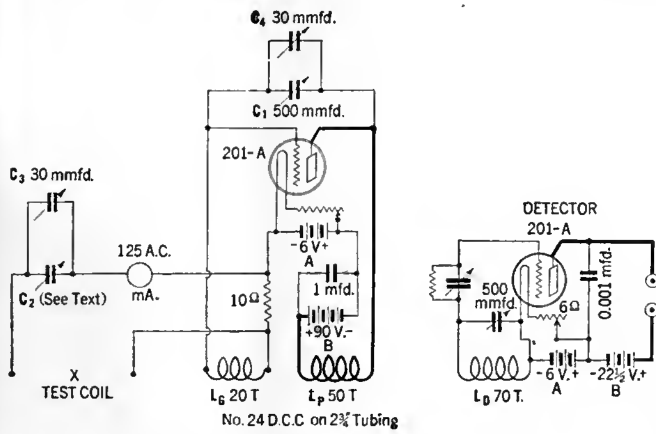


FIG. 3

The circuit of the auxiliary oscillator. A detector circuit is loosely coupled to it

of the crystal is found. A 5-milliampere d. c. meter is connected in the plate supply circuit and this serves to indicate the condition for maximum oscillation. When oscillation begins, the plate current decreases, and maximum oscillation corresponds to minimum plate current. It will be found best to operate with the tuning condenser set for a slightly lower capacity than that for best oscillation in order that oscillation will start when the switch is turned on. Crystals having an accuracy of $\frac{1}{10}$ of 1 per cent. may be obtained from the General Radio Company. Since only constant frequency is required, the crystals need not be ground accurately to any particular frequency, and hence may be obtained at a lower price.

The wiring diagram for the auxiliary oscillator is shown in Fig. 3. The oscillator is the same as that shown in Fig. 1 with the addition of a 30-mfd. vernier condenser, C_4, across the main tuning condenser, C_1, so that the latter may be set and locked and C_4 used to adjust this oscillator to the same frequency as that of the master. Loosely coupled to the auxiliary oscillator is a detector circuit consisting of a coil and condenser and a vacuum-tube detector. A pair of headphones is connected in the plate circuit. The auxiliary oscillator is tuned to the frequency of the master by the heterodyne or beat note method. In other words, the vernier is turned until the beat note heard in the headphones is lowered to "zero beat." The test circuit is placed across the ten-ohm resistance in the grid circuit in the same manner as shown in Fig. 1. This test circuit has the main condenser, C_2, and the vernier condenser, C_3, as before, the large main condenser being used to set the standard coil reading for maximum meter deflection when the vernier is set at mid-scale. The vernier condenser, C_3, is the only piece of equipment that has to be matched in each oscillator set-up. To facilitate this, the condenser is made of heavy plates with extra large spacing, and each condenser is measured on a capacity bridge before being used. This is necessary in order that coils tested on one set-up can be used with coils giving the same reading on another set-up.

A saving of one test set-up may be accomplished by adding to the crystal oscillator a coil test circuit. This is done by inserting a resistance in the plate or tuned circuit and shunting the wave trap circuit across it, as shown in Fig. 4. It is seen that the crystal oscillator is unchanged except for the introduction of the measuring circuit. This test circuit is identical with those used in the previously described oscillators with the exception that it is in the plate circuit instead of the grid circuit of the oscillator.

TEST PROCEDURE

IN USING this arrangement the following procedure is employed. The crystal oscillator is set to a stable operating condition as described previously. A standard coil is now connected at X and the tuning condenser, C_2, is adjusted until maximum current flows in the test circuit when the vernier condenser, C_3, is set at mid-scale. Limits are set on either side of the vernier mid-scale by inserting coils which are known to be plus or minus the desired amount in inductance. There are a number of ways by which a standard may be obtained. A number of coils may be made in experimental production, and these may be measured on an inductance bridge. One of these is used which is representative of the average. Another method is to run a large number of coils through the coil tester and pick

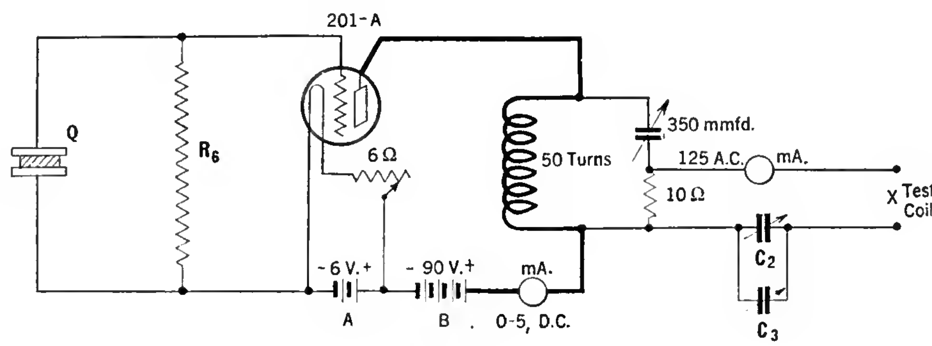


FIG. 4

A saving of one test setup is possible by combining the latter with the crystal oscillator

out a coil which is equal to the average. The choosing of limits is a difficult problem. It is possible to set up a radio-frequency amplifier and try coils which are plus or minus standard inductance and vary these limits until the radio-frequency gain is affected appreciably. These coils can then be placed in the tester and the maximum allowable limits determined. It is also possible to compute the limits which may be allowed and from this obtain the capacity variation which will tune these coils to resonance and thus obtain the allowable limits in terms of the vernier condenser capacity. Another and less accurate method is to choose limits from a study of the tests of a large number of coils. In this case the smallest limits possible, consistent with quantity production, may be selected.

All auxiliary oscillators are brought to the same frequency as that of the standard by the "beat frequency" method as described above. The oscillators are checked as frequently as possible, say every few hours.

The size of the tuning condenser (C_2 in the diagrams) necessary to bring the test coil to resonance will of course depend on the test frequency and the inductance of the coil to be tested. The proper value of C_2 can be easily computed from the following equation:

$$C_2 = \frac{1,000,000,000}{0.0395\ f^2\ L}$$

where C is in mmfd., L in microhenrys, and f in kilocycles. Thus, if the test coil has an inductance of 200 microhenrys and if the test frequency is 1000 kc., the capacity required is

$$C_2 = \frac{1,000,000,000}{0.0395 \times 1,000,000 \times 200} = 127 \text{ Mmfd.}$$

A 150 mmfd. condenser will, therefore, easily serve the purpose.

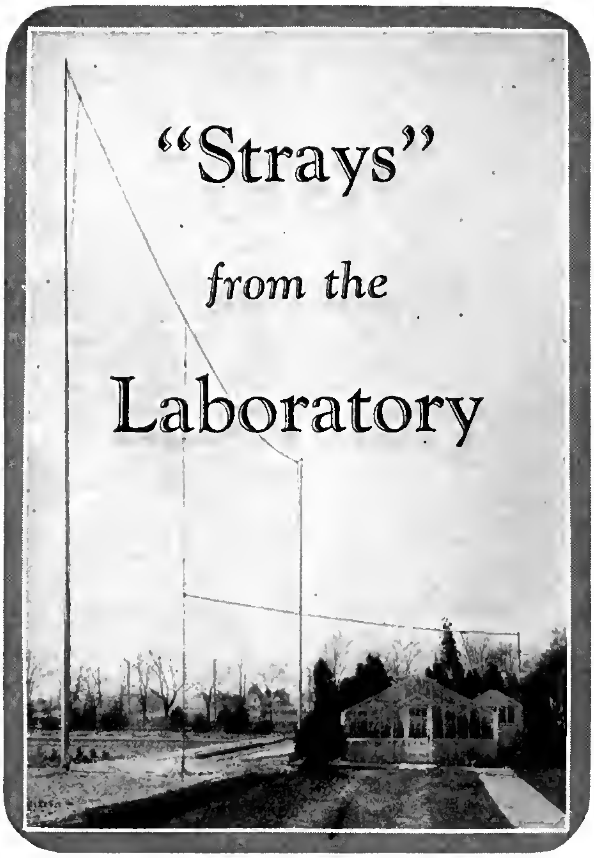
A photograph of the crystal-controlled oscillator described above accompanies this article. The test coil may be seen in the test position. The eyelets on each end of the coil serve as coil terminals and these are also used to make contact with the tips provided on the test setup. The adjusting condensers are placed inside in order to prevent the operators from tampering with them. The dial on the panel controls the vernier, C_3. The limits are either marked on the dial or they may be posted near the operator.

A photograph of an auxiliary oscillator and detector combination is also shown, in this case the main adjusting condensers are inside the case. The vernier, C_4, used for frequency setting, may be adjusted by means of a screw driver from the outside. The detector coil is on the right-hand side and is placed about eight inches from the oscillator coil so that the coupling is small. The dial on the panel is for the vernier, C_3.

The system described in this article has been in operation in a well-known laboratory for some time and has given very excellent results.

THE AUXILIARY OSCILLATOR AND DETECTOR

The circuit diagram of this unit is shown in Fig. 3



"Strays" from the Laboratory

New Tubes Mean Greater Economy

THE ARRIVAL on the open market of power tubes of the 112 and 171 types (the CX-312-A and CX-371-A, UX-112-A, and UX-171-A) which require but one-quarter ampere, half of the original filament current, is another step in the evolution of the vacuum tube. Now we hear rumors of new general purpose tubes of the 201-A type which will consume but one-eighth ampere, half the present tube's requirements, again reducing the power required by filaments to the low value of 5.25 watts for the average six-tube receiver. Years ago we used tubes which ate up our batteries to the tune of more than one ampere each—but in those days we did not have six-tube sets—and the new tubes, present and promised, mark one more step in a continual advance toward economy.

The 112-A type of tube, which is a quarter-ampere semi-power tube, has an amplification factor of 8 and an impedance of 5000 ohms, similar to the 210 power tube except that one cannot use plate voltages as high. This semi-power tube, in our opinion, is a tube which should be used more generally than is the 171 or 171-A tube. Two of them in parallel will deliver as much *undistorted* power as a 171 type on one-third the input a.c. voltage and with slightly less plate current drain from one's batteries. This business of requiring adequate volume with smaller input voltages is important to one who dwells over 100 miles from powerful stations. Here more voltage amplification is needed to bring signals to the volume level desired and, since the 171 type of tube with its low mu is essentially a local station power tube, that is, it requires large input signals, its advantage over the 112 type is not always apparent.

Two 112's in parallel, which is a better combination than push-pull when choke-coupled to the average low-impedance loud speaker, can be operated from B batteries economically. A single 171 tube with only 135 volts on the plate draws as much from the B batteries as two 112's in parallel with 157 volts on the plate and requires more than twice the input voltage to deliver less power output. In other words, weaker signals will deliver the volume required when 112 type tubes are employed.

The screened-grid tube is another step toward economy. Its filament operates from 3.3 volts and requires 0.132 amperes—the same filament as is used in the old and, we must say, rather poor, 120 type tubes—and delivers roughly three times the voltage amplification at high frequencies as the 210-A type of tube. Probably as many stages of amplification as we are accustomed to in r.f. circuits will be required with the screened grid tube to furnish sufficient selectivity, but the resultant input to the detector will be much greater than when our present general-purpose tubes are used.

Don't Overwork the A Battery

ONE OF THE most frequent complaints made to radio service men sounds like this: "My radio seems to be all right when I first turn it on, but then fades out. What is wrong?" This is invariably prefaced with the statement that all batteries are in good condition, *i.e.*, that new B batteries are in use and that the A battery has been newly charged.

What is wrong? The answer in nearly every case is that the storage battery is run down, and that if it is thoroughly charged trouble will disappear like dew in the morning. People using trickle chargers apparently fail to understand or appreciate the fallibility of all things mechanical or electrical. Over the week end, they work the radio for hours at a time giving it little chance to recharge from the trickle charger, until the little booster cannot hold up its end of the bargain longer. The battery is down and nearly out, the signals fade after a few minutes of the program, and the only thing left to do is to cart the battery to the nearest service station.

Better Loud Speakers Are Here

WE TAKE considerable pleasure in announcing that the loud speaker situation seems to be improving rapidly. For years we knew of no loud speaker that could be compared to the W.E. 540-AW, or the larger W.E. cones, either in sensitivity or in tonal range or in what we might call "intelligibility." This latter term is taken from telephone practice to mean the ability to distinguish the various instruments of an orchestra—when listening to it from a given loud speaker—or to recognize various consonants such as d, b, t, s, when spoken singly and without context, or to recognize the identity of an announcer. Many loud speakers convey sounds to us in a comparatively decent fashion, it seems, but when we try to distinguish the piano from a banjo, or to pick out the wood winds from the violins, we realize that something is wrong. All of the instruments seem "blended" together; we cannot distinguish one from another. We wonder how many loud speakers have been sold because the salesman, or the advertising told how carefully the loud speaker had been designed so that a proper "blending" had resulted?

We have listened to two cone speakers recently which will give the 540-AW a close race—the Fada 415-B and the B.B.L. Both of these are rather large cones, of about 24 inches diameter, and both are remarkably good. As a matter of fact they are so good that we have decided to call upon all of the loud speaker manufacturers to send their instruments into the Laboratory, and to get to the bottom of the present loud speaker situation.

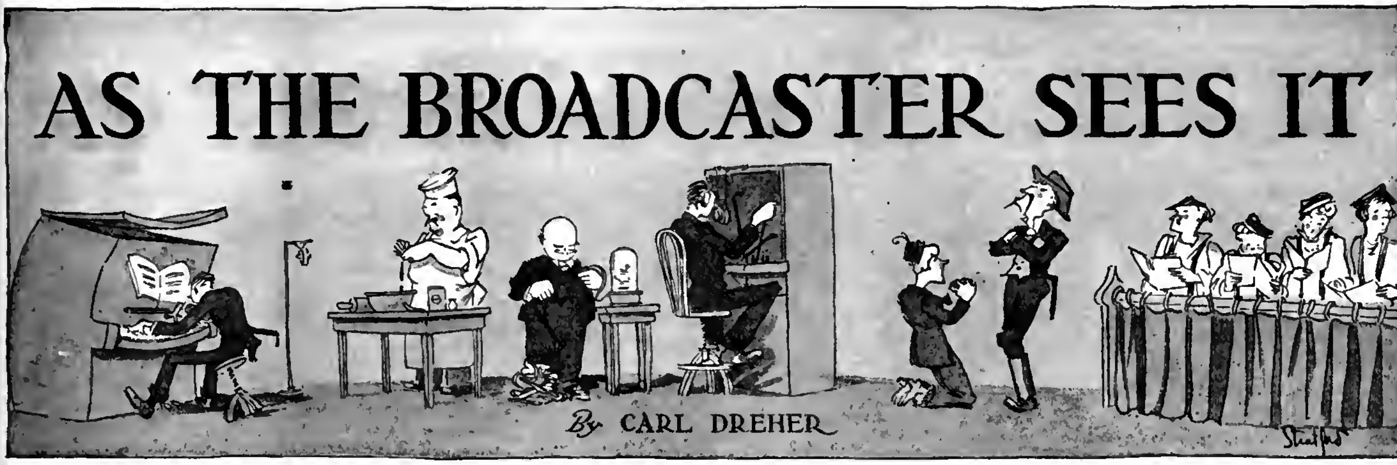
And speaking of loud speakers, it is our opinion that improving the loud speaker will spell trouble for the designers, manufacturers, and owners of a.c. sets. With a Balsa loud speaker which we operate with a Western Electric 540-AW unit out of a single 171 tube with about 160 volts on the plate, the average a.c. set is too noisy for pleasure although on other loud speakers the hum is inaudible. In other words, the a.c. tube either marks the limit of loud speaker development, or the newer and better loud speakers will force a.c. tubes to deliver signals unruffled by a.c. hum. We hope the latter, for the average loud speaker of to-day is less than five per cent. efficient, considering the entire audio band to be passed. Which prompts us to ask Mr. Burke, writing in the *General Radio Experimenter*, what he means when he states that most of the power delivered to a loud speaker by a power tube is transformed into sound waves and radiated. The average power radiated by man talking is about ten microwatts, and yet to get the same degree of loudness, we shove into the loud speaker 500 milliwatts of so-called undistorted power.

New Amateur Regulations

NEWSPAPERS credit the Radio Commission with following the advice of the A. R. R. L. in removing from the so-called 80-meter band the many amateur 'phone stations now existing, and opening up the 20-meter band for radiophone communication. In addition, the amateurs have from 1580 to 2000 kc. (150 to 190 meters) and a nice fat band between 56,000 and 64,000 kc. for communication by 'phone. This sounds fine until one realizes that the lower-frequency band has always been open for amateur 'phones—except when they caused disturbance to broadcast listeners, when they could not be operated until late at night—and the higher frequencies are in the so-called 5-meter band which is probably no good for code and worse for voice. The 80-meter band disturbed no B.C.L.'s, and was high enough up the wavelength scale that fairly good quality of speech could be transmitted.

But let us hasten to admit that we have had radiophone apparatus working in the Laboratory on as low as 3 meters and that with 20 watts input we were able to hear the ticking of a watch held near the microphone as far away as one mile. We didn't experiment over greater distances.

The new international regulations, probably in effect by 1929, narrow the so-called 40-meter band, but leave the other bands about as before. In this 40-meter band all of the amateurs of the world who once could be found from 30 to 50 meters will be shoved, and instead of listening for South America and South Africa on 27.5 to 33 meters and England and France above our American band, we may find them mixed up with 8's and 9's which are so numerous in this country. We shall be thankful for one thing when these new regulations go into effect—they will automatically remove from the amateur bands the many high-power commercial stations, such as FW in France and several in Germany, which clutter up amateur communications that seem futile to commercial interests, and yet which paved the way into a band that will in ten years carry the bulk of the world's communication.



Technical Radio Problems for Broadcasters and Others

QUESTION 1: What is usually wrong with a loud speaker of which it is said: "It sounds all right on music, but not as good on speech?" How may the characteristics of the monitoring loud speaker affect the output of a broadcasting station?

ANSWER: The fault in such a case is usually loss of the high frequencies, causing speech to sound muffled, and even unintelligible if the cut-off point is low enough. In reality the defect is equally present in musical reproduction, but most people are more sensitive to this particular defect in speech. A loud speaker which cuts off on the high end at about 3000 cycles will sound manifestly "tubby" on speech to almost any observer, but many listeners tolerate it readily for music, some even praising the result as "mellow."

The ideal condition for judging the quality of a broadcasting station would naturally be to have the apparatus, including the monitoring equipment, flat over the whole audio band, and to have the same condition hold for the receiving sets. The broadcast operators could then be assured that the listeners would hear everything just as it was heard at the station. Under existing conditions, with many types of receivers and loud speakers in use, the best course for the broadcasting station to follow is the same as if all the receivers were good. Its own monitoring equipment, including the loud speaker, should respond impartially over a band between, say, 100 and 5000 cycles. If the loud speaker at the station is "drummy," or "down" in high frequencies, the operators may tend to over-emphasize this portion of the band in microphone placing, equalization of lines, etc. If, on the contrary, the station loud speaker is "tinny," or relatively lacking in low notes, there may be a preponderance of bass in the station's output without the operators being aware of the fact. While such effects may benefit some listeners whose receiving apparatus requires acoustic correction, it will result in distorted reproduction in both the good receivers and those which have the opposite fault relative to the monitoring circuits at the transmitter. Thus the characteristics of the station loud speakers are often an important element in the fidelity of reproduction attained.

QUESTION 2: What amount of energy is required for effective loud speaker operation under the usual listening conditions?

ANSWER: A well designed cone loud speaker requires a telephonic level of plus 10 TU. This is roughly the maximum distortionless output of a tube of the 120 power type. Such a tube will deliver 110 milliwatts of undistorted output. On the basis of zero level equalling 10 milliwatts, and calculating from the formula for conversion from energy units into TU, which has been cited so often in this department that it need not be repeated, this corresponds to plus 10.4 TU. For broadcast transmitter monitoring it is preferable to use a tube affording more margin, say up to plus 15 TU (the 171 type or equivalent). On the other hand, if the loud speaker is improved in sensitivity 100 milliwatts of audio energy may be ample for its operation.

QUESTION 3: Why does a loud speaker sound "tinny" (lacking in bass tones) when the volume is decreased below the comfortable listening level?

ANSWER: The same effect occurs with natural sources of sound when the volume reaching the ear is decreased. The cause is found in the ear rather than in the source of sound. The ear is much more sensitive to relatively high-pitched sounds (say between 1000 and 4000 cycles) than to bass notes. For example, while the threshold of hearing in the favorable middle portion of the audio range, say at 1000 cycles, may be around minus 60 TU, at 100 cycles it may be no lower than minus 20 TU. When the volume is decreased the bass notes drop below the auditory threshold, so that the ear no longer responds to them, long before the treble disappears and all audition ceases. This phenomenon explains the effect observed. In some cases there may be contributing causes in the loud speaker mechanism.

Death Among the Broadcasters

TOO often we have had occasion, in this department, to discuss recent electrical fatalities among broadcast technicians and ways of avoiding such accidents in the future. It is admittedly impossible to render work with high-tension currents perfectly safe, and there will always remain an irreducible minimum of unavoidable mishaps. A transformer may break down without warning, admitting high voltage to a circuit where no one expects it, lightning surges may take place, psychological lapses sometimes upset the most carefully planned precautions. A fatal casualty in the last class occurred recently at the Daventry station of the British Broadcasting Company. The man killed was W. E. Miller, a Maintenance Engineer. The B. B. C. gives the following account in its announcement:

"Mr. Miller threw in a high-tension switch in connection with the apparatus at 5 GB and a few minutes later was observed to lean over a guard rail apparently with the object of making an adjustment which should not have been undertaken with the switch on."

The death of Mr. Miller is stated to be the first in the five years of operation of the B. B. C.

The question in such a case is whether mechanical precautions can be elaborated to a point where a man will be protected against his own temporary unawareness of danger. In other words, must a sharp distinction be made between accidents due to circuit breakdowns and the like, and psychological failures resulting in death or serious injury? Knowledge of circuits appears in some cases to be no protection at all. As I have pointed out in previous articles on the subjects, some of the men, or rather boys, working on broadcast transmitters are altogether too young for dangerous jobs, but older men, it must be admitted, are sometimes no more fortunate. What, then, can be done to establish safety by machinery?

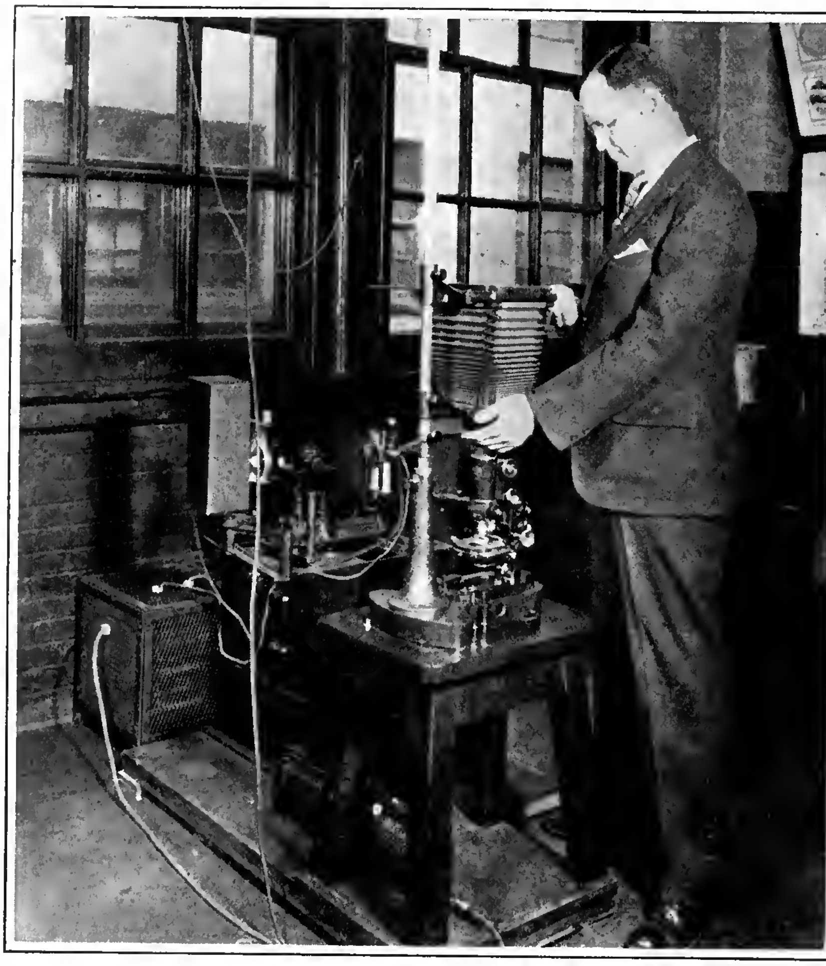
One device is to enclose all the high-voltage apparatus in a grounded cage with special doors. The doors may be opened by turning a wheel which cuts off the high tension inside the cage and grounds the plate circuits. The wheel cannot be turned back while the door is open. This comes close to being an absolute safeguard when only one man is involved. He cannot get into the dangerous portion of the station without cutting off the current. If another operator is involved, however, it may happen that one man is working on the apparatus while another, unaware of the fact, closes the door, locks it with the wheel, and burns up the operator inside the cage. A red tag system will obviate this, if it is faithfully followed—but where there is an "if," someone will get killed some day.

A similar device consists of circuit interrupters on doors in panels giving access to tubes from the front of the panel. When the door is opened, for replacement of a tube, or observation, the plate supply to that tube is cut off. But it is sometimes almost imperative to allow a man to observe the operation of the set, from a point behind the panel, while the circuits are energized. If that man starts to touch the equipment, he is on his way to the undertaker. Or, if he leans over a guard rail, as Mr. Miller did, he invites immediate death in the same way. Such a guard rail, it may be pointed out, has scarcely more than a symbolical value.

There are, in sum, two schools of design, working on opposite fundamental assumptions. One group contends that the best thing is to leave the high-tension circuits open and accustom the operators to keeping away from them. If they realize fully, it is argued, that only their own care stands between them and death, they will be careful. The other group carries out the design on the assumption that human beings are irremediably fallible and must be safeguarded by forethought operating through mechanical devices. Probably one system fits some men best while others are safer under the opposite scheme. But unfortunately we do not select personnel on the basis of temperament in such details, nor do we possess adequate psychological data which would enable us to control accidents by such means.

It is in this general direction that I would suggest study and thought. Personally I am not convinced of the superiority of either of the design systems outlined above. There is no doubt that much can be done with mechanical safety devices. One has only to consider the low ratio of accidents in a well conducted vacuum-tube factory to realize that. With highly dangerous potentials distributed through such a plant, and most of the workers on the forty-cents-an-hour level, it is possible practically to eliminate accidents by careful safety engineering and attention to orderly procedure and cleanliness. Nevertheless, with highly-trained technical personnel the margin of safety may be as great at the end of a hooked stick, even with the live parts of the set accessible, if a special effort is made to control the psychological factors. At army aviation fields the pilots are frequently under the scrutiny of surgeons who are expected to detect anomalies of sight and hearing, chronic fatigue, and emotional disorders in time to prevent avoidable accidents. The engineer in charge of a broadcast transmitter should watch his men in somewhat the same way. Usually he is in a position to know when anyone on the staff is in some personal difficulty which might interfere with his ability to keep out of danger. Psychiatrists can cite cases where men working in factories have injured themselves as a result of lack of normal coördination clearly traceable to domestic troubles and other emotional disturbances. In a broadcasting station the part of wisdom would be to detach a man in such a condition from transmitter duty and place him temporarily in the control room or wherever he would be safe.

But, aside from such acute cases, preventive measures of a psychological nature may also be applied at intervals. After the monthly resuscitation drill for members of the staff a discussion may be started on accidents which have occurred in the experience of the men, and how they might have been prevented. This will direct attention to the problem and may in a measure preclude the contemptuous familiarity with the apparatus into which technicians are apt to fall after nothing has happened for a period. There is no danger of making radio men morbidly conscious of such danger as exists. Their faults are in the opposite direction; they are not afraid enough. Yearly medical examinations, with special attention to the condition of the heart, are very desirable, in that a man with a sound heart who is caught on a high-tension circuit usually has a good chance for his life if he is released quickly, whereas a cardiac case is snuffed out in the first few seconds. To compel or allow men to work excessively long hours is plain criminality on the part of the employer.



HOW ULTRA-VIOLET RAYS AID PHOTOGRAPHY

Ultra-violet photomicrographic apparatus in use at the Bell Telephone Laboratories, New York. The lenses of the apparatus are of quartz and the ultra-violet rays are furnished from an arc light using rods of cadmium or magnesium instead of carbons. A system of quartz prisms, in front of the lamp house, permits the operator to "tune-in" on one particular frequency of the invisible rays

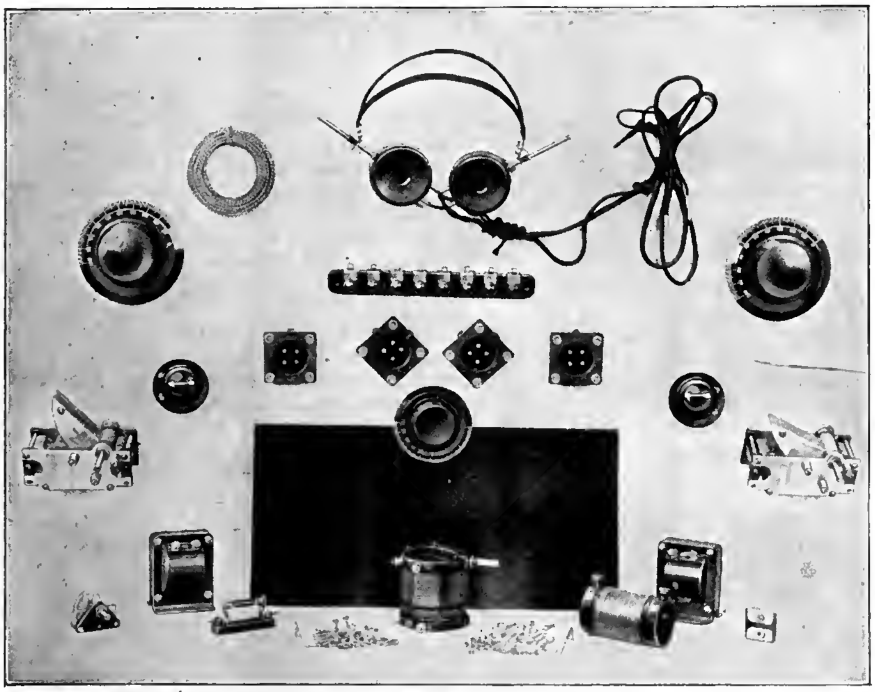
Antennas from 1913 to 1927

BACK in 1913, when I was just getting out of preparatory school, the Marconi Company was engaged in erecting a series of transmitting and receiving stations for transoceanic communication. The receiving stations on the Atlantic seaboard were located at Chatham, Massachusetts, and Belmar, New Jersey. At each of these points the placid skyline of the countryside was broken by a string of four-hundred foot iron masts, mounted on cement emplacements, and guyed to anchorages in the surrounding fields. Much money went into those hollow masts—and never came out again. Within a year the development of the vacuum tube had reached a point where an amplifier, fed from an antenna of moderate height, would produce as readable a signal from over the ocean as the mile-long antenna strung on four-hundred foo masts. The four-hundred footers were take down and stored away. When, four years late I viewed the cement blocks still set in the eart I reflected with amusement that the engineer of the Marconi Company had been bad proph ets, and, with the superficial confidence of young man, I probably thought I could hav done better had I stood in their shoes whe the decision was to be made.

In 1923, ten years after that die was cast, left the Riverhead transatlantic receiving sta tion of the Radio Corporation of America, hav ing served my time as a re ceiving engineer. The wav antenna at Riverhead, type developed by Harol H. Beverage, stretched t the southwest over miles o Long Island sand, throug forests of scrub pine, an oak, almost to the sea. I did its stretching on thirty foot telephone poles. It wa a good antenna, one whic was kind to European sig nals and not at all kind t the static which came fro the opposite direction. Man more such antennas hav been built since that time on the same sort of poles When I left Riverhead, ha anyone told me that trans oceanic receiving antenna would ever be built other wise, I should have ex pressed polite doubts. Ha my informant added tha steel towers would rise i Riverhead almost as hig as the Marconi masts a Belmar, before I returne to the town, I should hav expressed doubts not nearl as polite. Had he state finally that there would be five of them, with ninety-foot cross arms at the top, I should have taken him, I am afraid, for a harmless lunatic whose aberration led him to imagine towers instead of the more usual pink elephants or snakes.

Another four and one-half years flit past. The short-wave explorations of the ether (if you care to assume one) begin, and soon reach formidable portions. A short-wave receiving system is developed in which vertical antenna wires hang from steel crossarms which, curiously, are supported by steel towers three hundred feet high, while at the other ends of the crossarms reflector wires sweep gracefully to the earth. The wave antennas are still at Riverhead, combined and phased for even greater efficiency, and even more inconspicuous, for five of the three-hundred foot towers have come to keep them company. The fact that none of us expected them did not keep them from coming. They obeyed a different sort of logic than that which ground out conclusions in our brains. They followed the innate logic of invisible oscillations propagated through space and the laws of the materials which men use in communicating over the distances separating one continent from another. And so, for the moment, they stand proudly over the scrub pine woods.

LEARN RADIO and find



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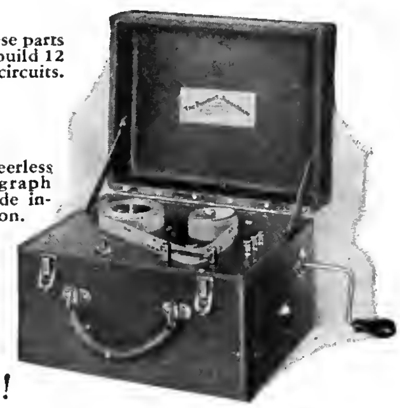

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The *Radio Broadcast* LABORATORY INFORMATION SHEETS

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. In July, 1927, an index to all Sheets appearing up to that time was printed.

All of the 1926 issues of RADIO BROADCAST are out of print. A complete set of Sheets, Nos. 1 to 88, can be secured from the Circulation Department, Doubleday, Doran & Company, Inc., 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 occur, a new Laboratory Sheet with the old number will appear.

—THE EDITOR.

No. 161 RADIO BROADCAST Laboratory Information Sheet February, 1928

Comparing the 112, 171, and 210 Type Tubes

THEIR RESPECTIVE OUTPUTS

ON LABORATORY SHEET No. 162 are shown three curves that indicate an interesting relation between the three most common types of power tubes, *i.e.*, the 112, 171, and 210 types. The curves indicate the relation between the power output of the tubes and the value of the signal voltage impressed on the grid. The plate impedance and amplification constants of the 112 and 210 type tubes are practically identical and, therefore, the curves for these two tubes coincide from zero up to that point corresponding to the maximum output power of the 112, which is approximately 195 milliwatts, or 0.195 watts.

If a vertical line is drawn at any point on the curve, for example, at A, the points at which this line crosses the various curves will indicate the power output obtained from the particular tube associated with the curve being examined. In this particular case, line A, drawn at the point corresponding to a signal voltage on the grid of 15 volts indicates that, with this value of signal voltage, the power output of a 210 tube with 425 volts on the plate is approximately 0.34 watts. The power output of a 171 at the same point is approximately 0.1 watts. The maximum grid voltage that can be impressed on a 112 without resultant output distortion is about 10.5 volts and, therefore, a 112 tube cannot be used if the signal input voltage is greater than this value. At B we have drawn another line corresponding to a signal on the grid of 8 volts. Here we find that the power output of a 112 is approximately 0.1 watts and the power output of a 171 about 0.04 watts. It is therefore evident that at low values of input voltage a 112 tube is capable of putting more power into the loud speaker than is a 171. If the signal voltage, however, is in excess of 10½ volts, the 112 cannot be used and the choice then lies between the 210 and the 171. The curves indicate that the 210 will give much more power output than a 171 but it should be realized that much greater plate voltages are necessary on the 210 than on the 171. With 180 volts on the plate the 171 can deliver approximately 740 milliwatts of power, but 250 volts on the plate of the 210 will only permit this tube to handle signal voltages up to 18 volts and the maximum output power will be only 460 milliwatts. From these data the following conclusions can be arrived at:

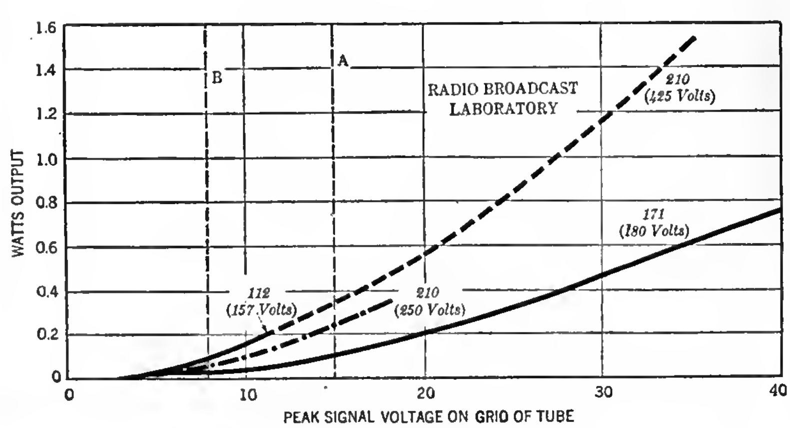
(1.) For input signals on the grid of the power tube of 10 volts or less the 112 tube will deliver the most power to the loud speaker.

(2.) When more power output is required and only moderate plate voltages are available (not in excess of 200 volts) a 171 is capable of giving greater output than can be obtained from a 210 under similar conditions of plate voltage.

(3.) Where high plate voltages around 400 volts are available the 210 should be used and under the same input signal it will give approximately 2½ times as much power as can be obtained from a 171.

No. 162 RADIO BROADCAST Laboratory Information Sheet February, 1928

112, 171, and 210 Tube Curves



These curves indicate how the power output of the 112, 171, and 210 type tubes varies with different values of signal voltage on the grid of the tube. The significance of these curves is explained in detail on Laboratory Sheet No. 161.

No. 163 RADIO BROADCAST Laboratory Information Sheet February, 1928

Testing Receivers

USING THE MODULATED OSCILLATOR

THE accurate determination of the characteristics of a radio receiver requires a careful laboratory test, but it is possible to construct comparatively simple apparatus of much practical value for the testing and repairing of receivers. The instrument that will enable us to make such tests is the modulated-oscillator. From a modulated oscillator we can obtain an audio-frequency tone which can be fed into the input of the audio amplifier in a radio receiver and the functioning of the audio amplifier thus checked, or by turning on both r.f. and a.f. oscillators we can obtain a modulated wave which can be used to test both the r.f. and a.f. circuits.

The circuit diagram of a modulated-oscillator will be found on Laboratory Sheet No. 164. The following paragraphs will explain how to use the instrument for testing receivers.

(1.) Audio Amplifiers

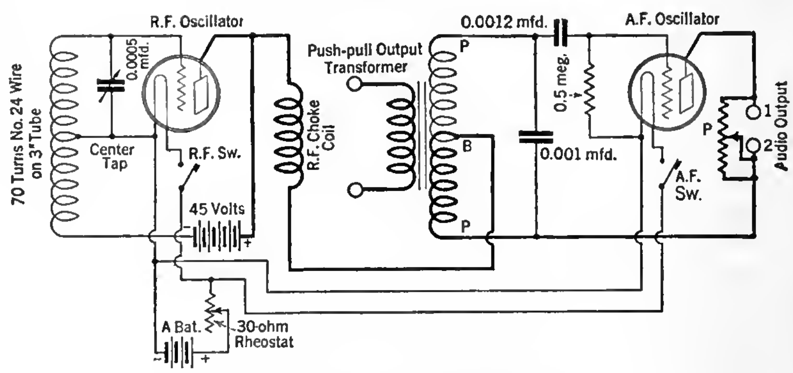
Place all the tubes in and connect all the batteries to the amplifier. Do not place the detector tube in its socket. Connect the plate terminal of the detector tube socket to audio output terminal No. 1 on the modulated oscillator. Connect both the B + detector lead on this receiver and terminal No. 2 on the modulated oscillator to B — on the receiver. Turn on the receiver and audio circuit of the modulated oscillator and adjust potentiometer P to give an output of medium intensity from a loud speaker connected to the output of the audio amplifier. A defect in the amplifier is indicated if the output is low or distorted or both.

(2.) Radio-Frequency Amplifiers.

A test of the r.f. amplifier of a receiver is accomplished by first placing all the tubes in the receiver and connecting all the batteries, and then winding about two turns of insulated wire around the coil on the oscillator, connecting the other end of this wire to the antenna post on the receiver. The oscillator should be located about ten feet away from the receiver. If the a.f. and r.f. tubes in the modulated oscillator are turned on and the receiver's tuning circuits adjusted to resonance, an audio-frequency tone should be audible in the output. Since the a.f. amplifier in the receiver was tested previously, any defect in the operation of the receiver must be located in the r.f. amplifier or detector circuit.

No. 164 RADIO BROADCAST Laboratory Information Sheet February, 1928

A Modulated-Oscillator



All the constants of the apparatus used in the instrument are given on the diagram. Some information on the use of this instrument will be found on Laboratory Sheet No. 163. The frequency of the audio-frequency oscillations can be varied by using various values of capacity across the push-pull transformer.

No. 165 RADIO BROADCAST Laboratory Information Sheet February, 1928

Audio Amplification

GENERAL CONSIDERATIONS

AN AUDIO system can be considered satisfactory if it amplifies the signals impressed on its input sufficiently to operate adequately a loud speaker and does so without distorting the signals to an extent sufficient to become apparent in the output of the loud speaker. Such performance can only be realized when the amplifier has been correctly designed and is operated properly.

The overall frequency characteristic of an amplifier is frequently quite dissimilar to the characteristic of a single stage. This is especially true of transformer- or impedance-coupled amplifiers and is probably due, in most cases, to coupling in the plate supply. Regenerative effects are thereby introduced into the circuit, which may produce considerable changes in the frequency characteristic of the audio system. Such effects are also present, at times, in resistance-coupled amplifiers and generally cause such an amplifier to "motor-boat."

The solution of such difficulties is either to design the amplifier so that with the regenerative effect present the system has a flat characteristic or to design two units to have a flat characteristic and then arrange the circuit so carefully that regenerative effects will not be present. This necessitates feeding all the grid and plate circuits through resistances or choke coils and bypassing all the circuits with condensers.

Some recent audio transformers are designed to have a fairly sharp cut-off at about 5000 cycles to reduce the effect of various extraneous sounds, such as tube noise, high-frequency heterodyne whistles, etc., which are composed mostly of frequencies above 5000 cycles. Frequencies above this value add little to the quality of the speech or music and can therefore be eliminated without introducing noticeable distortion. It is doubtful whether the majority of broadcasting stations themselves transmit notes of more than 5000 cycles in frequency.

Also many amplifiers have a tendency to oscillate at very high audio frequencies and sometimes at supersonic frequencies. If the amplifier is designed, however, to give little or no amplification to frequencies much above 5000 cycles, this tendency of the amplifier to oscillate will be nullified.

Sovereign A C

HEATER TYPE

STANDARD SOCKET

TUBE

More "Pep"

With Sovereign A. C. Tubes

In addition to freedom from all bother with "A" Batteries or "A" Battery Eliminators—freedom from hum—noise -microphonics—Sovereign A-C Tubes will make your set seemingly 100% more powerful. The music will roll in full, rich, clear-toned.

Write for treatise on how to convert your set to A-C power. No obligation.

Sovereign Electric & Mfg. Co.
127 N. Sangamon St., Chicago, Ill.

Don't burn out your Loudspeaker!

make it more responsive to weak signals—IMPROVE TONE QUALITY—eliminate tube noises.

THE Sterling Power Output Transformer connected between the radio set and loudspeaker absolutely prevents the high voltages now delivered by "B" Power Units from ruining the speaker. This transformer is more than a protective device. It permits closer adjustment of speaker diaphragm, increasing its sensibility to weak signals. Prevents shock when using headphones. Eliminates tube noises and IMPROVES TONE QUALITY of the speaker. Attach in two minutes, leave permanently connected, Model R-360—$5.00.

Sterling

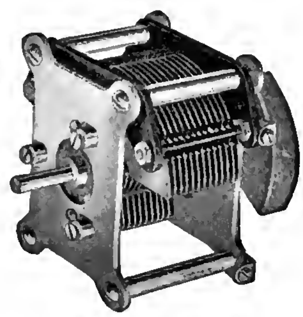
POWER OUTPUT TRANSFORMER

THE STERLING MFG. COMPANY
2831 Prospect Avenue, Cleveland, Ohio

General Radio

Quality Apparatus

THE apparatus manufactured by the General Radio Company is the result of careful engineering design. Every Laboratory instrument and part is guaranteed, and in many cases they represent the result of years of development work and investigation in the General Radio laboratories. It has been the aim of this Company to contribute only quality instruments to the radio and electrical industry.



Type 334 Condenser

Low loss condenser design has received much attention and the General Radio Company was the first concern in this country to supply such condensers commercially. The Type 334 Variable Condensers illustrated are of the grounded rotor type and soldered plate construction.

Type 334-F 500 MMF Panel mounting without gear $4.25

Type 334-H 500 MMF Panel mounting with gear $5.25

Type 334-N 350 MMF Panel mounting without gear $4.00

Type 334-P 350 MMF Panel mounting with gear $5.00

Type 334-K 250 MMF Panel mounting without gear $3.75

Type 334-M 250 MMF Panel mounting with gear $4.75

Type 445 Plate Supply and Grid Bias Unit

The General Radio Type 445 Plate Supply has been designed to meet the demand for a thoroughly dependable light socket "B" Power unit. The current output is sufficiently high to permit its use where the current drain is unusually large. Through the use of a wire wound voltage divider, equipped with movable clamps, any combination of voltages from 0–180 may be obtained. An adjustable grid bias voltage from 0–50 is also available for use on the power tube of the amplifier.

The Type 445 Plate Supply is designed for use on 105 to 125 volt A.C. lines (50-60 cycles) and uses the UX 280 or CX 380 rectifier tube. This unit is licensed by the Radio Corporation of America for Radio amateur, experimental, and broadcast reception only, and under the terms of the R.C.A. license the unit may be sold only with tube.

Type 445 Plate Supply and grid bias unit $55.00
UX-280 or CX-380 Rectifier tube . . . 5.00

Write for Bulletin No. 929 describing our complete line of Quality Apparatus

General Radio Co., Cambridge, Mass.

No. 166 — RADIO BROADCAST Laboratory Information Sheet — February, 1928

Acoustics

DAMPING AND REVERBERATION

THE quality of reproduction from any loud speaker depends to a considerable extent upon the room in which it is used and upon the room's furnishings. The reason why the room and its furnishings influence the output of the sound generator, whether it be a piano, phonograph, or a loud speaker, is not difficult to understand, and will be explained briefly here.

In an average room the sounds from a piano, for example, are somewhat damped by the hangings, carpets, furniture, etc., so that they decrease to inaudibility quite rapidly. When the furniture, rugs, etc., are removed and the piano is permitted to stand on the bare boards, the sounds from it will be prolonged and the music will become jumbled, especially when playing forte. This effect is due to the absence of the furniture, which normally acts as a damping agent, and also due to the fact that the piano is resting directly on the floor so that the latter acts to increase the effective area of the sound board. The sounds produced by the piano when it is in direct contact with the floor will be somewhat louder than usual, indicating increased efficiency.

Under any given room conditions the rate at which a sound dies away is the same whether the sound at its beginning is loud or soft. However, the time taken for the sound to become inaudible depends upon the loudness of the original sound and, of course, the louder the sound, the longer it will take to decrease in volume to a point where it is inaudible. In a room containing furnishings that cause considerable damping, we may, therefore, play much louder than in an unfurnished room without causing any excessive blurring.

A room can be too completely damped, when the playing will sound "dead." A certain amount of blurring or intermingling of succeeding chords is considered good, for it adds coloration to the music.

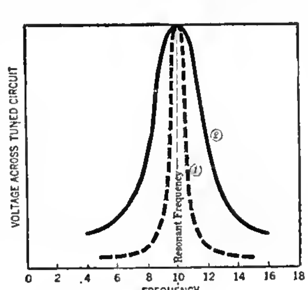
The importance of these matters in relation to the design of the studios in broadcasting stations is evident. The correct amount of damping must be obtained to prevent deadening the music (too much damping) or to obviate difficulties due to reverberation (too little damping.)

No. 167 — RADIO BROADCAST Laboratory Information Sheet — February, 1928

Resonant Circuits

GAIN AND SELECTIVITY

THE current at resonance in a tuned circuit is equal to the voltage induced in the circuit divided by the total resistance of the circuit. The actual capacity of the condenser or the inductance of the coil used in the circuit do not enter into the calculation once the induced voltage and the resistance are known. The voltage across the coil in the circuit is equal to a constant times the current times the inductance of the coil and, the voltage is, therefore, larger the greater the inductance of the coil. Since a vacuum tube is a voltage rather than a current operated device, it might appear that best results, *i.e.*, greatest amplification, would be obtained by making the coil very large. When we increase the inductance of a coil by adding to the number of turns, however, we also increase the resistance and the increase in resistance nullifies to some extent the advantage gained through the use of a larger coil.



The selectivity of a tuned stage in a receiver depends upon the series resistance of the circuit; with low-resistance circuits the selectivity is good while with high-resistance circuits the selectivity is poor. The curves on this Sheet indicate the effect of resistance in the tuned circuit. Curve 1 shows the characteristic of a very low-resistance tuned circuit and curve 2 a comparatively high-resistance circuit. Since practically all of the resistance in a tuned circuit is in the coil, it follows that carefully constructed, fairly "low-loss" coils should be used in a radio-frequency circuit. A coil can be made so good as to cut "side-bands," however, and thereby distort the received signal head-band suppression results in the loss of the high audio frequencies in the modulated wave.

If the ratio of the inductive reactance of the coil (6.28 times the frequency times the inductance of the coil) to the radio-frequency resistance of the coil at the same frequency is made much more than 250, distortion of the "side-bands" results.

No. 168 — RADIO BROADCAST Laboratory Information Sheet — February, 1928

The Ear

ITS CHARACTERISTICS

THE characteristics of the human ear have been determined and investigated by many different scientists, and some of these characteristics are given below:

(a.) There is a minimum sound intensity below which the ear cannot detect any sounds. A curve was published on Laboratory Sheet No. 109, indicating how this minimum audible intensity varied with frequency.

(b.) There is a maximum intensity of sound above which the auditory sensation is one of pain rather than sound. The intensity and its variation with frequency was also explained on Lab Sheet No. 109.

(c.) There is a lower limit of the pitch of a sound below which the ear will not respond. This lower limit is about 20 cycles.

(d.) There is an upper limit to the pitch of a sound above which the ear will not respond. The upper limit is about 20,000 cycles.

(e.) The ear can distinguish between about 300,000 separate sensations of sound.

(f.) The ear can respond to pressure changes between the pressure required to produce a minimum audible sound and a pressure 100 million times greater. These two pressures correspond to an energy ratio of 10,000 trillion.

(g.) The ear can distinguish between the loudness of various sounds. At low levels of sound intensity a change of about 25 per cent. is necessary to be distinguishable. At greater intensities a change of 10 per cent. in loudness is detectable by the ear.

(h.) The ear can distinguish between the pitch of various sounds. At medium frequencies a change in frequency of about 0.3 per cent. can be detected; at low frequencies a change of about 1 per cent. is necessary.

A knowledge of these characteristics is useful to the student interested in problems of sound reproduction.

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 328. 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.

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.

7. TRANSFORMER AND CHOKE-COUPLED AMPLIFICATION—Circuit diagrams and discussion. ALL-AMERICAN RADIO CORPORATION.

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 construction. 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.

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.

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.

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.

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. WHY RADIO IS BETTER WITH BATTERY POWER—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.

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-milliampere 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.

(Continued on page 328)

"RADIO BROADCAST'S" DIRECTORY OF MANUFACTURED RECEIVERS

¶ A coupon will be found on page 331. 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 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. 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. Milliammeter 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, 23¾ x 12¼ x 15 inches; No. 90, 37¼ 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 60¼ 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. 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. 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, $2.50

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: 17¾ x 5¾ x 7¾ 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. 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 7⅛ 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. 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. 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: 25⁹⁄₁₆ x 7¾ x 8½. Price: $130 without accessories.

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. 522. CASE, 62B AND 62C

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 62B, 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. 542. PFANSTIEHL JUNIOR SIX

Six tubes: 3 t. r. f. (01-A), detector (01-A), 2 audio. Pfanstiehl circuit. Volume control: variable resistance in r. f. plate circuit. One dial. Shielded. Battery cable. C-battery connections. Etched bronze panel. Antenna: outdoor. Cabinet size: 9 x 20 x 8 inches. Price: $80, without accessories.

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 15mA. Volume control: potentiometer. Cabinet sizes: table, 20 x 8¾ 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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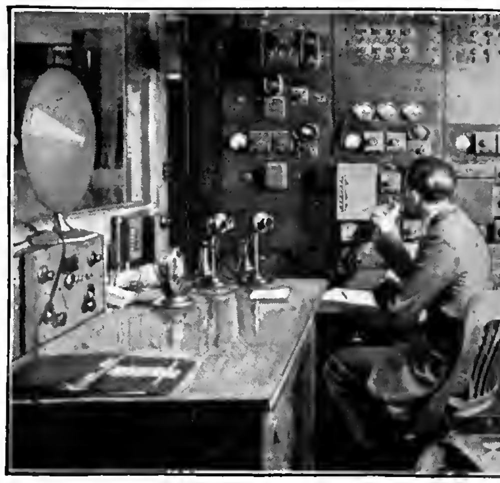

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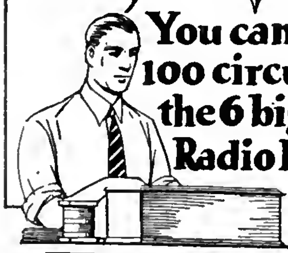

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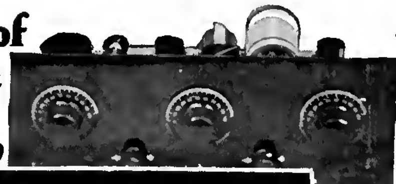

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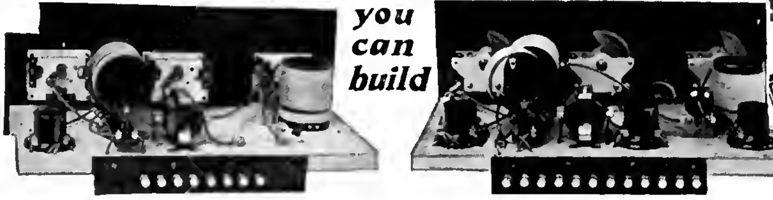

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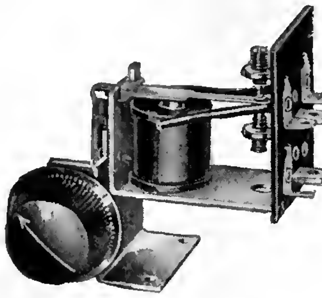

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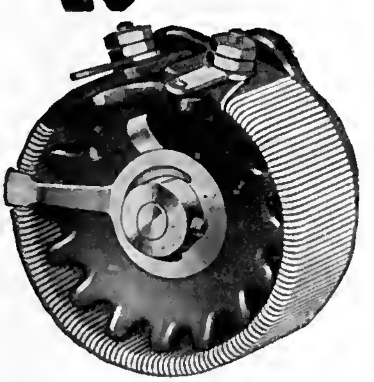

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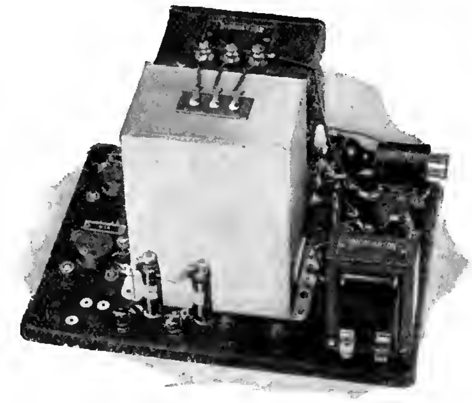

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RADIO BROADCAST

MARCH, 1928

WILLIS KINGSLEY WING, Editor
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Vol. XII, No. 5

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The contents of this magazine is indexed in *The Readers' Guide to Periodical Literature*, which is on file at all public libraries.

AMONG OTHER THINGS. . .

THE many radio experimenters who are looking forward to a college course to lead them farther in their chosen field will find this month's leading article, by Carl Dreher, of considerable value. Mr. Dreher's story on radio instruction in colleges and universities is not exhaustive and there are many other colleges which have courses of value to the student who plans eventually to go into radio work. The article does, however, answer many of the general questions most frequently asked us in correspondence.

THIS issue contains a great deal of interesting material for the experimenter and home constructor as well as some pages of especial importance to the many who are connected with the business of selling radio apparatus. The description of the Crosley "Bandbox" receiver is one example; Sylvan Harris' article describing the Stewart Warner receiver is another. The interesting illustrations in the full pages of radio set and accessory pictures form a useful guide to interesting new products. The description of the a.c. Browning-Drake set shows this popular tuning unit combined with an excellent amplifier unit working on the push-pull principle. Thus far, we have described the Samson push-pull amplifier and B-supply, the Thordarson push-pull amplifier and B-supply; and in this issue reference is made to the AmerTran push-pull amplifier. Each of these devices will give the user excellent audio quality when combined with a good loud speaker. The Knapp A-Power unit, described on page 350, should appeal to many home-constructors because of its performance and price. And on page 355 and following, a remarkably inexpensive screened-grid receiver is discussed.

FOR those who like to discuss the design and performance of amplifiers, the leading article in our technical editorial section, "Strays from the Laboratory," will provide plenty of material for discussion. Keith Henney, who writes this department, will be pleased to hear from those of our readers who have ideas on the matter. On page 352, the average characteristics of the 226 and 227 type tubes are presented.

READERS who are interested in receiving additional information from the makers of the Cooley Rayfoto apparatus may send their names to the undersigned who will forward them. The April RADIO BROADCAST will contain a long-awaited article on the RADIO BROADCAST "Lab" circuit, a description of an interesting short-wave phone and code transmitter, and a wealth of other interesting constructional material.

THE Laboratory Data Sheets, which have been one of the most popular features of RADIO BROADCAST since they first appeared in our June, 1926, issue, are the work of Howard E. Rhodes of the technical staff of RADIO BROADCAST Laboratory. Of necessity they cannot be signed, but so many have written us in complimentary terms of them that we feel that the many readers who have expressed interest in this regular feature should know to whom they are due. The first eighty eight Data Sheets, by the way, are available in bound form from the Circulation Department of Doubleday, Doran and Company, Inc., and sell for one dollar.

—WILLIS KINGSLEY WING.

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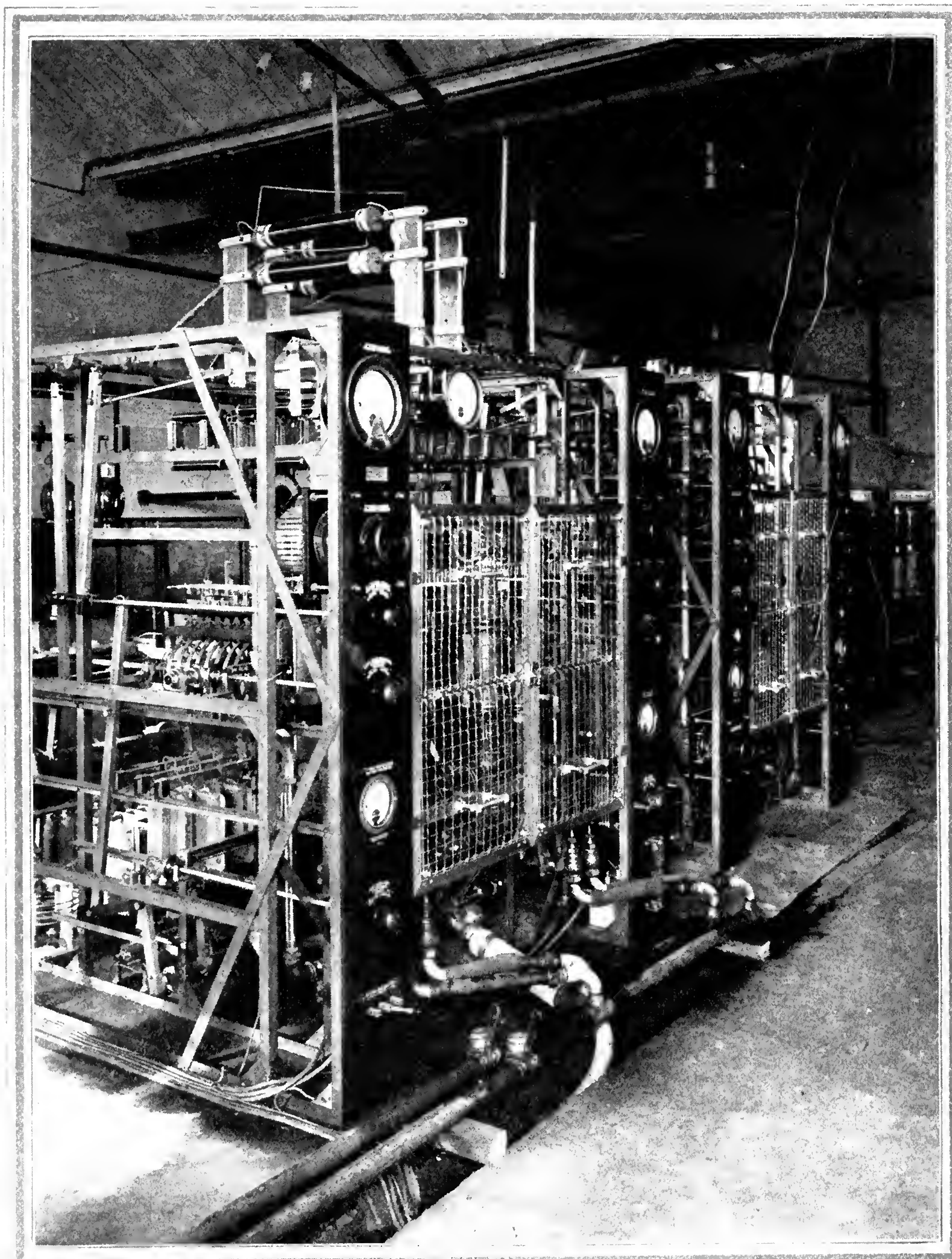


A Short-Wave Transmitter for Imperial Broadcasting

ANIMATED by the success of other European countries in this field, the British Broadcasting Corporation finally permitted itself to fall victim to short-wave broadcasting. The purpose of 5 SW is to unite the radio audiences of the far-flung corners of the British Empire, and reports so far received would indicate that quite a large degree of success is being met with in this effort. The wavelength of 5 SW is 24 meters (12,500 kc.) and it may be heard well in this country. With the exception of Saturdays and Sundays (when the schedule is irregular), 5 SW broadcasts daily from 7:30 to 8:30 A. M. E. S. T., and from 2:00 to 7:00 P. M. E. S. T. The power is 20 kw. The transmitter is at present erected in the experimental laboratories of the Marconi Company at Chelmsford, some thirty miles from London. The apparatus consists of two panels of a Marconi short-wave beam transmitter (shown in the foreground) with the addition of three modulating panels, which may be discerned faintly in the background

WHERE ELECTRIC COMMUNICATION ENGINEERING MAY BE STUDIED

Students at work in the Cruft Memorial Laboratory, Harvard University. Professor G. W. Pierce is Rumford professor of physics there. In the article below he tells what courses are available at Harvard for the radio man

University Offerings in Radio Education

By Carl Dreher

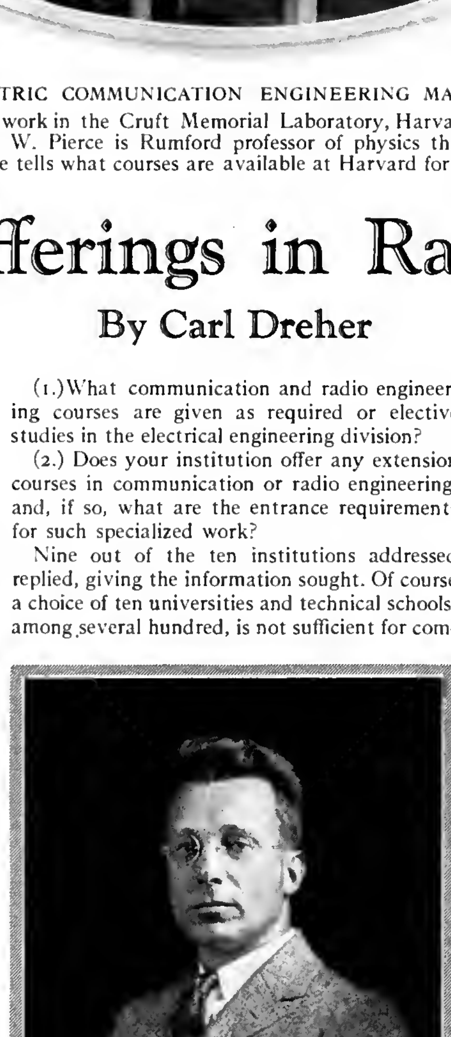
NOT infrequently readers address this magazine with questions regarding university training in radio. They are interested in such matters as entrance requirements at various institutions, courses offered, prerequisites, and the practical value of the training available. As a rule the questions come, not from the usual group from which college students are drawn, but from young men who feel the need for adding to their knowledge but lack formal preparation. Secondary school graduates, and those who have been fortunate in securing college preparatory education at the usual age, generally are familiar with the educational system beyond this point, but many others have only the vaguest ideas about the procedure of technical study in institutions. They imagine, in some cases, that all universities admit students to certain courses of interest to them, regardless of aptitude or previous training on the part of the student. Actually there is a wide range of flexibility among technical colleges, some offering a wealth of extension courses, with little scrutiny of the applicant's credentials, while others have rigid entrance qualifications, no extension courses, and, in a number of instances, no electives and no variations in the curriculum. The relation of radio engineering to the more fundamental divisions of technology is also frequently misapprehended, the importance of radio being naturally exaggerated in the minds of some of its devotees. All this has made it appear worth while to conduct an inquiry into the subject of university training in radio communication, with a view to supplying information regarding conditions in representative institutions, and also to make clear the relation of university training in radio to other forms of study of the subject.

Letters were written to the professors of Electrical Engineering at ten institutions, with requests for answers to the following questions:

(1.) What communication and radio engineering courses are given as required or elective studies in the electrical engineering division?

(2.) Does your institution offer any extension courses in communication or radio engineering, and, if so, what are the entrance requirements for such specialized work?

Nine out of the ten institutions addressed replied, giving the information sought. Of course a choice of ten universities and technical schools, among several hundred, is not sufficient for comprehensive conclusions, but it does serve to show the general trend of higher education in radio. Colleges known to be interested in the radio field were rather favored, although not exclusively, and there was some attempt at territorial distribution.



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J. H. MORECROFT

Professor of Electrical Engineering, Columbia University, New York City: "I do not recommend that a man specialize too much while he is at college"

The answer of Prof. J. H. Morecroft at Columbia University is well worth quoting, inasmuch as it represents one reasoned policy in higher technical education:

"Both Professor Slichter and I have always felt that it is extremely foolish for a young man to specialize on a specific branch of engineering work before he is well aware of his aptitude and of the opportunities awaiting him in any special field, and naturally the courses at Columbia are laid out in accordance with this idea.

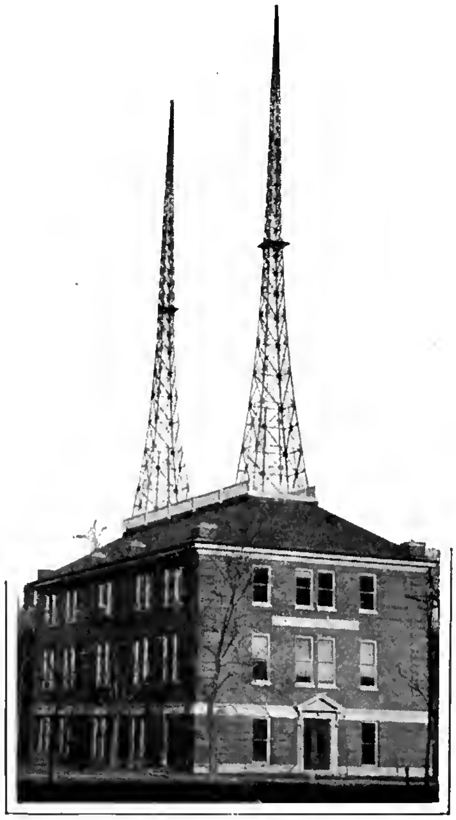
"The very large companies which are always ready to take any men whom we regard as well fitted for research work have this same idea with regard to specialization. Our largest communication company, for example, does not desire to have men trained in specialized communication theory and practice. Their representatives have always expressed to me their desire for men who are trained rather in the general fields of science and engineering than those who have attempted to specialize in some certain phase of the work.

"Whereas the fundamental principles of communication, including radio, are given to all of our electrical engineering students, there is no special arrangement of courses for those who might desire to specialize in radio. In the senior year the electrical engineering students at Columbia are allowed to take more than half of their work from a list of elective subjects and at this time of course a man desiring to do so can pick out most of his work in the communication field.

"I myself do not recognize radio engineering as being apart from telephone engineering or other similar types and do not recommend that a man specialize too much while he is at college. When he starts to work he will have to specialize to earn his living and will get but little opportunity to carry on studies outside of those required by his daily tasks, so that it seems foolish for him to give up the opportunity for broad training while at college."

These views of Professor Morecroft's are an authoritative statement of what might be called the broad-training policy in engineering education, which in my own opinion, is the best thing for those who fortunately have the time and money to take advantage of it. Columbia does, however, offer an extension course, "Electrical Engineering e9-10-Radio Communication," which "is not intended for those who are already familiar with radio theory and practice but rather for those who have had no training in this particular field, and is so designed that anyone who has had the equivalent of an ordinary high school course will be able to do the work satisfactorily." The class meets twice a week for an aggregate of three hours. The admission requirements for Columbia University Extension students are very elastic. For "mature students whose chief interest lies outside the University and who have leisure to pursue only a few courses in the late afternoon or at night . . . the sole condition is that they show their ability to pursue the work with profit." In practice this amounts to satisfying the instructor or a supervising professor that one has some background in the subject and an earnest desire to learn more of it. In past years Columbia has given some excellent advanced extension courses in vacuum-tube theory and other branches.

Professor Morecroft is one of the most prominent of American radio engineers, and a past president of the Institute of Radio Engineers. Dr. G. W. Pierce likewise ranks among the highest radio technicians, and is similarly a past president of the Institute. Nevertheless Harvard University, where Professor Pierce is Rumford Professor of Physics and Director of the Cruft Memorial Laboratory, pursues a policy differing from that of Columbia, in that Harvard offers a "Programme of Study in Electric Communication Engineering," and confers the degree of "Bachelor of Science in Communication Engineering" upon candidates who complete the four-year course satisfactorily. The course is substantially one in electrical engineering, with specialization beginning in the third year. Of the eight courses listed in that year four are radio, or, broadly, communication subjects ("Electric Oscillations and Their Application to Radiotelegraphy and Radiotelephony; Electric Oscillations, Electric Waves, and Radio-Frequency Measurements; Electron Tubes—Amplifiers, Detectors, and Oscillators; Electron Tubes, Advanced Course"). The other courses in the third year are in electrical engineering and mathematics. In the fourth year there are five communication subjects and four courses in electrical engineering.



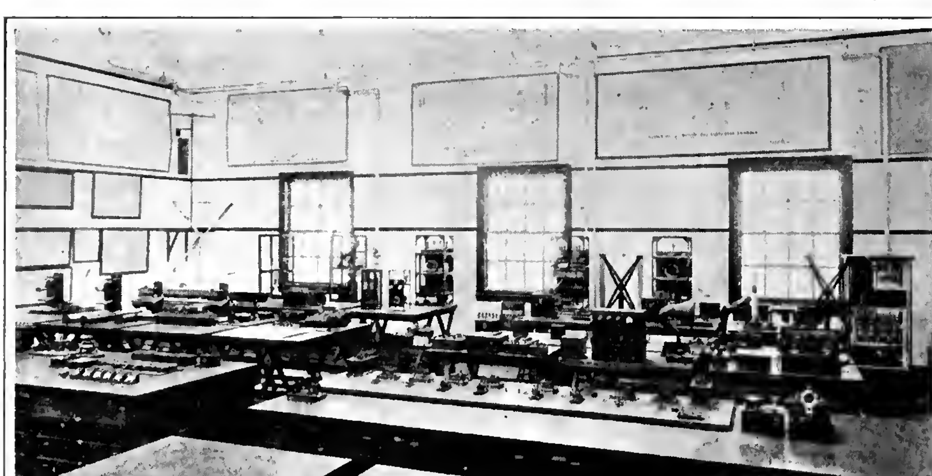
AT HARVARD UNIVERSITY
The Cruft Memorial Laboratory

Harvard University also offers work in communication engineering to graduate students and on occasion confers the degrees of "Master of Science" and "Doctor of Science in Communication Engineering." The admission requirements in all cases are high. In the case of the four-year course leading to the bachelor's degree the entrance requirements are the same as for admittance to the Freshman Class of Harvard College, the academic elements being substantially those provided by a first-class high school or preparatory training.

The Massachusetts Institute of Technology answered the questionnaire through Prof. Edward L. Bowles. In the regular electrical engineering course intended for students who seek training in electrical power engineering, two optional one-term courses, "Principles of Radio Communication" and "Principles of Wire Communication," are available. Students who desire to specialize in electrical communication, after taking the regular E. E. course for two years, may register for the "Electrical Communication Option" at the beginning of the junior year. This option "embraces work covering wire telephony, carrier telephony and radio telephony, also wire telegraphy, carrier telegraphy, and radio telegraphy. The properties and engineering applications of electron tubes are also included." During the third year only one specific communication course, "Electrical Communications, Principles," appears, but there are other modifications in the work, such as the addition of a course in vector analysis, the omission of a course in heat engineering which appears in the regular E. E. outline, etc. In the fourth year there is marked specialization in communication and electro-magnetic theory. Incidentally, a one-term Senior course in "Sound, Speech, and Audition" is included. The degree is that of "Bachelor of Science." M. I. T. also offers a number of limited-attendance five-year "co-operative courses in electrical engineering" which, for the first two years, are the same as the regular E. E. course, while for the last three years, the student's time is equally divided between instruction at the Institute and work in industrial plants. "Option 3," in Communications, is arranged in co-operation with the Bell Telephone Laboratories in New York City. These co-operative courses lead to the degree of "Bachelor of Science" after four years, and "Master of Science" after five years. Admission to the Institute is by examination. There are no extension courses.

At Stevens Institute, Hoboken, N. J., where the Department of Electrical Engineering is headed by Prof. Frank C. Stockwell, succeeding no less a radio man than L. A. Hazeltine, no special attention is paid to communication training. Stevens offers only a single course, leading to the degree of "Mechanical Engineer," and has no electives in any engineering subject. Extension courses are unknown, nor does Stevens accommodate special students. However, as part of the regular work in electrical engineering, a certain amount of radio engineering is prescribed for all students, including laboratory exercises and class room practice.

Undergraduate students at Rensselaer Polytechnic Institute, working for their E. E. degrees, after the usual grounding in mathematics and physics, followed by general electrical engineering courses, receive a communication engineering course in the last seven weeks of the senior year. The following subjects are presented



A WELL-EQUIPPED LABORATORY
A view of the electrical-engineering laboratory of the Rennsselaer Polytechnic Institute, Troy, New York. R. P. I. offers special and graduate work in communfcation to qualified students

in the order named: "Telephone transmitters; telephone receivers; transformation of medium-frequency alternating currents and electromotive forces; resistance, inductance, and capacitance in medium-frequency alternating-current circuits; distribution of current and electromotive force over telephone lines; electrical filters, transmission line impedance, and equivalent networks; fundamental telephone and telegraph circuits; telephone transmission and its measurement; telephone and telegraph systems and telephone service; vacuum tubes and their application; telephone repeaters and public address systems; multiplex or carrier current telephony; radio telephony and telegraphy; interference and cross-talk."

Rensselaer men seeking the B. S. in Physics are required to take a general course in electrical engineering covering the production, transmission, and utilization of electrical energy for light, power, and communication purposes. In the junior year these students have a seven-week course in radio communication. The topics are as follows: "Underlying electrical theory; properties of oscillatory circuits; antenna systems and radiation; damped and undamped wave radio telegraphy; general properties of the three-electrode vacuum tube; the three-electrode vacuum tube as detector, amplifier, oscillator, and modulator; radio telephony."

R. P. I. offers special and graduate work in communication engineering to qualified students. Applicants who have acquired the physics and mathematics covered in the first and second years at Rensselaer, or in equivalent courses elsewhere, may be admitted to a special course in radio communication whereby practically the entire third year is devoted to laboratory and theoretical study of radio. "We do not advise students to take this special course unless they know positively that they are going to enter some branch of the radio industry at the completion of their course," writes Prof. W. J. Williams, who supplied all the information regarding communication training at R. P. I. It would appear that this special course is in the line of definitely vocational training in radio engineering for men who have the requisite grounding in the general engineering field, including, necessarily, considerable mathematics and physics. Two one-year graduate communication courses are also given in alternate years. One covers wire communication and general electric circuit theory. The other is in radio communication and advanced electromagnetic theory. About twelve hours of work a week are required. The content of these courses is variable, the effort being to keep the subject matter up to date. This work is necessarily limited to students who have the E. E. or B. S. in Physics from Rensselaer, or equivalent degrees from some other institution.

At the Polytechnic Institute of Brooklyn, on the basis of Prof. Erich Hausmann's reply, four subjects are given as required studies in the curriculum leading to the degree of Electrical Engineer. These are "Telegraphy" (two hours per week of class work in the second semester of the Junior year); "Telephony" (two hours per week of class work in the first semester of the Senior year); "Radio Communication" (two hours per week of class work in the second semester of the Senior year); "Communication Laboratory" (three hours per week of laboratory work in the second semester of the Senior year). The course in radio communication is described as "A practical and theoretical course on the generation of radio oscillations of the sustained and decadent types, damping of wave trains, resonance of single and coupled circuits, plotting of reactance diagrams and resonance curves reception of electric waves, the use of vacuum tubes as amplifiers, detectors and oscillators, the forms of antennas, and the design of commercial forms of radio telegraphic and telephonic apparatus. Prerequisite, Alternating Current Circuits." The "Communications Laboratory" work covers operation of telephone, telegraph, and fire alarm installations, tests of characteristics of spark, arc, and tube oscillation generators, measurements of such quantities as coupling coefficient and decrement, etc.

The four courses outlined above are also given in the Evening Session of the Polytechnic, the first three during one year and the fourth during the following year, alternating. The prerequisites are "Electricity and Magnetism," "Direct-Current Machines," and "Calculus," For "Telephony," "Alternating Current Circuits" is an additional prerequisite, and the three class room courses must precede the "Communication Laboratory" course. "A few years ago," writes Professor Hausmann, "an elementary evening course in radio was given which did not require a knowledge of calculus: while this course has not been offered for several years, there is no reason why it should not be given again. What do you think of the demand for such a brief course, say of 15 lectures?" The best way to gauge the demand is to propound the question and to invite any readers who are interested to communicate with Professor Hausmann. The writer believes that there is a sufficient demand for such a course to warrant offering it again.

Stanford University in California, while offering no extension work of any kind, lists four communication engineering courses described by Prof. Frederick Emmons Terman as follows:

(1.) *Lecture course in principles of radio communication.* Three lectures a week for ten weeks, open to seniors who have taken the regular electrical course, and to graduate students.

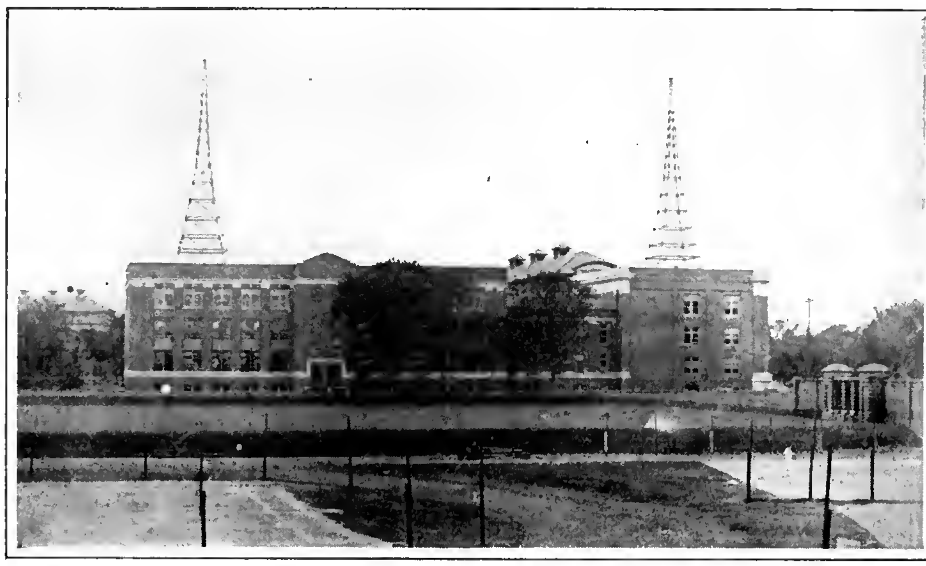
(2.) *Laboratory course in radio measurements.* Two lectures and one afternoon in laboratory per week for ten weeks. Reports are required. The experiments consist of bridge measurement of vacuum-tube amplification factors, dynamic plate resistance, etc.; radio-frequency resistance; resonance curves; detectors; audio-frequency transformer characteristics; adjustment of vacuum-tube oscillators, etc. This course is open to graduate students who have completed the fourth year electrical courses, as well as to other students with similar qualifications.

(3.) *A combination lecture and laboratory course on the theory of transmission circuits,* intended to occupy about one third of the student's working time for ten weeks. The subject matter includes the theory of long-distance power and telephone circuits, waves on transmission lines, theory and design of simple and composite wave filters. Probably half of this course applies directly to telephone communication problems. It is open to electrical engineering graduate students in full standing.

(4.) *Another graduate course with the same prerequisites is about fifty per cent. concerned with communication problems,* such as skin effect, transient oscillations, theory of telephone receivers and loud speakers, and harmonics, the treatment being of an advanced mathematical nature. There are two lectures a week for ten weeks.

All these courses are given by Professor Terman, who is in charge of communication and analytical work at Stanford University.

The University of Wisconsin, with its College of Electrical Engineering located at Madison, cannot be said to neglect the field of communication engineering. Four resident elective courses in "Radio Telegraphy"; "Electric Amplifiers and Oscillators"; "Radio Circuit Analysis and Design"; and "Telephony and Telegraphy," are provided. The first is substantially the "application of alternating-current theory to radio problems and measurements," accompanied by laboratory work. The second includes "analytical study of the properties of amplifier and oscillator circuits and of the characteristics of tri-electrode thermionic amplifiers," likewise with laboratory sessions. "Radio Circuit Analysis and Design" is described as "a continuation of the above courses, treating such topics as amplifiers and their design, operation of oscillators in parallel, design of oscillators, modulation and demodulation, and analysis and design of radio transmitting and receiving sets." The theory of instruments and lines is treated under "Telephony and Telegraphy," laboratory work being included. The above are all one-semester courses. Other courses bearing on communication problems are also available for graduate students, such as "Advanced Theory of Electric



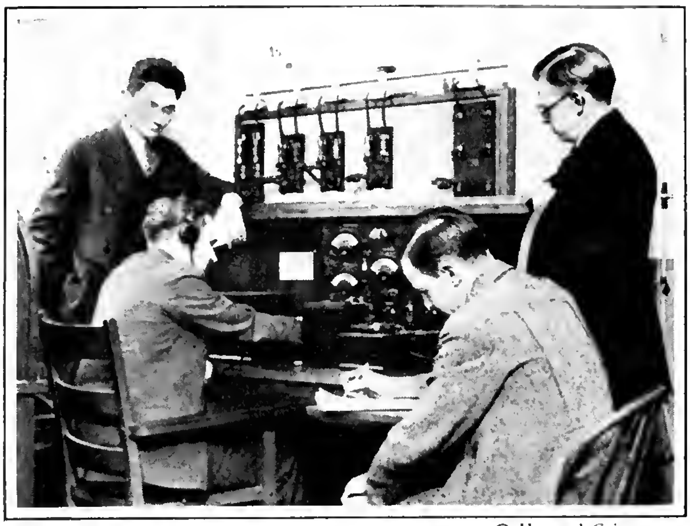
ELECTRICAL ENGINEERING BUILDING, UNIVERSITY OF MINNESOTA

The communication laboratories of this fine building occupy the third floor. The University has an experimental radio station and, like R. P. I., operates a broadcasting station

Circuits" and "Seminar in Electric Circuit Theory." The content of both of these courses is largely in the field of transient and high-frequency phenomena, behavior of networks, etc.

A number of correspondence courses in communication work are included in the bulletin "Courses in Electrical Engineering" issued by the University Extension Division of the University of Wisconsin. Course 318, "Principles of the Telephone" is given in three parts: "Subscriber's Apparatus," "Central Office Equipment," "Aerial and Underground Construction." The instruction fee for the first part is $6, with ten assignments in this portion. "This course," according to the catalogue, "includes study of the laws underlying speech, transmission, of the instruments, switchboards, and other apparatus in an exchange, and of the laying, testing, and maintaining in good condition of the circuits outside the exchange." Course 329, "Principles of Radiotelegraphy" treats the standard topics in twenty assignments, for an instruction fee of $12. An understanding of trigonometry is stated to be essential. An evening course on "Theory of Radio Circuits" is also being given in Milwaukee under the auspices of the Extension Division. This is an engineering course, open to "graduates of scientific courses of college grade or men of equivalent training," and may carry credit for degrees. It provides "a quantitative treatment of radio circuit theory" and aims to demonstrate "the dependence of radio circuit theory upon fundamental electric theory." The fee is $10 for the course of eighteen sittings. Four other radio courses are given by the Extension Division in Milwaukee, these being designed for amateurs, so that the treatment is more popular and elementary.

The Professor of Electrical Engineering at the University of Wisconsin, Edward Bennett, is a well-known radio engineer and has contributed extensively to the literature of the subject.



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IN THE CRUFT MEMORIAL LABORATORY, HARVARD UNIVERSITY

The picture shows a group of students making measurements during one of the courses

For the University of Minnesota, C. M. Jansky, Jr., Associate Professor, Radio Engineering, writes as follows, after referring to his paper, "Collegiate Training for the Radio Engineering Field" in *The Proceedings of the Institute of Radio Engineers* for August, 1926:

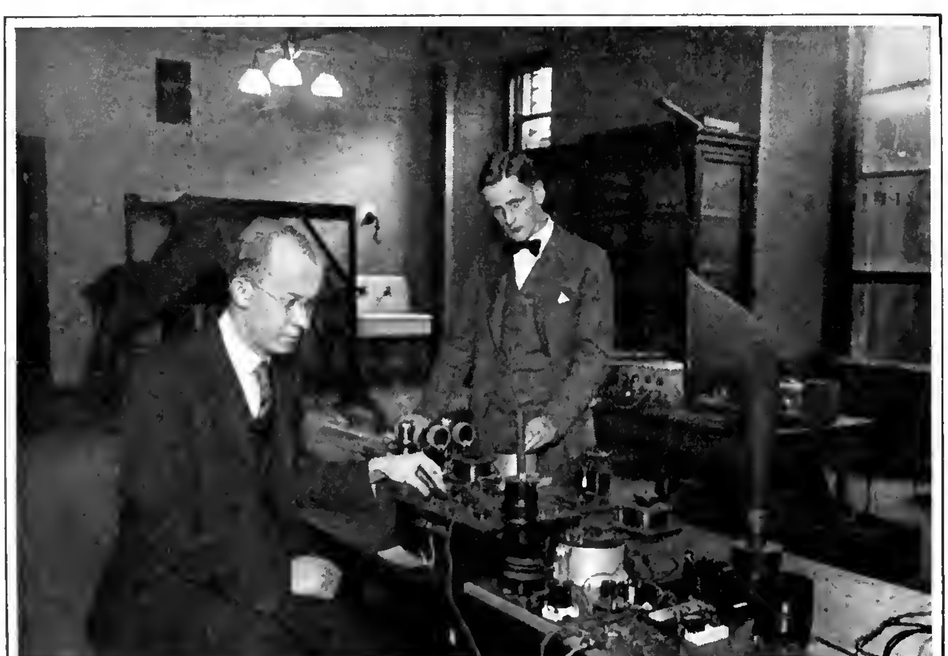
"Collegiate work in the field of radio engineering is given in the Department of Electrical Engineering of the University of Minnesota. Students desiring to specialize in communication engineering in general, or radio engineering in particular, take their work in this department. Upon completing the four years' work they receive the degree of 'Bachelor of Science in Electrical Engineering,' and upon completing an additional year of graduate work they receive the degree of 'Master of Science in Electrical Engineering.' The student gets his first course in the communication field in his junior year. He gets a year's course in radio engineering in the senior year. Where men are specializing in radio, I select such elective courses as will be of particular value to them, such as 'Transient Electrical Phenomena' and 'Differential Equations.'

"This year the Electrical Department has approximately 80 senior students, about 40 of whom are registered in radio engineering. Not all of these 40 will, however, become radio engineers, as many of them will go into other fields of electrical engineering.

"We are obtaining an increasing number of post-graduate students who are specializing in radio communication. These students, in addition to advanced courses in electrical engineering, take advanced courses in physics and mathematics. Where possible, I recommend the fifth year.

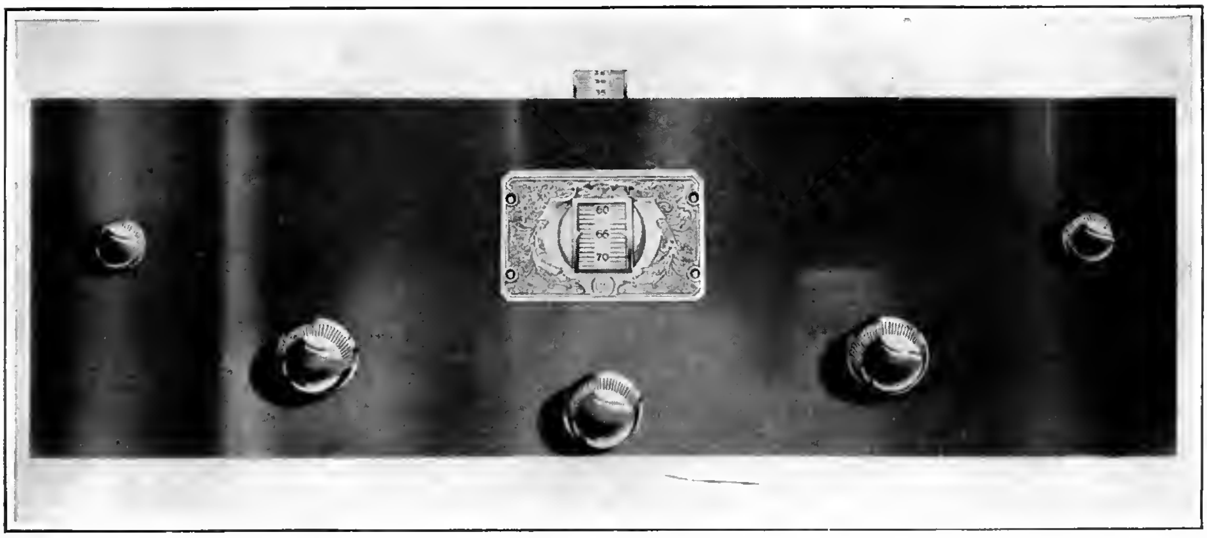
"I believe our building and equipment excel that of the majority of institutions. We have approximately 7000 square feet of floor space devoted to communication laboratories and research rooms. In addition, we operate an experimental radio station and a broadcasting station."

The above summaries of communication engineering training which is offered at nine centers of higher learning afford a view of some of the main trends in the field. At some institutions there is little interest in communication engineering except as a part of general electrical engineering. The philosophy underlying this attitude is that industry is so highly specialized that it is hopeless to give a man more than the broad fundamentals at school, and that if this is accomplished, he will make his way after he gets into business by the addition of his common sense and the training provided by the job itself. Some of the large communication concerns, in fact, set up schools of their own for the engineers on the staff, evidently with the thought that the technological content of their particular jobs cannot be secured in any outside school. Many colleges, on the other hand, teach the theory and some of the practice of telegraphy and telephony, by wire and radio, to qualified students of junior and senior grade. Still others go further and, in addition to such studies, offer popular extension courses, correspondence study, and the like. If there is a demand for vocational study, for example, in a neighborhood, the local university is probably better qualified to fill the need than some primarily commercial institution. Study, even if it is not of the most scholarly sort, is not apt to do anyone harm, and it may do good, as long as it is not allowed to interfere with the rigorous and inexorably thorough training which makes a real engineer. Again, it may be argued that communication engineering courses deal with fundamentals just as much as the older power engineering subjects, that nowadays a vacuum tube is as important a machine as a dynamo. Different courses are for different people, we may conclude. If a man has the intellectual equipment, the money, and the time required for a thorough study of the subject he intends to make his lifework, by all means let him spend four or six years preparing himself. Let him specialize only after he has mastered the fundamentals. But if at some time a man wants to learn something special in a superficial way, no harm is done, provided he knows what he is getting, and does not take it for more than what it is.



A CORNER OF ONE OF THE COLUMBIA UNIVERSITY LABORATORIES

Making measurements on a resistance-coupled audio amplifier in the Hartley Laboratory



HOW THE COMPLETED TWO-TUBE TUNER LOOKS
The five knobs, from left to right, are: "On-Off" switch, trimmer condenser (C_3), main tuning control, volume control, regeneration control

An A. C. Browning-Drake Receiver

By Glenn H. Browning

THE Browning-Drake circuit has been popular for a number of years, due, probably, to the fact that the set is very easy to build and operate, sufficiently sensitive to receive most distant stations which are above the noise level, and selective enough to cope with present broadcasting conditions, except when located in extremely congested regions. The sensitivity of the set is primarily due to the tuned r.f. transformer which Dr. Drake and the writer developed a number of years ago at Cruft Laboratory, Harvard University. Also, the antenna tuning system, which is a conductively coupled one, gives more signal strength than any the writer has tested so far. This is especially true when operating the set with a short antenna.

The electrical engineering in the Browning-Drake receiver has been changed very little during the last three years, though minor improvements have been incorporated from time to time. With the introduction of a.c. tubes and the popularity of so-called single control receivers, however, it seems particularly advisable at the present time to change the mechanical layout of the receiver and add any refinements in the electrical design which constant work on the circuit have indicated as worthy of recommendation.

As most radio constructors know, the Browning Drake circuit consists of one stage of tuned r.f. amplification with some type of neutralization, coupled to a regenerative detector. Any form of audio amplification may be used with this tuning arrangement, but, of course, the audio amplifier determines to a large extent the quality of the received signals.

This article deals essentially with the new two-tube receiver unit, employing a.c. tubes and making use of single control, and we will not go into detail about the audio channel. In passing, it might, however, be mentioned that the Browning-Drake Corporation supplies a foundation kit for a five-tube receiver, which includes the necessary sub-panel for the mounting of whatever audio equipment is used, and a larger base panel than that used in the two-tube tuner unit described here.

After experimenting for some time with a.c. tubes two cx-327 (ux-227) tubes were chosen for the tuner unit. With a tuner constructed according to the instructions in this article, and used with a three-stage amplifier also wired for a.c. tubes, there is very little audible 60-cycle hum in the loud speaker. Sometimes it is necessary to experiment with the voltages used and also with the tubes in order to get the best combination, otherwise there may be some hum in the loud speaker, and the quality would be impaired

The nucleus of the Browning-Drake set described here is what might be called a single drum control unit; it consists of a single illuminated drum type dial driving two variable condensers. The necessary coils for the two-tube tuner are also an integral part of the drum unit. As antennas differ a great deal, it is advisable to put a small condenser in parallel with the first tuning condenser in such fashion that it may be controlled from the front panel, and variations in antenna length thus compensated. In actual tuning, this condenser is used as a minor control. In Fig. 1, the diagram of the complete tuner unit, this condenser is indicated as C_3.

As will be noted, a slightly different system of neutralization than has heretofore been used is employed; also parallel plate-voltage feed for the r.f. tube is featured. The parallel feed, which consists of an r.f. choke coil in series with the r.f. B-battery lead, together with a 0.5-mfd. condenser, keeps all r.f. current from entering the B supply, and forces this current to go through

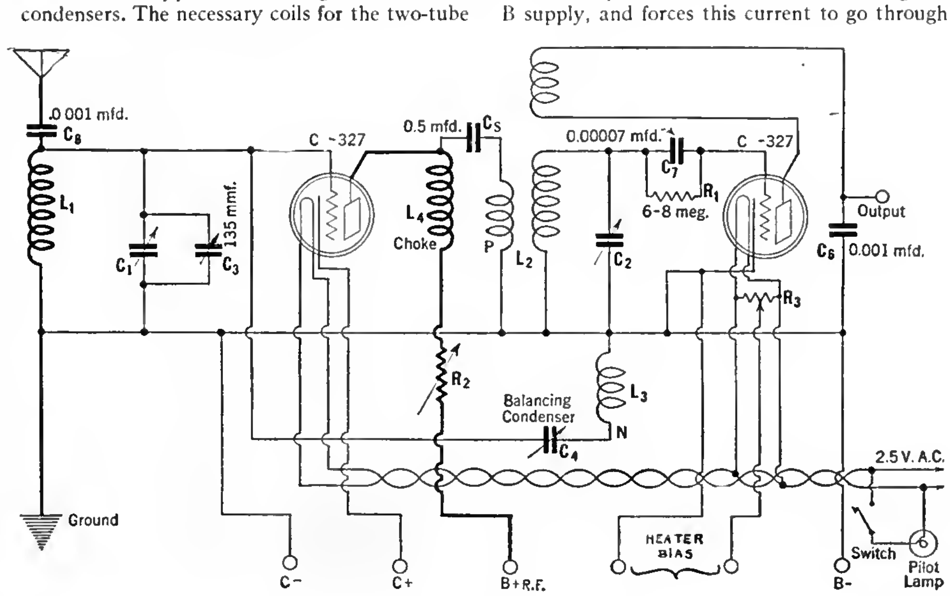
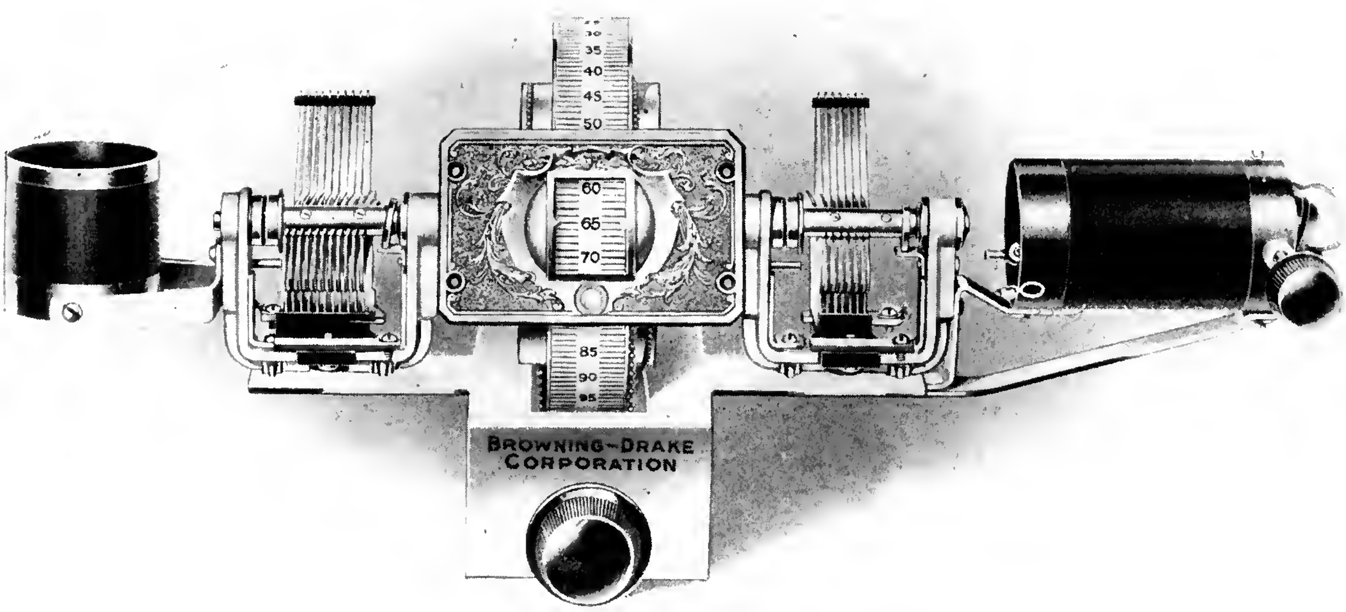


FIG. 1

This diagram gives the complete connections for the two-tube tuner unit. Manufacturers of a. c. tubes of the heater type state that less hum will be evidenced if the heater is biased with respect to the cathode. This bias may be plus or minus, depending upon which gives the better results



THE NUCLEUS OF THE BROWNING-DRAKE A. C. TUNER

It is known as the single drum control, and comprises (refer to fig. 1, page 343) C_1, C_2, L_1, L_2, L, regeneration coil, and the receptacle for the pilot light

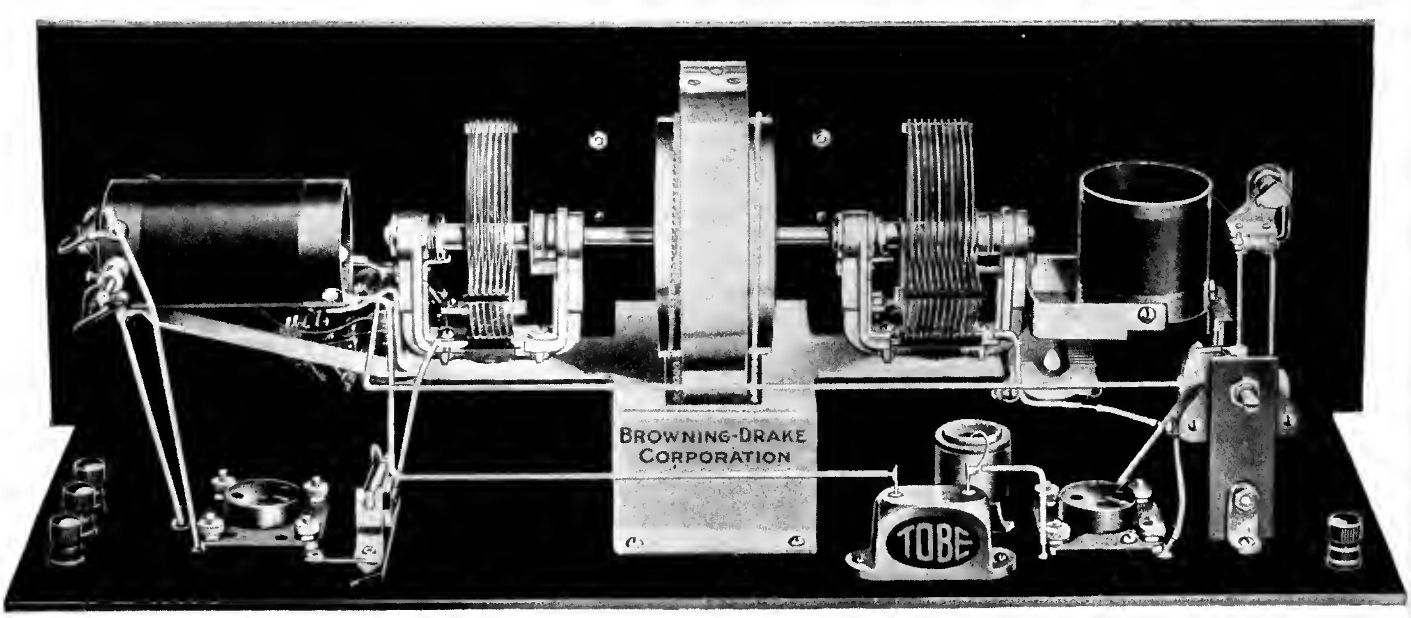
the 0.5 mfd. condenser and the primary of the r.f. transformer. Neutralization is then accomplished by means of a few extra turns, L_3, on the r.f. transformer, the end of which is connected through a neutralizing condenser, C_4, to the grid of the tube. In practice, it is necessary to have the stator plates of the neutralizing condenser connected to the grid of the first tube rather than the rotor plates. It is found that a tube with a much larger capacity between grid and plate can be tolerated by the use of the above-mentioned system of neutralization.

When the set builder is located in a very congested region and there are a number of local broadcasting stations within a radius of three or four miles from the receiver, shielding is to be recommended, and a complete shield for the Browning-Drake receiver will probably be commercially available soon. Such shielding eliminates all pick-up by coils and the wiring of the set, and adds materially to the selectivity of the receiver when it is used under the above conditions. Where the set builder is located in the country or suburbs, shielding is unnecessary.

The parts necessary for the construction of the single-control a.c. Browning-Drake tuner unit are listed below:

LIST OF PARTS

Official Browning-Drake Single Drum Control Kit comprising C_1, C_2, L_1, L_2, L_3, the regeneration coil and pilot light socket	$26.00
Official Browning-Drake Type T-2 Foundation Unit consisting of Westinghouse Micarta drilled and engraved front panel, base panel complete with mounting hardware. Also miscellaneous machine screws, nuts, and wire	13.50
L_1 Browning-Drake Radio-Frequency Choke	2.00
C_3 Browning-Drake 135-Mmfd. Trimmer Condenser	2.50
C_4 Browning-Drake 30-Mmfd. Neutralizing Condenser	1.75
Yaxley Filament Switch No. 10 B-D	.60
C_5 Tobe 0.5-Mfd. Moulded Condenser	.90
R_1 Tobe 8-Meg. Grid Leak	.75
C_6, C_7 "Tinytobe" Condensers (0.001 and 0.00007 Mfd.)	.80
C_5 Mica Fixed Condenser (0.0001 Mfd.)	.75
Five Eby Binding Posts (Ant., Gnd., B + Amp., B + Det., B—)	.75
One Set of Shields (Optional)	8.00
R. Clarostat	2.25
R_3 Browning-Drake Center-Tapped Resistor	.60
Two Benjamin Five Contact A-C Sockets	2.40
One Flashlight Lamp (2.5 Volt)	.10
TOTAL	$63.65



A REAR VIEW OF THE COMPLETE TWO-TUBE UNIT FOR D. C. OPERATION

After the parts are mounted on the drilled and engraved panel it is a simple matter to complete the wiring. The use of the single drum control unit greatly helps matters. This layout is similar to that employed in the a. c. model

CONSTRUCTION OF THE RECEIVER

THE receiver is very easy to build and for most set builders detailed constructional information is unnecessary. The leads running to the B supply and filament supply for the a.c. tubes are placed underneath the sub-panel, while the high-potential leads, which carry r.f. current, are placed above the sub-panel. These high-potential leads comprise:

The connection from the stator plate of the first tuning condenser to the grid of the first tube; the plate of the first tube through the 0.5-mfd. condenser, and from the 0.5-mfd. condenser to the primary of the r.f. transformer; the neutralizing lead, which comes from one end of the secondary of the r.f. transformer to the rotor plates of the neutralizing condenser. Of course, the connections between the grid leak, grid condenser, and the grid itself, should be as short as possible. These are the most important connections in the set, and they should be run as directly as possible and kept away from other connections

In connecting the A supply of the tubes, twisted pairs must be run from the power supply to their filaments. This is extremely important for if the wires are not carefully twisted together, a.c. hum may be noticeable. Also, the power apparatus, which should consist of a good B supply device and the necessary transformer for lighting the filaments of the tubes (the latter being either incorporated as a part of the B supply or as a separate transformer), must be kept several feet away from the receiver; otherwise there might be some 60-cycle voltage induced in the audio circuit of the radio set.

As will be noted in Fig. 1, a Clarostat inserted in the B plus lead of the r.f. tube is used for volume control. This the writer has found quite satisfactory as long as the parallel feed shown in the diagram is used. Some experimenting will be necessary on the C battery bias for the r.f. tube, as the voltage may vary between 1½ and 4½, according to the individual characteristics of the tube used.

BALANCING AND OPERATION OF THE RECEIVER

WHEN the set has been connected up according to the instructions given, and attached to the power supply (note: the filaments of the C-327 [UY-227] tubes take about 45 seconds to a minute to heat up sufficiently for satisfactory operation), it is ready to balance. Turning the tickler coil in one direction or the other should throw the second circuit into oscillation. This condition may be determined by placing the finger on the stator plates of the second tuning condenser, whereupon a distinct "click" or "plop" will be heard in the loud speaker. Then turn back the ticker coil until the circuit just goes out of oscillation. If the set is improperly balanced, turning the trimmer condenser slightly will throw the circuit into oscillation again, which state can be determined as before. The neutralizing condenser then can be varied by means of a wooden or bakelite screwdriver until turning the antenna trimmer has no effect whatever on oscillations produced in the second circuit.

There is another method which will give almost the exact point of neutralization. Tune-in a local station, remove one of the leads going to the C battery of the r.f. tube and, by careful retuning, the local station can in all probabilities be heard. Set the neutralizing condenser so that a minimum amount of signal is heard. This point on the neutralizing condenser is almost the correct one, and the test given above can then be applied for the exact point. It will be found that neutralization is quite critical. Of course, when neutralizing, the Clarostat should be turned up as far as it will easily go (in a clock-wise direction.)

AN AMERTRAN PUSH-PULL AMPLIFIER

As mentioned on this page, it is a two-stage push-pull affair, provision being made for the use of either a 201-A type tube or an a. c. type tube in the first audio stage

In operation, the a.c. Browning-Drake is exactly like previous models. The tickler coil may be turned up to a point where the set is just oscillating and the dial rotated, whereupon a station will be indicated by a whistle. Set the dial where the whistle is lowest in pitch and turn back the tickler coil and adjust the antenna trimmer condenser until the signal is plainly heard. Readjustments of the drum dial will then probably be advantageous.

AUDIO-AMPLIFIER SUGGESTIONS

AS HAS already been mentioned, the choice of an audio amplifier is left entirely to the constructor. There are several amplifier units and plate supply units now on the market which have very good characteristics, and it is believed that the combination of such apparatus with the two-tube tuner unit described here will provide the user with as simple and as effective a receiver as he may need.

As an example of the type of audio-frequency amplifier and power supply that can be constructed and which will work very satisfactorily with the two-tube tuner, there is shown in Fig. 2 the circuit diagram of a combined push-pull amplifier and power unit which may be made from Amertran parts.

The amplifier is a two-stage transformer-coupled affair, designed to use in the first stage a C-327 (UY-227) type a.c. tube. The other two sockets in the amplifier are for the power tubes. Tubes of the CX-371 (UX-171) or CX-310 (UX-210) may be used in conjunction with either a type 271 (for 171 tubes) or a type 152 (for 210 tubes) Amertran push-pull output transformer. With a push-pull amplifier similar to that shown here, the comparatively large amount of undistorted power necessary for high-quality reproduction, can be obtained.

Completely assembled power amplifiers and A, B, C supply units can also be obtained from the Amertran Company. The amplifiers, when combined with the power units, result in a circuit differing slightly from that given in Fig. 2, in that they are designed to use either a CX-301-A (UX-201-A) or a C-327 (UY-227) type tube in the first stage, and CX-371 (UX-171) or CX-310 (UX-210) type tubes in the push-pull stage.

The type 2AP-10 amplifier is designed for CX-310 (UX-210) type output tubes while the type 2AP-71 is for CX-371 (UX-171) type tubes. Both of these amplifiers are the same in external appearance. The necessary Amertran power unit will furnish complete A, B, and C power to the push-pull amplifier and to all the other a.c. tubes used in the receiver proper.

The complete type 2AP amplifier (either type) lists at $60, without tubes. A set of Amertran push-pull transformers, which might be used in the home-construction of a power amplifier, can be purchased for $30. The Amertran power supply (the A, B, C Hi-Power Box) lists at $95.00.

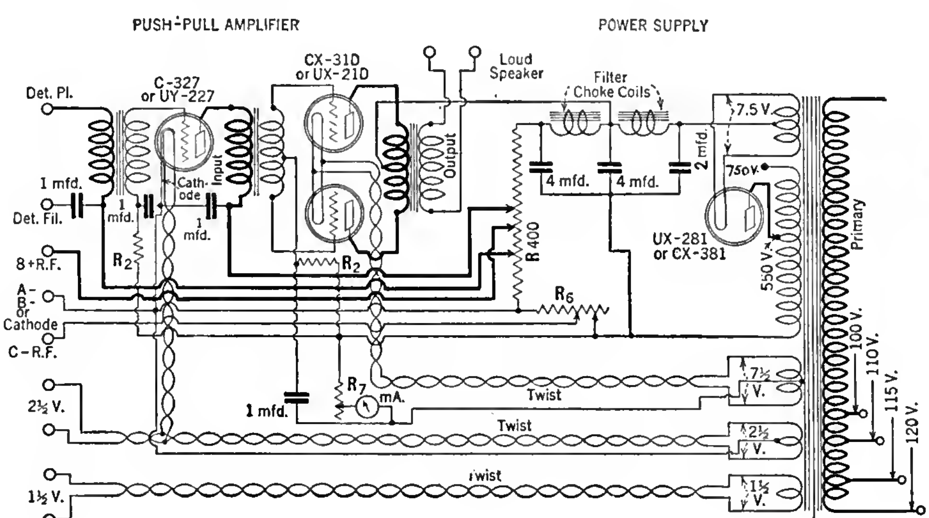


FIG. 2

The circuit diagram of an amplifier which may be used with the two-tube tuner unit. It is made with Amertran parts

THE MARCH OF RADIO

NEWS AND INTERPRETATION OF CURRENT RADIO EVENTS

What Is the True Broadcasting Situation?

WHENEVER we see the name of Senator Howell of Nebraska in print, our eyes blaze, because we consider him to be the man who, single handed, did more to obstruct the proper administration of radio during the last nine months than any other Senator. During the closing days of the last session of Congress, his was the only dissenting vote raised to a unanimous consent agreement to vote an appropriation for the maintenance of the Federal Radio Commission.

Thereby deprived of an appropriation, the Federal Radio Commission has been most seriously embarrassed in its labors. Its effectiveness has been crippled because a petulant Senator chose to throw a monkey wrench at the radio listeners of America. The Commission can issue orders to broadcasting stations, but has no means whatever of finding out whether those orders are complied with. When its members travel, they advance the money out of their own pockets.

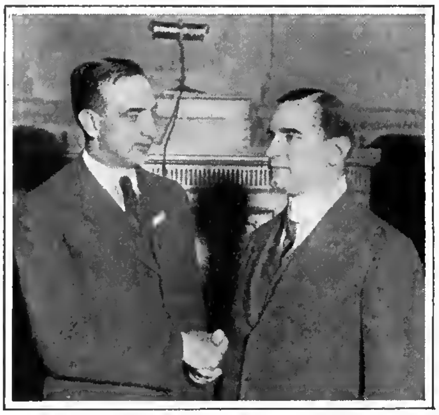
Instead of a staff of expert observers with high-grade measuring instruments, the Commission has had nothing to guide it but the reports of the public, the complaints of station owners and the protests of politicians, advancing the fatuous claims of every broadcasting station represented in their particular constituencies, regardless of the public interest. The Commission has not been able to employ consulting experts in order to evaluate the numerous panaceas offered it in the direction of frequency stabilization, synchronization of stations, and to determine quantitatively the exact minimum spacing which may prevail among stations of various power combinations without heterodyning within their service areas.

Consequently, when we saw Senator Howell's name in a dispatch from Washington, we expected bad news for radio. The Senator, we find, is now engaged in a war with the ghost of monopoly, which he finds skulking behind every microphone radiating chain programs. He wants a Congressional investigation, perhaps as a vehicle of publicity, perhaps for some other purpose. He may suspect that Mr. Aylesworth, president of the N. B. C., once bought a lunch for a Federal Radio Commissioner or that George McClelland, vice-president of the same company, sent a basket of apples from his Queens fruit ranch to Sam Pickard. Whatever he finds will be sensational and well phrased for newspaper publication. To save time, we offer the proposed Committee's findings even before the hearings are arranged:

Does Monopoly Rule the Commission?

THE Federal Radio Commission, at this writing, has cleared twenty-five channels and picked the best stations in the country to utilize them. Naturally, these stations, since they have been well selected, are the ones which offer the greatest variety and the best type of program. Such programs are not available in every hamlet from which a Congressman comes, but are centered at the musical and artistic centers of the United States. From such centers, a company, the odious and monopolistic National Broadcasting Company, has offered a wire service to which independently owned broadcasting stations have subscribed, making superior programs available to them. This service has been conducted at a tremendous loss, met out of the treasuries of receiving set and accessory manufacturers so that their customers would derive pleasing entertainment as a result of their purchases and therefore continue to patronize them.

Utilizing the chain programs has made the subscribing stations superior in program value to those which must rely for their programs on the Squeedunk church choir and the piano-playing professor at a roadside speakeasy. And so, by selecting good stations for good channels, the Federal Radio Commission has become guilty of inflicting the Red, Blue, and Columbia chain programs upon practically all the channels in the cleared band. This is the situation which Senator Howell will uncover, perhaps by spending a few hundred thousand dollars of the Government's money to do so.



AT THE INSTITUTE OF RADIO ENGINEERS
The old president and the new. On the left, Ralph Bown, president for 1927, greets Dr. Alfred N. Goldsmith who has been chosen to lead the Institute for 1928. Doctor Bown is a radio engineer for the American Telephone & Telegraph Company and Doctor Goldsmith is chief broadcasting engineer of the Radio Corporation of America as well as one of the board of consulting engineers of the National Broadcasting Company

We recognize, without the aid of a Congressional investigation, that this situation is not an ideal one. It would be much more desirable if only four or five leading stations on each chain, widely separated at such points as New York, Chicago, Denver, and New Orleans, for example, should be given clear channels so that long-distance listeners who are not within the service range of other stations on the chain can secure them via a cleared route.

The rest of the chain stations should also have good channels so that they can be heard throughout their service area without an annoying heterodyne. This requirement, however, does not call for a nationally clear channel, but merely one which is free of excessive congestion. The claimed service range of chain stations, as expressed in their prospectuses, on the basis of which they sell radio advertising, clearly indicates that nationally clear channels are not contemplated by them nor is national service attempted by all or any of their stations.

But certainly such stations as WJZ, WEAF, WOR, WGY, and WGN are worthy of a nationally clear channel. Allowing five clear channels to each of the three chains would account for only fifteen of the twenty-five clear channels. The remainder should be reserved for some of the better stations, offering high grade programs from local sources, for example, WPG, Atlantic City, WBBM, Chicago, WCCO, Minneapolis, and WHAM, Rochester. These latter two do use chain programs but the excellence of their local programs ranks them high indeed.

We understand that WCCO, recognizing that chain programs are available from so many points and are therefore needed only locally, has decided to distribute its chain programs through a smaller Minneapolis station, which covers only the local Minneapolis-St. Paul area. The programs of WCCO will be almost entirely from local program sources, such as their famous symphony orchestra and other individual and distinctive programs, thus contributing to the variety of programs offered listeners near and far. This policy should be encouraged by offering such stations clear channels, thereby increasing program variety.

The long-distance listener, remote from the local service area of any broadcasting station, and that includes sixty or seventy per cent. of the radio audience, is not served if, with twenty-five cleared channels, he can hear but three different programs. Under those circumstances, there is no necessity for clearing such a large number of channels. Each clear channel means that three or four higher frequency channels must be more seriously congested. If greater program variety for the rural listener is not gained by additional channel clearing, it will soon cease. But, if there are sufficient independent stations, originating their own high-grade programs, or more chains, then the clearing process can continue even to the point where we have only clear channels with either independent or chain stations serving them and local channels for low- and medium-power stations.

At the present time, there is a monopoly of good program service, attained by subscription to the three chain programs—the Columbia and the Red and Blue Networks of the National Broadcasting system. This monopoly has been won by good service and by public tolerance. It is hard to name ten or fifteen independent stations truly worthy of cleared channels; the writer confesses he knows of but four, WPG, WCCO, WHAM, and WBBM, the latter more because of its good carrying qualities than because of any especially good programs. Of these, two use chain programs, but to a limited extent. The Commission would not for a moment hesitate to assign clear channels to good independent stations, but most broadcasting stations are hopelessly mediocre. The broadcasting band is much larger than is required to accommodate the good stations of the country. Southern politicians cry discrimination, but they cannot name five stations having program standards sufficiently high to attract consistent audiences outside their local service areas.

The Growing Political Pressure on the Commission

IN CONGRESS, the evaluation of a station is measured by the amount of pressure which the station owner can bring upon his particular Senator and Congressman. A Congressman can readily be induced to raise a large howl about the most puny, insignificant, puerile, useless, annoying, broadcasting station on earth. He can wax eloquent before the Federal Radio Commission and praise alleged services which he has never heard of except from the owners of the stations claiming to render them, an eloquence usually entirely unwarranted. Never would such an alleged statesman ask a local station owner to modify his demands for increased power or a clearer channel in the slightest iota in deference to the national situation and to aid in securing uniformly good broadcasting conditions all over the country.

We visited one of the most annoying and obnoxious stations in New Jersey which spreads a blanket of odoriferous advertising throughout the northern part of the state. This station owner was able to show us a pile of letters which he had obtained by solicitation from his Senators and Congressmen, commending its service, although they had probably never listened to it voluntarily. These legislators urge the Federal Radio Commission to give that station special consideration over other stations in the metropolitan area of New York, simply because it means political support next time elections come around.

Our prophecy, made before the Radio Act was written, that placing broadcasting regulation in the hands of a Commission at the mercy of Congress would simply make political lobbying the criterion by which broadcasting rights are distributed, may, unfortunately, be fulfilled. The Commission has done its best to educate or to disregard the politicians, but both courses have their difficulties. If the Commission does not heed the politicians and their local needs and impossible requests, it is bound to suffer chastisement by failure to secure confirmation of its members, by curtailing of its appropriations or by special legislation requiring recognition of principles incompatible with good allocation but favoring station owners above the listening public.

Limitations to the Use of High-Frequency Channels

WE HAVE already mentioned the problem of selective fading on short-wave channels, which causes varying audio-frequency distortion, but there are a number of other points, equally potent, which must be considered when appraising the value of the short-wave region for broadcasting purposes. If the number of broadcasting stations on high-frequency channels continues to increase, the short-wave DX audience will show continued growth. Any great increase in the number of radio receivers working on the short waves will render these waves useless for radio telephone reception because only a radiating regenerative receiver can be made to work on these waves. No sets have yet been built successfully which do not oscillate at the high frequencies, although the new UX-222 tube promises to make short-wave neutrodynes and super-heterodynes practical. With the receivers now available, however, tuning is so critical that the most skilful operator cannot avoid radiating whistles when tuning-in a station. Consequently, wide-spread listening will make the short waves even more disturbing than the broadcasting channels were during the oscillating receiver days of 1922 and 1923.

A channel utilized on short waves is international in scope, almost regardless of the amount of power used. Even a fifty-watt station, broadcasting on short waves, requires an internationally exclusive channel. Therefore, there are a maximum of 2700 channels in the entire world between 10 and 200 meters (30,000 and 1500 kc.), of which the United States might justly claim perhaps 250 for all purposes. Already the band between 25 and 50 meters (12,000 and 6000 kc.), is completely filled with stations and there are few blank spots in the remaining channels. Hence, instead of a vast unused ether territory, as those suggesting a broadcasting band seem to consider it, the high-frequency territory will soon have a congestion problem of its own.

The needs of broadcasting and the needs of the radio listener can be adequately met by a well allocated layout of broadcasting stations confined to the present broadcast-

RADIO ON CANADIAN TRAINS

Many of the crack trains of the Canadian National Railways are equipped with radio receivers to entertain passengers on long daylight runs. The sets were especially designed for this service. Loop operation is not used, every set receiving its energy from a low antenna on the car ing band. Such an allocation can provide ample program choice, equitable service for all parts of the country, and sufficient long-distance reception to meet the needs of the public for years to come. The present band is the only one ideally suited to broadcast transmission and reception. Stable, non-radiating receivers which can select stations ten kc. apart are easily made. Neither of these features can now be embodied in sets working on the high-frequency band. Below 25 meters (12,000 kc.) channels for radio telephony must be separated by 75 to 100 kc. because we do not yet know how to avoid cross talk with closer spacing.

A further difficulty is introduced by varying hour to hour transmission qualities of the high frequencies, which requires changing of the frequency of a station every few hours if it is to give reliable service between any two points. Short-wave, transatlantic telegraph communication stations need three and four channels in order to maintain satisfactory twenty-four hour service between two points on opposite sides of the Atlantic.

More important than any of these objections to the use of high frequencies for general broadcasting, however, are the needs of the world for short-wave, radio telegraph communication networks. The high frequencies are extremely prolific in telegraph channels. For speech and music, a frequency space ten kc. wide is required but, in a band of this width, fifty short wave transmitters could be accommodated.

This is assuming, of course, that means of establishing perfect frequency stability has been discovered so that a high-frequency station might stay exactly on its channel. While there would be a maximum of 2700 broadcasting channels in the ether space from 30,000,000 to 1,500,000 kc. or 200 down to 10 meters, there are actually about 275,000 potential telegraph channels.

The needs for these channels are literally enormous. Already they are extensively used in high-frequency beam transmission across oceans and even to the opposite side of the earth. They are needed for transmitting news to large numbers of newspapers by syndicate news services. They will be needed for the tens of thousands of aircraft transmitters which will fill the skies within a decade or so and which will depend upon radio for weather information and for the safety of the lives of the passengers. Navigation companies, railroads, bus systems, police and fire systems, and forest and water patrols, will require these channels in increasing numbers. Then there are a host of private communication systems in contemplation where the use of high-frequency radio service will effect tremendous economies and savings which will be reflected in the cost of goods purchased by the public. Department store chains, businesses having factory branches at widely distributed points, ranch owners who have to communicate with employees fifty and a hundred miles away, lumber operators, packers and shippers, and numerous other services can use short waves and use them effectively.

There is need for ship beacons, fire and signal systems, aircraft service, aircraft beacons, landing field radio beacons, and a host of other services which dwarf radio broadcasting into insignificance so far as social and economic importance is concerned.

As radio listeners and as those participating in a large and prosperous radio industry, we are inclined to exaggerate the importance of broadcasting. The most important service which radio renders is in promoting the safety of the lives of those at sea. Radio has saved thousands of lives annually by bringing aid to ships in distress. The ships of the air are not as staunch as ships at sea, and radio is much more vital to their safety. Ether congestion will add material problems to the expansion of aerial navigation.

The clamor for short-wave communication in order to soothe the feelings of broadcasting station owners must cease. We have learned the lesson of conservation of forests and now go to great effort to replenish the trees which have been so ruthlessly cut. Once they are assigned to a service, there is no way of planting new ether channels. The mistakes of to-day are not easily rectified to-morrow.

The broadcasting stations, which go on short waves for any reason other than serious research or to effect the rebroadcasting of special international events, are doing so in order that they may claim to advertisers that they cover the civilized world. Without doubt, going down on short waves will bring responses from foreign countries. If all the letters received by all the short-wave broadcasters were put in a heap, it would be found that there are three men in South Africa, about ten in Argentina, and about thirty in Australia and New Zealand who are the sources of seventy-five per cent. of all of these letters. These short-wave transmitting outfits, for which so much publicity value is claimed, are serving audiences of very small numbers.

Broadcasting on the regular channels, it may be claimed, started in the same modest way, serving only small numbers. But it had the opportunity to grow because the medium was suited to good transmission and reception. That consideration does not apply to high-frequency broadcasting. It has DX fascination but not esthetic value. As a means of distributing goodwill programs, the short waves are useless because the musical reproduction is not sufficiently good to please the listener. Those who listen to radio for the entertainment will prefer the stabler low-frequency broadcasting band.

May the publicity-seeking gentlemen who solve the broadcasting problem by newspaper interviews cease misleading the public about the possibilities of short-wave broadcasting!

The First Rayfoto Transmission

THE backers of Austin G. Cooley are exhibiting pleasing conservatism in going forward with their Cooley Rayfoto transmissions. Instead of accepting the numerous offers to broadcast through every station which invites them to the microphone, they are still quietly conducting tests with the aid of qualified experimenters. Some twenty picture recorders are in the hands of experienced set builders and they are making radio pictures, sent occasionally during the early morning hours through WOR, of L. Bamberger & Co. Newark, New Jersey. If these twenty experimenters are successful in securing reliable and satisfactory pictures without special instruction or experience with the Cooley Rayfoto apparatus, more recorders will be distributed until the reliability of the apparatus is fully established. The equipment will not be offered to the general public until it has been fully tested by typical users to their entire satisfaction.

Mr. Cooley's representatives are being flooded with inquiries both from broadcasting stations and from experimenters who desire to purchase the apparatus. Phonograph records for transmission and testing, and the complete equipment, will be distributed as soon as existing receivers have been fully tested. The recorder at RADIO BROADCAST Laboratory has been very satisfactory.

Two Stations Cannot Occupy the Same Ether Space

A NEW YORK *Times* headline proclaims that Dr. Lee DeForest has discovered room for 500,000 broadcasting stations. It is most irritating to read such misleading statements because they afford an excuse for not dealing with broadcasting conditions as they exist in the present. The remedies of to-morrow do not alleviate the problem of to-day.

Scrutiny of Doctor DeForest's remarks shows that the usually accurate *Times* misinterpreted what he said. He merely stated that there are some 6000 channels, with 10-kc. separation, between 200 and 10 meters (1500 and 30,000 kc.) and that perhaps 500,000 radio-telegraph stations could be disposed upon these frequencies if the double-heterodyne method of transmission, requiring the use of low-frequency super-audible, master oscillators, were employed.

Doctor DeForest also suggests that the same system might be utilized in the broadcasting band. Such a course would necessitate the complete scrapping of all transmitting and receiving equipment and add a delicate manipulation somewhat beyond the skill of the average listener, to the tuning process. The remedy would cost a billion dollars—or what you will—and would not even accommodate all our present stations.

Between 10 and 200 meters—considered a radio utopia by experts in publicity and politics, there are 27,500,000 cycles, or 27,500 kilocycles, of frequency space. At 10-kc. separation, which is necessary for ordinary radio telephony, there are 2750 broadcasting channels for distribution among all the nations of the world. Some twenty of these are already used by stations broadcasting on this band as well as their regular longer-wave channels some of which boast that they are broadcasting "to the civilized world" through their short-wave stations.

This is a misconception because the only persons who listen to broadcasting on the short waves now are DX cranks. No civilized person would seek musical entertainment on these short waves because of the existing audio-frequency distortion for which no one has found a cure. Programs are quite distinguishable at enormous distances but they appeal to musical tastes about as much as a five-legged calf appeals to a stock breeder. To suggest relief from broadcasting congestion by pointing to the numerous high frequencies is as practical as offering the vast Arctic spaces to the overcrowded populations of India.

The problems of the broadcasting situation are extremely complicated. Experts have no easy remedies to offer. With the unwearying persistence of Cato, we repeat that excess broadcasting stations must be eliminated. The rights of the listener and the property rights of the broadcaster are in conflict. No one, not even the broadcasting station owner, at least when speaking for publication, denies that the listeners' rights are paramount. Therefore, the question centers on how great are the rights of the broadcasting stations involved because the broadcasting station owner must make sacrifices so that the listener may hear undisturbed programs.

The National Association of Broadcasters estimates that the total investment in broadcasting stations, as computed on March 1, 1927, is $19,283,000. These figures were probably obtained in answer to a questionnaire and are therefore the broadcasters' own valuation of themselves. We are inclined to regard the figure as a good guess. The one hundred leading stations are probably the larger part of this investment. That leaves only about ten million dollars of disputed rights involved, of which only half need be confiscated to bring good broadcasting. If that problem is too great for the master minds in Congress to solve, we had better employ some foreign broadcasting experts.

Will the Radio Industry Do It Again?

WITH great secrecy, a score of manufacturers are designing new radio sets to utilize the experimental UX-222 (CX-322) tube. This tube is virtually a laboratory product, the much heralded double-grid type tube, having four elements. Everything points to a repetition of the radio industry's annual suicide because undoubtedly one manufacturer or another will soon startle the world with the statement that he has a set using this great tube which will make all rivals and predecessors obsolete. Then will follow the usual race and a score of manufacturers will announce new UX-222 sets, and all their previous models, some of them hardly perfected by experience, will go into the discard. In this way, the radio industry forces itself into a seasonal state and adopts new methods and types before the old ones are hardly introduced. The way in which the a.c. set was heralded completely ruined the business in battery sets. Everything points to a repetition of precedents, that the a.c. sets will be rendered obsolescent by the new UX-222 tube.

There is no sense whatever in this procedure. There is no reason for stopping the manufacture of touring cars and sedans because the roadster is popular. On the contrary, development should be pursued on all types because all have their particular and distinctive fields of service.

The annual destruction of last season's stocks by the vainglorious announcements of next season's improvements has forced the radio industry to concentrate its production during only four months of the year and to maintain its factories in virtual idleness during the remaining eight months of the year. Manufacturers do not dare to accumulate stock in excess of the immediate demands and the result of hand to mouth manufacture has been to reduce the quality and grade of workmen who can be attracted to the industry. Look at the advertising now current, and observe that the a.c. set has in no way reduced the simplicity, the tonal quality, or the usefulness of the battery-powered set.

The first radio set manufacturer who promises the public a revolution in radio next year by his UX-222 tube set should be squelched by the radio trade. He is paving the way to wreck the values of existing stocks of a.c. sets. The industry should determine, from now on, to make its announcements of new styles and types modest and in true perspective with the facts, and leave revolutions to Mexican bandits.

The Month In Radio

THE Secretary of the Navy's annual report states that 119,337 vessels were furnished 267,486 bearings by the Navy Radio Compass Service. The savings to other government departments by the use of the naval radio communications service amounted to about a million dollars.

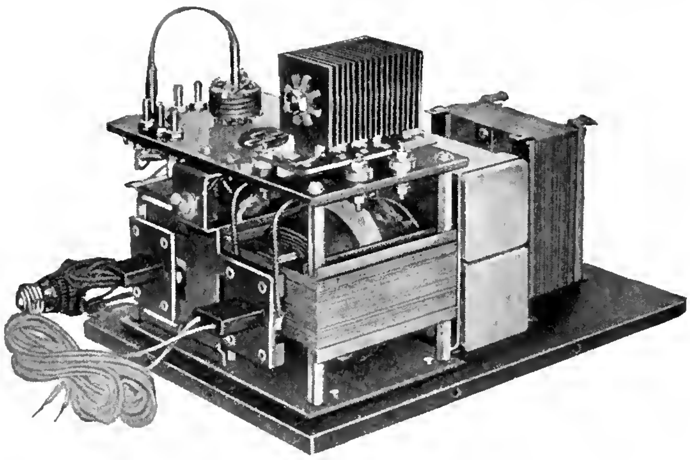
IN A report on beam and directional short-wave radio telegraphy, issued by the Transportation Division of the Department of Commerce, V. Stanley Shute points out the advantage of the American beam system over the British. The American beam antenna requires only ordinary telegraph poles while the Marconi system uses expensive and complex steel masts. Another feature of the American antenna system is that provision is made for the melting of ice, overcoming serious difficulties in winter transmission. This feature is impossible with the Marconi beam. Other advantages, common to both systems of beam transmission, is the possibility of high-speed transmission, economy of power, and stability of the received signal.

Mr. Merlin Aylesworth, in his New Year statement, informs us that the Red, Blue, and Pacific Coast networks, during 1927, spent approximately six million dollars in program presentation, of which over two million was for talent on sponsored programs, presented by some fifty American concerns. The Company itself spent a half a million dollars for its own sustaining programs. Wire cost, involving 10,270 miles of regularly used circuits, was in excess of $1,350,000. ❦ ❦ ❦ Our attention is frequently called to the verbose claims made by Norman Baker, operating direct-advertising station KTNT. He writes listeners that "his is the only station in America that is dedicated to the farm, labor, and general public's problems, which we will always fight for against powerful interests. Do you realize that advertising by radio, cuts overhead expenses so low, that merchandise can be sold at prices meaning from twenty-five to fifty per cent. saving to you?"

We have examined some of these prices, for example, the claim that Mr. Baker is selling "tires, far below others, in fact we sell 12,000 miles guaranteed tires as low as others ask for 8000 miles tires." Specifically, the 30 x 3½ oversize cord, clincher tire, guaranteed for 12,000 miles, sells for $7.70 through KTNT's radio emporium. The corresponding Sears, Roebuck, tire sells for $7.75, making the possible saving less than one per cent. Can this be called a substantial saving?

There is no law protecting the listener against untruthful statements in radio advertising, although firms, subjected to unfair competition, may invoke the aid of legal protection on that ground. ❦ ❦ ❦ Station 3 LO of Melbourne, Australia, has begun to transmit on 36 meters, and has been reported in many parts of the world. The station's organization has made application to install a number of relay stations with a view to making its programs available to all parts of the Australian continent. ❦ ❦ ❦ The Mackay interests will erect a short-wave transatlantic radio station on Long Island to supplement their Commercial Cable Company's submarine cable service. The progress which has been made in short-wave radio telegraph communication makes it unlikely that any more cables will be laid in the ocean.

AT THE BUREAU OF STANDARDS
The illustration shows a field set-up for comparing "coil antennas," more familiarly known as loops



A HOME-CONSTRUCTED A SUPPLY
A view of the A power unit described in this article. It is here shown with the metal cover removed

A New A Power Unit

By Ralph Barclay

THE convenience and desirability of a radio receiver that requires no attention other than to turn it on and off, is obvious, and to produce such a receiver has been the aim of set designers for the last few years. The problem has now been more less surmounted and it is possible to-day to purchase many receivers which are completely a.c. operated.

The design of apparatus for use in conjunction with existing battery-operated receivers to obtain socket power operation has also been satisfactorily solved, and preceding articles in RADIO BROADCAST have described many B power units and A power units which will give socket power operation of a receiver designed originally for use with batteries. These preceding articles have, however, described completely manufactured units, while it is the purpose of the present article to give the characteristics of the Knapp A power unit, parts for which can be obtained for *home* assembly.

The characteristics of the Knapp A power unit are as follows:

(a.) It can be used to supply A power directly from the light socket, to any receiver using up to about ten 201-A type tubes or combination of tubes drawing an equivalent amount of filament current. No changes at all are necessary in the receiver, the two leads from the unit merely being connected to the A plus and A minus terminals on the set.

(b.) The hum audible in the loud speaker when the tube filaments in the receiver are supplied from the power unit is so low as not to interfere at all with reception.

(c.) The cost of operation is very low—about 25 cents per month if the receiver is an ordinary five-tube set, in use an average of four hours a day.

(d.) The cost of a complete kit of parts from which the A power unit may be constructed is $22.50.

(e.) The device requires no maintenance attention other than to turn it on and off.

The circuit diagram of the device is given in Fig. 1. The transformer, T, steps down the line voltage to the correct value, the various taps on the secondary being used to adjust the output voltage. The taps are all numbered and the movable contact should be clipped onto a low-numbered tap if the receiver is a small one; if the receiver contains a large number of tubes, the clip should be placed on a high-numbered tap. The two condensers, C_1 and C_2 designed especially for use in this A power unit, and the filter choke coils, L_1 and L_2, combine to make the final output of the unit free from hum. C_1 has a capacity of about 1000 to 1500 mfd. and C_2 has a capacity of between 1500 and 2000 mfd. It is the design of these condensers, in which compactness combined with high capacity is embodied, that makes possible the A device described here. The choke coils each have an inductance of about 0.1 henry, a resistance of 3 ohms, and a current-carrying capacity of approximately 3 amps. The rectifier, R, is a dry metallic one and the particular unit used in this power unit contains sixteen pairs of electrodes arranged in a bridge circuit to give full-wave rectification. At times, when the power is first turned on, the rectifier will spark over but this does not injure it in any way for the device is self-healing, a characteristic not found generally in rectifiers of this type. The rectifier has a life, according to its manufacturers, generally in excess of 1000 hours. It is held in place by several clamping screws and can easily be replaced when necessary. A new rectifier can be obtained for $6.00.

A complete kit from which the power unit can be constructed should contain the following parts:

T—Transformer
Rectifier Unit
C_1, C_2—Special High-Capacity Condensers
L_1, L_2—Choke Coils
Drilled Base Plate (Copper-Plated Steel)
Drilled Top Plate (Brown Bakelite with Studs in Place)
Contact Plate (With Mounting Bracket)
H & H Toggle Switch
Drilled Baseboard
Metal Cover
A. C. Line Attachment Cord with Plugs
Output Cord for Connecting to Set with Polarized Plug
Complete Instructions for Assembly and Operation
Necessary Nuts, Screws, Clamps, etc.

The constructional data supplied with the kit of parts are very complete and with their aid, the building of the unit may easily be accomplished in an hour or two. The baseboard is all drilled and the first job is to fasten all the parts to it. The unit may next be wired with any ordinary kind of rubber-covered wire.

In order that it may operate most satisfactorily, it is essential that either the A plus or A minus be grounded. In most receivers one side of the filament circuit is grounded but in those cases where this is not true, it will be necessary to connect a ground between the A minus, preferably, and the regular ground post on the receiver.

Light socket operation of a radio receiver is, therefore, a simple matter using a Knapp A power unit and good B power unit. The Knapp A power unit is supplied with an extra plug into which the supply lead for the B power circuit may be connected, and the entire installation is then controlled from the single power lead on the A power unit, and turning on your receiver becomes a matter of merely pushing a plug in a light socket receptacle.

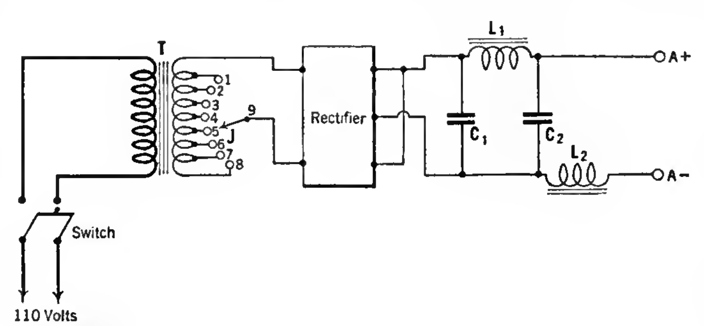


FIG. 1
A circuit diagram of the home-constructed A supply

"Strays" *from the* Laboratory

Poorly-Designed Amplifiers

In the Laboratory at the present moment is an a.c. receiver with a well-known name which uses a three-stage audio amplifier, two stages being resistance-coupled and one transformer-coupled. Although the power tube, a 171 type, draws no measurable grid current, and although the plate current of this tube is constant as measured by a d.c. meter, the quality is bad; something seems to overload. What is wrong?

The transformer couples the detector to the amplifier while resistance-capacity units connect together the remaining amplifier stages. There is no C bias on either of the resistance-coupled tubes (this seems to be standard practice, although one has difficulty in understanding why). To load up the final tube, 40 volts are required on its grid. Since the next-to-the-last tube is coupled to this power tube by a resistance-capacity unit, there is no voltage gain except that due to the tube. In other words, the next-to-the-last tube must have 40 volts a.c. in its plate circuit, necessitating about 5 volts a.c. on its grid, if the amplification factor of the tube is 8, which is correct for a 226 type tube. Five volts a.c. on the grid of a tube which has no C bias will cause severe overloading, and when a voltmeter is placed from the plate of this tube to the negative filament, the needle jumps violently. The voltage between negative filament and the plate battery side of the resistor shows a voltage which is found constant at 175 volts.

When the next-to-the-last tube overloads, considerable d.c. plate current is generated. This plate current generated in the tube, due to overloading, is opposite in direction to the no-signal plate current and the voltage drop across the coupling resistor due to this decrease in plate current reduces the voltage drop across the resistor due to the no-signal current. This allows more plate voltage to be impressed on the tube, so that the plate voltage varies from a steady no-signal value of 25 to 50 on the modulation peaks.

Now let us suppose that the transformer is used to couple the second stage of the amplifier to the power tube, which still requires 40 volts a.c. on its grid. The turn ratio is 3 so that across its primary are required $40 \div 3$, or 13.3 volts which, divided by 8, the mu of the tube, gives 1.67, which is the grid a.c. voltage which the next-to-the-last tube requires. If no C bias is used, much less severe overloading will occur than if 5 volts appear here, and in a fair loud speaker it is true to say that no loss in quality will be noticeable.

The answer is naturally to use C bias on all tubes, but if this cannot be done, the transformer should be used last in the chain. This is a better plan for another reason—that of using as high an impedance as possible in the plate circuit of the detector.

The plate resistors are each of 100,000 ohms value, and for a transformer to have that impedance at 60 cycles—which is as low a frequency as anyone need worry about—its primary must have 160 henries inductance!

This amplifier is clearly a case of poor engineering, and a small amount of pencil and slide rule work would have shown the designers of this receiver what could have been expected before they had even bult one up and put it on the laboratory bench and tested it with expensive instruments.

Quartz Transmitting Tubes

From time to time we read and are mildly amused, about the new glass substitutes which admit ultra violet into our homes—even in large cities where there is practically no ultra violet because of smoke. During the early development of the General Electric's fused quartz, which transmits 92 per cent. of all radiation, from ultra violet to heat, we had the pleasure of working with Dr. Berry of the General Electric Company and the Harvard Cancer Commission, on some uses of this beautifully transparent glass.

General Elec. Co.

A SLAB OF FUSED QUARTZ

The writing would not be legible through a piece of ordinary glass of equal thickness

Fused quartz has another important quality in addition to its transparency to ultra violet. This is its coefficient of expansion which is so low that it is possible to grind telescope lenses of quartz without the many hours of slow work necessary when our best lens glass is used. Under the heat produced by the grinding process the quartz expands so little that there is no danger of cracking, and it is possible to grind the lens to the desired dimensions with less regard to internal mechanical stress.

One of the great difficulties with high-power transmitting tubes lies in the heat generated, which must be dissipated without danger to the glassware. Water-cooled tubes mark one step in the development of safe high-power tubes; another may be the use of fused quartz, as is being done experimentally in England.

We remember a demonstration in a motion picture projection room where glass condensing lenses are used which get very hot and which occasionally crack because of the severe mechanical stress in the glass. A pair of lenses had been made—large pieces of convex quartz carefully ground and polished—and were taken to the motion picture house for test. They worked beautifully, of course, and after the show it was necessary to remove the lenses and take them back to the laboratory.

This would have meant a delay of appreciable time for them to cool if they had been made from glass, but despite the operator's disclaiming any responsibility (the quartz lenses were worth their weight in gold) the lenses were removed, thrown into a pail of water, and within a very few moments they were sufficiently cool to be removed to the laboratory.

While there is no prospect that there will be any need to cool a 100-kw. tube as quickly as this, or that anyone would want to carry such a tube around, hot or cold, a tube that is impervious to temperature changes will relieve engineers from one worry at least.

Fused quartz is wonderfully transparent; one can read a paper through a yard of it; it expands but little under application of heat and, as a matter of fact, is difficult to heat because the radiation passes through it without being absorbed. It has another characteristic—it is frightfully expensive.

Quiet A. C. Sets

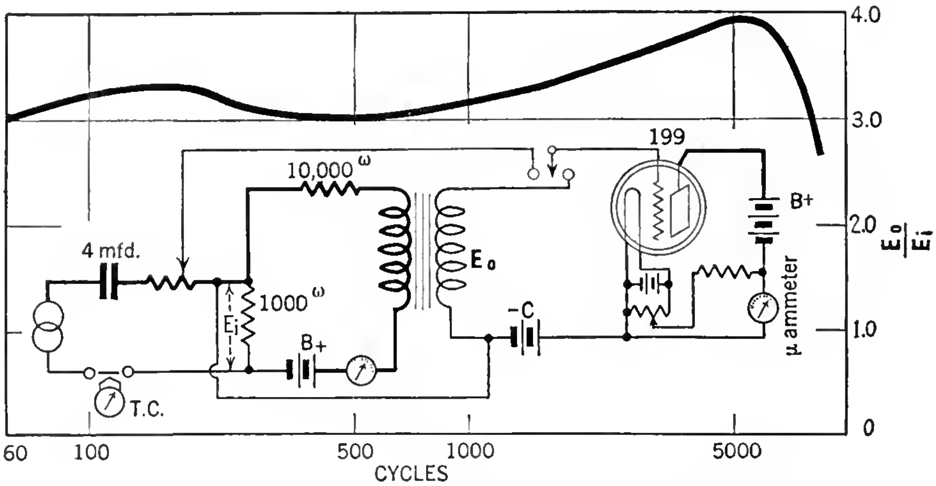
Some interesting tests have been made by the manufacturers of Kuprox, one of the dry rectifiers, on using a combination of rectifier and a.c. tubes. In every case the audibility of hum emanating from the receiver was decreased by the use of partially filtered a.c. on the filaments.

One receiver was a standard five-tube set using McCullough a.c. tubes. With d.c. throughout, the audibility of hum—the origin of which was unknown—was 2; with a.c. on the heaters of these tubes, the hum rose to 250 audibility units, and dropped to 46 when the Kuprox rectifier and a single choke coil was used to rectify and partially filter the a.c. Another receiver was a well-known product requiring no batteries. With d.c. on the filaments and a socket power device for supplying the plate current, the hum was from 120 to 150 units as measured on a General

Radio audibility meter. When the special a.c. converter supplied by the manufacturer furnished power for the filaments, the hum increased to 1000 units, but dropped to from 90 to 120 when the Kuprox was added.

While we do not agree with the manufacturers that Kuprox is "the most important discovery in radio since the first three-element vacuum tube was successfully used", and cannot agree with advertising writers of a.c. sets who state that there is absolutely no hum from their sets, if a Kuprox unit, or other rectifier, and a choke coil, will enable one to use a.c. tubes without appreciable hum, we are willing to advise our friends to go in for a.c. receivers.

At the present moment it is difficult to subscribe whole-heartedly to the apparent craze for a.c. sets. Without a doubt the ultimate receiver will require no attention, will be foolproof, and will operate from any lamp socket, but at the present moment we are not convinced that we should junk our storage battery and charger outfit, which is perfectly quiet and which requires an expenditure of about eight minutes a week to put on and take off the charger, for a newfangled receiver that can be neglected as soon as it is plugged into a socket.



A CIRCUIT USED FOR TRANSFORMER MEASUREMENTS

In the Laboratory the voltage appearing across the secondary of a new type A Sangamo audio transformer was measured with this set up with a constant d.c. flowing through the primary and a constant a.c. voltage impressed upon the primary. The resultant curve is also shown here

While on the question of a.c. operation, we might give the following data on Radio Corporation of America a.c. tubes, which come from the Technical and Test Department of that concern, and are average data of a great many measurements:

Measurements Made with D.C. Filament Supply

ux-226

$E_f = 1.5$ v.; $E_c = -9.0$ v.; $E_p = 135$ v.

Plate Impedance	8000 Ohms
Amplification Factor	8.2
Mutual Conductance	1050 Micromhos
Filament Current	1.05 Amperes
Plate Current	5.2 mA.

uy-227

$E_f = 2.5$ v.; $E_c = -6.0$ v.; $E_p = 90$ v.

Plate Impedance	9810 Ohms
Amplification Factor	8.9
Mutual Conductance	907 Micromhos
Filament Current	1.75 Amperes
Plate Current	3.1 mA.

Into What Impedance Should the Tube Work?

CONSIDERABLE uncertainty seems to exist in the minds of popular writers as to whether the impedance into which a tube works should be equal to that of the tube or several times greater. The answer is that it all depends.

If any source supplies power to a load, the maximum output of power will be absorbed when the effective resistances of the source and the load are equal and when the reactances are equal but opposite in sign. Under these conditions the power absorbed will be the voltage squared divided by four times the effective resistance of the source.

In other words, to supply power the numerical value of the impedances must be equal—to use the usual semi-technical language.

If a tube is to be used as a voltage multiplier, say in a resistance-coupled amplifier, greater amplification will result if the load resistance is several times that of the tube resistance. In a transformer-coupled amplifier, the impedance which the tube looks into—the effective impedance of the primary of the transformer,—should be several times the impedance of the tube at the lowest audio frequency which it is desirable to transmit. At the higher frequencies a combination of effects takes place to maintain the amplification more or less flat. With a good transformer, that is, one which has a very high primary impedance, and a high impedance tube, the amplification will still be peaked. This is the price one pays for amplification—loss in fidelity. If it were possible to make a tube whose impedance would be low and still have a high amplification factor, it would be possible to use good transformers and have high amplification and a high degree of fidelity. Or, if it were possible to build 10:1 ratio audio transformers which would not "go resonant" and otherwise cause trouble at audio frequencies, we should have high gain and high fidelity—but here again we are in difficult water.

This impedance matching problem prompts one reader to ask if it is wise to add resistance to a tube plate circuit in case we desire the tube to work into a resistance several times the internal impedance of the tube and if the load impedance is not this great. A concrete example will illustrate the question. Suppose we have a 10,000-ohm tube and a 10,000-ohm load. Since greatest amplification will result if the load has, say 30,000 ohms impedance, shall we add 20,000 ohms to the plate circuit? The answer is no, unless the voltage across the entire 30,000 ohms is made use of, and not that across the 10,000-ohm load alone. If the additional 20,000 ohms can be included in the load, somewhat greater voltage amplification will result.

Audio Transformer Measurements

THE LABORATORY has recently had the pleasure of measuring, according to the N. E. M. A. standard method already described in these columns, the voltage appearing across the secondary of the new Sangamo Type A audio transformer when a constant d.c. current flowed through the primary, and when a constant a.c. voltage was impressed upon the primary in series with 11,000 ohms. The circuit is given on this page as well as a curve representing the result of the measurement, which should be interesting to all pursuers of fidelity in reproduction.

As mentioned before, we do not believe measurements, such as this, on single transformers without accessory tubes and common impedance which always exist in a standard two-stage amplifier, mean a great deal, because we have found in practice that the curve obtained by measuring the voltage across an output resistance of a two-stage amplifier may differ altogether from what one obtains by measuring a single stage only. This should not be taken to indicate that a two-stage amplifier using Sangamo Type A transformers would not be as good as is indicated in our curve—it might be better. It all depends upon the care taken in the construction and the amount and kind of feedback existing in the circuits.

A single Silver-Marshall type 220 audio transformer falls off badly above 3000 cycles when measured singly, while a two-stage amplifier using these transformers is perfectly good up to 5000 cycles, the additional amplification at these higher audio tones being due to regeneration. Many two-stage amplifiers will howl or sing at the higher audio frequencies if sufficient impedance exists in the common negative plate-battery lead. This difficulty is easy to remedy, usually, and necessitates the use of a 2-mfd. condenser across the B batteries, or socket power device. The transformers used in such amplifiers usually have a rising characteristic when measured singly, as was done in the Laboratory to measure the Sangamo transformer.

AN EARLY PICTURE OF MR. HOGAN
He is here shown using the first audion ever made, at which time he was DeForest's Laboratory assistant

An Interview With J. V. L. Hogan

By Edgar H. Felix

NO INDUSTRY is more clearly the product of inventive ingenuity than radio. If necessity is the mother of invention, radio must take after its paternal parent—creative imagination. It has grown to its imposing importance, not by virtue of necessity, but by discovering for itself a new field—the bringing of entertainment into the home.

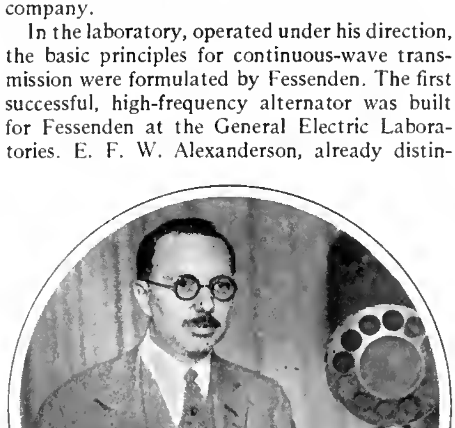
"It is my belief" says John V. L. Hogan, pioneer radio engineer and technical authority, "that a vital and fundamental change has taken place in the spirit of the industry. Instead of a competition of ingenuity, the majority of manufacturers are now content to copy the designs of a few leaders who shape the trend from season to season."

Mr. Hogan is qualified to speak of the spirit of the radio industry because he has been intimately associated with the progress of that industry for more than twenty years. Shortly after Marconi had sent his famous first signal across the Atlantic in 1901, Hogan, then a boy in his teens, witnessed a demonstration of wireless telegraphy at the University of Wisconsin. Two years later, he spent a summer at San Juan, Porto Rico, most of it within the four walls of the radio station there. As it has with so many after him, radio made short work of its victim, imbuing him with its incurable fascination. From then on, radio has been his principal interest in life. He did not lose time in associating himself with the best minds in the art.

During 1906 and 1907, Hogan worked as DeForest's laboratory assistant and, in that capacity, used the first audion ever made. After his association with DeForest, he continued his studies at Yale University, specializing in mathematics and physics. But, before his work was completed, Reginald Fessenden, recognizing his natural ability for conducting experimental work, employed him to assist with his experiments at Brant Rock, Massachusetts. Here, in 1909, the Arlington Naval Station transmitter was designed, assembled, and tested. Mr. Hogan's association with Fessenden extended over a period of many years.

After completion of the Arlington transmitter and its acceptance by the United States Government, Fessenden and his National Electric Signalling Company transferred their activities to Bush Terminal in Brooklyn. Hogan became chief research engineer and later manager of the company.

In the laboratory, operated under his direction, the basic principles for continuous-wave transmission were formulated by Fessenden. The first successful, high-frequency alternator was built for Fessenden at the General Electric Laboratories. E. F. W. Alexanderson, already distinguished by his achievements in electric railway locomotive design, was assigned to the problem and successfully built and later perfected the high-frequency alternator. These were fruitful periods of research, both in transmission and reception. Hogan is credited with many inventions, perhaps the most important of which is the detector heterodyne which he described in the Proceedings of the Institute of Radio Engineers in 1913. He was a founder and later became president of that body.



J. V. L. HOGAN

Fessenden is the inventor of the heterodyne principle. In its original reduction to practice, two windings in the telephone receiver were used, one to carry the incoming detector signal and the other to superimpose the local high-frequency oscillations. Hogan's invention is the method of combining the incoming signal with the local heterodyne signal before detection by an electrical rectifier. Owing to the square law action of the detector, enormous increases in sensitiveness are attained, accounting largely for the effectiveness of the regenerative and superheterodyne systems. He was also the first to disclose the advantages of single control, so widely applied in broadcast reception, even before the various tuning circuits of receiving sets followed any law of regular and equalized progression.

Identified so closely with the early growth of radio, Hogan is now recognized as a leader in the patent and engineering fields. His views on the patent situation of to-day and the causes underlying its complexity are founded on the best possible authority.

"Contrasting with the early tendency toward extraordinary ingenuity," said Mr. Hogan, in answer to the writers' request that he amplify the statement which opened the interview, "the radio industry has largely adopted the habit and practice of copying the designs developed by the leaders of the industry. For example, the most widely used modern radio receiver, almost a standard design for the entire radio industry, is the alternating-current, tuned radio-frequency set, employing no batteries, self-contained with all the necessary power supply, and using a single-control tuning system.

"Following so closely the same design principles, practically all makers use the same inventions, covered by the same patents. With such a formidable array of patents, some adjudicated and some not, the decisions of the courts are bound to have salutary results upon the economic situation in the radio industry. As an example of the effect of only a single patent, the recent adjudication of the Alexanderson tuned radio-frequency patent was sufficient incentive to more than twenty of the leading manufacturers of the industry to obtain licenses from the Radio Corporation of America, which holds the right to issue licenses under this patent. If future adjudications continue favorable to the Radio Corporation, these licensees will not suffer any great changes in their status. But suppose that the Latour, the later Hazeltine, the Lowell and Dunmore patents, and some of the other patents whose scope and validity are not yet tested in the courts, should be adjudicated in favor of their holders, there may be another set of substantial royalties to pay. The holders of patents applying to vacuum tubes, such as the thoriated filament, pure electron discharge, and the magnesium keeper, may collect large penalties from independent tube manufacturers who have so far disregarded them.

"The radio industry has problems still ahead of it," continued Mr. Hogan, "although there is no doubt that they do not mean its destruction or its paralysis. Their existence is due to a very fundamental weakness in the present conduct of most manufacturers in the field, namely, the tendency to stereotype and imitate.

"The radio industry has not always been prone to follow the designs of its pioneers, but showed independent inventiveness on the part of many individuals. Marconi, in the early days, held a patent on the insulated, grounded antenna. Instead of waiting for the adjudication of that patent, or entirely disregarding it, rival inventors worked out means so that they would not have to use the Marconi antenna system, by devising the loop type of aerial for instance.

"In the field of detectors, after the coherer and the magnetic detectors had been invented, the manufacturers in the field simply developed other forms of detector. The electrolytic of Fessenden, the crystal detector, and the three-element vacuum tube of DeForest, each a valuable contribution to the industry, were invented to improve service and, at the same time, their manufacturers and users were practically cleared of infringement of existing patents. Thus patents, instead of serving as a constricting and restraining influence, were the stimulus to making some of the most important inventions in the radio art.

"Only three sensible courses are open to those who find patents apparently covering devices which they desire to make or actually do make," said Mr. Hogan. "They are either pay, or fight, or don't use. The second of these is often hazardous. Many members of the radio industry elect a still more hazardous course—to use without paying until patents are adjudicated. Naturally, these are likely to have to pay dearly in the end. Many of those who fight do so in the spirit that patents are a danger and a menace, to be fought and destroyed, though this is obviously not a sound position. When forced to do so, they pay reluctantly because there is no other course open to them, rather than encouraging inventions and utilizing them legitimately and without restriction. The alternative of developing new means so as to avoid infringement is the one least used, although it is the course that would contribute most to the progress of radio."

Mr. Hogan cited specific instances of unadjudicated patents which are almost universally used by the industry and which manufacturers are seemingly making no effort to circumvent by developing substitute or improved means. He even showed how, in the field of broadcast transmission, the tendency is to endeavor to make the best of conditions as they are instead of attempting seriously to develop and put into use new means and methods.

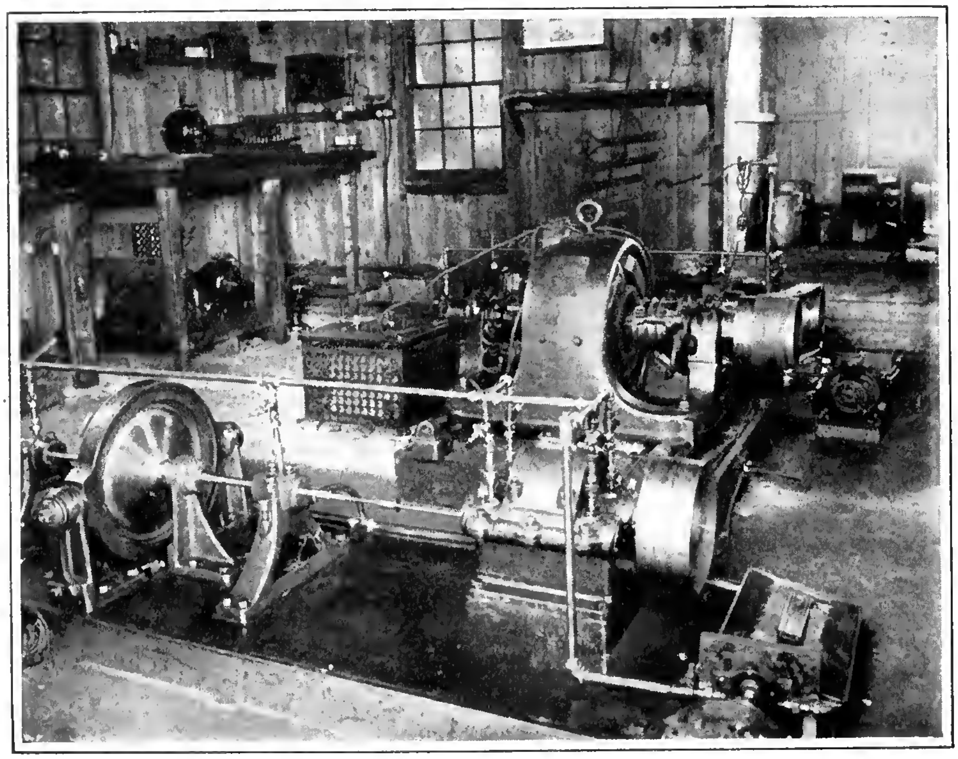
Mr. Hogan has had exceptional opportunities in studying transmission phenomena. Fessenden was one of the first to build a successful radio telephone transmitter, having established a record of several hundred miles' range as early as 1906. When the Arlington transmitter was still installed at Brant Rock, prior to its acceptance by the Navy, a most comprehensive series of tests, the first extensive study of radio transmission phenomena, were made with its aid. Data as to attainable range, with various powers, at all hours, were collected aboard the U. S. S. *Birmingham*. Out of this mass of data, the historic and useful Austin-Cohen formula was worked out. Hogan was intimately concerned with these tests, being in entire charge of the Brant Rock end. With such pioneer study of transmission phenomena as a foundation and the many subsequent years of research and contact, his suggestions as to the most effective way to attack the present broadcasting problem are worthy of most profound consideration.

"The limitations of our ether channels are almost as definite and specific as familiar laws of physics," Mr. Hogan stated to the writer. "The number of solid bodies of a certain size that can be fitted into a room of certain dimensions is readily calculated and no one attempts to deny the operation of the law which determines it. In the available ether, likewise, there are just so many broadcasting channels, each of which can accommodate just so many stations of a certain power. There is no evading this law. If we squeeze more programs than fit in our ether space, the programs are certain to be damaged.

"The number of stations which can be accommodated in the broadcasting band is directly a factor of their power. Either we maintain many stations comfortably in the band by reducing their power, or we increase their power and reduce the number of stations. If we exceed the capacity of the ether, as we are doing at the moment, we have confusion. There is no successful evading of technical laws upon which the capacity of the ether is founded, unless we establish new laws by making new discoveries. As in patent tangles, so in ether tangles, inventions may cut the Gordian knot.

"To continue to increase the number and the power of stations on the air, we must attain such objectives as perfect synchronization of carriers and their modulation, limitation of carrier range to the area actually served by programs, or modulation of the carrier in a new way which narrows the band occupied by a fully modulated carrier. None of these things is impossible, but how much more energy is spent by broadcasters in clamoring to stay on the air than in developing the means which will make room for them on the air.

"Founded, as the radio industry is, upon ingenuity and invention, the work of the research laboratory is still its most valuable asset and is still the only really effective gateway to the solution of its problems. Mere imitation is fatal to its growth and to its economic future. To-day, for every dollar spent on research, hundreds of dollars are spent on imitation. The crying need of the industry is research and originality, the employment of engineering genius and continuous technical growth. With proper concentration on these factors, patent difficulties will be mitigated and the fullest potentialities of the industry and its field of service will be developed."



THE FIRST PRACTICAL HIGH-FREQUENCY ALTERNATOR

It was built for Fessenden at the General Electric Laboratories, by E. F. W. Alexanderson. The latter is now in the public eye on account of his television experiments

Radio Broadcast Photograph

THIS IS HOW THE COMPLETED RECEIVER LOOKS
It fits into any standard cabinet that will take a 7 x 18 inch panel

A Four-Tube Screened-Grid Receiver

By McMurdo Silver

THE four-tube all-wave receiver described herewith represents what is probably the most profitable application to a radio receiver of the new screened-grid tube, from a performance per dollar per tube standpoint.

The new screened-grid tubes, offered, as they have been, by the tube makers with little or no actual practical operating data, present most attractive possibilities to the experimentally inclined by virtue of the increased amplification that they theoretically make possible. The application of one of these tubes in the four-tube all-wave receiver described here provides a receiver of high sensitivity, selectivity, and general worth, and the methods of utilizing the UX-222 (CX-322) tube should be of considerable interest to the experimentally inclined in view of the dearth of practical operating information; a number of misconceptions concerning the UX-222 tubes have already arisen in the minds of many radio fans.

The receiver pictured in the accompanying illustrations employs one UX-222 tube in a tuned r.f. amplifier stage with conventional transformer coupling between this tube and the detector, despite popular belief that the UX-222 tube should work with tuned impedance coupling. The detector is made regenerative by the use of a fixed tickler winding, with regeneration controlled by a midget variable condenser. The two-stage audio amplifier, employing two large-core heavy 3:1 ratio transformers, provides a practically flat curve from below 100 cycles to over 5000 cycles. The measure of the receiver's true worth is its performance compared against other sets. Operated in a steel building in Chicago with a forty-foot wire hanging out of a window for an antenna, a model set brought in stations within a range of 1000 to 1500 miles on the loud speaker, while KFI, in Los Angeles, was faintly heard on the loud speaker through local interference. A couple of popular one-dial factory sets on the same table refused to "step out" at all. The four-tube receiver was moved to a Chicago suburb, where it brought in stations on the East and West coasts with ample loud speaker volume, pulling in some fifty stations in one evening on a fifty-foot antenna. Yet the parts for the whole set cost less than $50.00.

THIS article describes a four-tube receiver which is notable chiefly because of its economy—all the parts listing for a total of $46.75. This feature alone should attract many a home constructor and professional set builder. As the author states in the article, the use of the screened-grid tube increases the voltage to the detector, from a distant station, about twice compared to that delivered by a 201-A type tube. This gain is not all that the new shielded-grid tube is capable of producing, but is about all that is possible in a single stage and with the requisite degree of selectivity. This is a distinct gain, and is desirable, and is due to the new tube alone, but the home constructor should not expect a doubling of voltage before the detector to work miraculous results on extreme DX; it means, simply, that louder signals will be received without the bother of neutralizing apparatus or tricky adjustments. The receiver delivers excellent tone quality.

—The Editor

In developing the set, experiments were started on the basis of individually shielded stages for the r.f. amplifier and detector, using tuned impedance coupling as recommended in the UX-222 data sheets. It was immediately found that, while quite high amplification could be obtained, varying from 20 per stage at 550 meters (545 kc.) to about 55 per stage at 200 meters (1500 kc.), the amplifier was far too broad for practical use. Using the optimum value of coupling between r.f. amplifier and detector, the selectivity was even worse, though the amplification increased. All this was previously predicted by mathematical analyses of the system, which experiments simply served to confirm. Tuned impedance coupling was then abandoned, and a standard tuned r.f. transformer employed, having a secondary coil equivalent to the coil previously employed in the tuned impedance amplifier circuit. This transformer was provided with adjustable values of primary coupling. and a series of amplification measurements were made at different wavelengths, the different primary sizes providing varying degrees of selectivity. Some representative amplification curves are reproduced in Fig. 1. The final transformer selected employs ninety turns of No. 20 plain enamelled wire wound on a threaded moulded bakelite form, with turns spaced to provide low r.f. resistance, this coil being tuned by a 0.00035-mfd. variable condenser to cover the wavelength band from 200 to 550 meters (1500 to 545 kc.). The primary consists of 55 turns of No. 32 d.s.c. wire wound on a 1½-inch tube slipped inside the secondary form, the primary winding being at the filament end of the secondary. The actual amplification obtained with this coil and a UX-222 tube is shown on the accompanying curves, varying from 11 at 550 meters to 35 at 200 meters for the stage. This value is very low as compared to the mu of the UX-222 tube (about 250) but it is about all that can be realized without adversely affecting the selectivity. Actually, the figure of merit for the UX-222 tube is only about twice that of a UX-201-A, despite its misleadingly high amplification factor, so that it is entirely proper that the actual amplification obtained in practice from the UX-222 tube should only be about double that of a UX-201-A tube, *at substantially equal values of selectivity*. As stated, throwing selectivity to the winds, the gain could be almost redoubled—an impossible condition in practice.

At this point, conclusions arrived at on the laboratory bench were checked experimentally, and it was found that shielding was not necessary or even helpful in the four-tube circuit, providing the coils were spaced about twelve inches apart, as has been done in the final receiver layout. Precautions were taken to keep coupling between the r.f. amplifier and the detector circuits at a minimum by proper bypassing, but even with shielding it was found that "motor-boating" was experienced when the detector was adjusted for critical regeneration. An analysis of the UX-222 tube's action indicated that this was due to changes in screen grid current reacting on the detector, and vice versa, through the coupling of the B battery. This was eliminated by an r.f. choke in the screen grid lead. The operation then became entirely stable, and the results obtained in tests were quite gratifying.

The physical aspects of the set are well illustrated in the photographs. On the attractively decorated walnut-finished metal front panel are mounted the vernier drum dials controlling the two 0.00035-mfd. tuning condensers, which are of the modified straight frequency-line—straight wavelength-line—type. These drums read nearly alike in operation, log definitely for any station

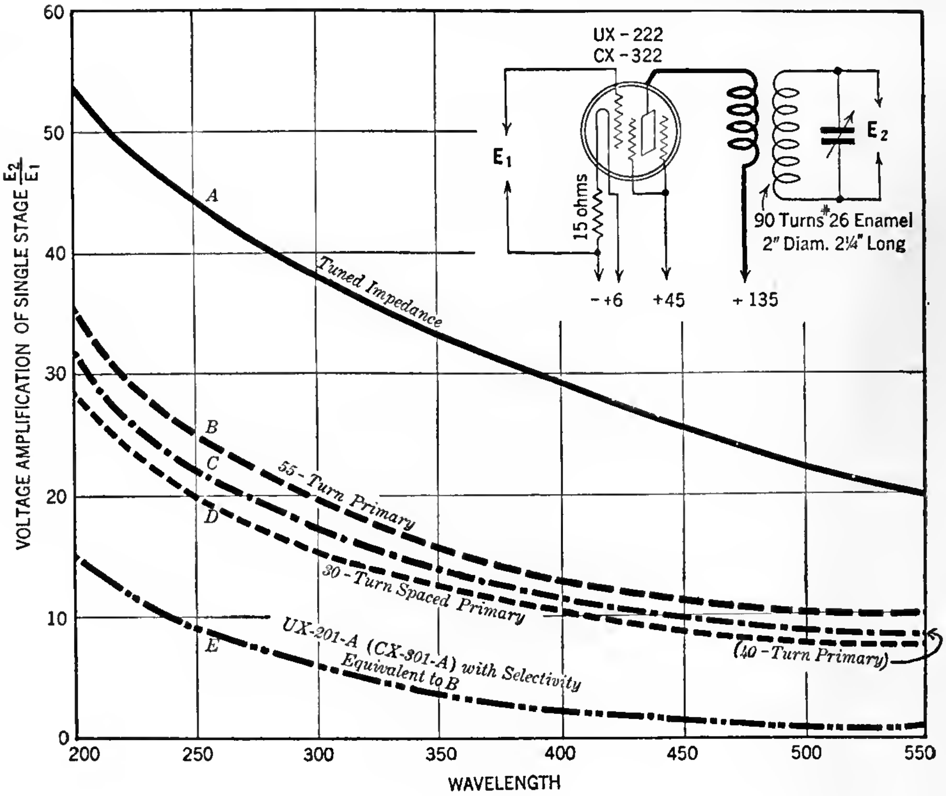


FIG. 1

heard, and are provided with small lamp brackets for illumination. Between them is the 0.00075-mfd. midget condenser controlling regeneration, and below it the 50-ohm rheostat controlling the filament voltage of the UX-222 tube to regulate volume. Attached to the rheostat is an automatic "On-Off" switch turning the set on or off at will.

The a.f. amplifier is unusual in that it employs UX-112-A (CX-312-A) type tubes in both the first and second stages. The first stage operates at 135 volts plate potential, with 4½ volts C bias. These values insure good handling capacity and a low plate impedance, favoring good bass-note reproduction. The second stage should have from 135 to 180 volts of B battery with 9 to 12 volts of C bias. At the higher value, the undistorted power output is nearly 300 milliwatts, a respectable value. Of course, a UX-171 (CX-371) tube could be used with greater undistorted power output, but in this case an output device should be used. The total current consumption of the whole set is about 15 milliamperes, a very low value even for battery operation.

The simplicity of the front panel is in keeping with the general design of the receiver, which is simple in the extreme. All parts not on the panel are mounted on the wood sub-base. The antenna coil and coil socket are at the left end, and the r.f. transformer and its socket at the right end

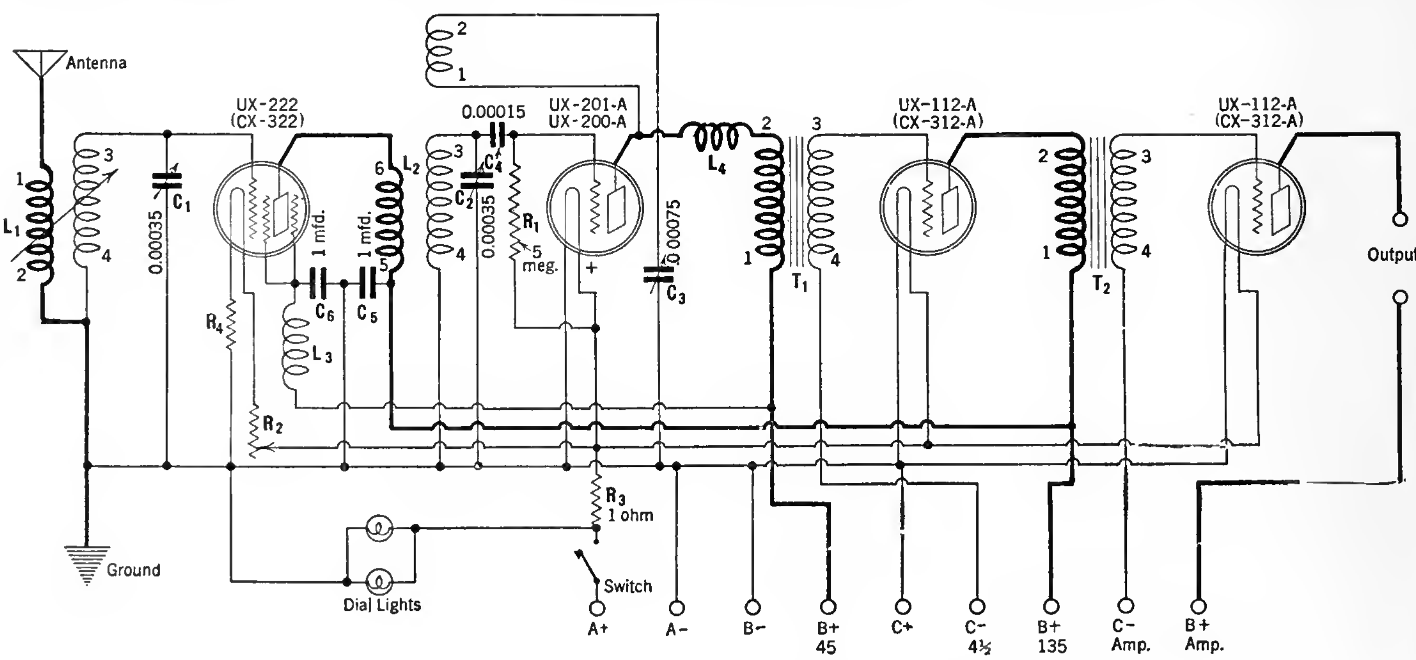
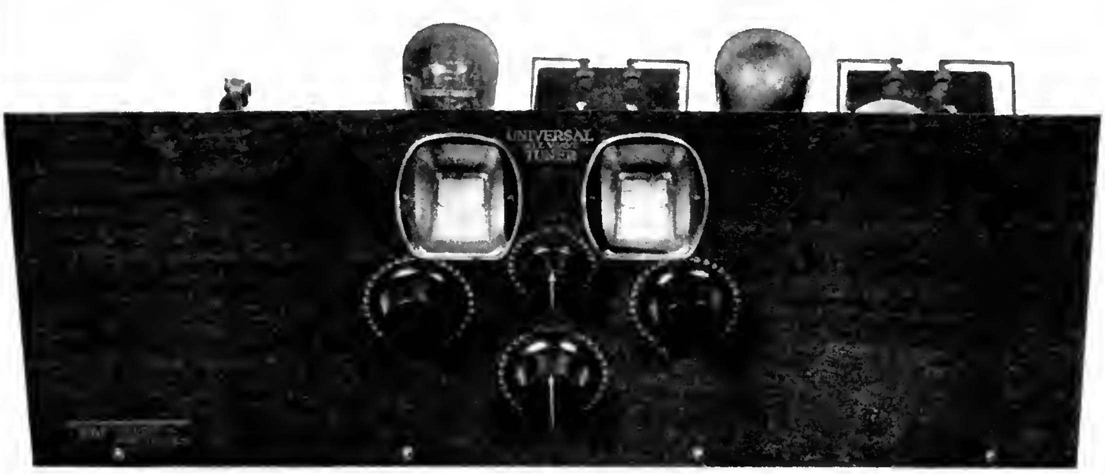


FIG. 2

The schematic diagram of the four-tube receiver which uses a screened-grid r.f. tube



A CLOSE-UP OF THE FRONT PANEL

of the base. On the baseboard beneath the variable condensers are fastened the 1.0-mfd. bypass condensers. The positions of all other parts is clearly illustrated in the photographs.

The actual parts used in the set are listed below, and due to the possible complexities that might arise on account of the UX-222 tube, it would be well not to substitute other parts for those specified, particularly as the wavelength ranges might also be affected were parts of the oscillating circuits changed in any way.

LIST OF PARTS

L_1—S-M 111A 190-550 Meter Antenna Coil	$ 2.50
L_2—S-M 114SG 190-550 Meter R.F. Transformer	2.50
Two S-M 515 Universal Interchangeable Coil Sockets	2.00
L_3, L_4—S-M 275 Chokes	1.80
T_1, T_2—S-M 240 Audio Transformers.	12.00
C_1, C_2—S-M 320 0.00075-Mfd. Variable Condensers	6.50
C_3—S-M 342 0.000075-Mfd. Midget Condenser	1.50
C_4—Sangamo 0.00015-Mfd. Condenser	.40
C_5, C_6—Fast 1-Mfd. Condensers	1.80
R_1—Polymet 5-Megohm Grid Leak	.25
R_2—Carter IR50-S 50-Ohm Switch Rheostat	1.50
R_3—Carter H1 1-Ohm Resistance	.25
R_4—Carter H15 15-Ohm Resistance	.25
Polymet Grid Leak Mount	.50
Ten Fahnestock Connection Clips	.50
Four S-M 511 Tube Sockets	2.00
Two S-M 805 Illuminated Vernier Drum Dials	6.00
7 x 17 x ½ Inch Wood Baseboard with Hardware	1.50
Van Doorn 7 x 18 Inch Decorated Metal Panel	3.00
TOTAL	$46.75

The assembly of the set is very simple. The condensers are first mounted on the dial brackets, the drums attached, and the brackets fastened on behind the front panel, which also carries the dial windows and the small dial lamp brackets. The rear of the panel should be scraped to insure good contact between the panel and dial brackets and the same precaution should be observed in mounting the midget condenser so that its shaft bushing makes good contact with the panel. The switch rheostat should be thoroughly insulated from the metal panel by means of two extruded fibre washers.

All parts mounted on the base are screwed down as shown, taking care that terminal 3 of the antenna coil socket is to the right, and post 3 of the detector coil socket (r.f. transformer) is to the left. The positions of these sockets, audio transformers, etc., should be exactly as shown, all being screwed down using roundhead No. 6 wood screws from ⅜ inch to 1⅜ inches (for the r.f. chokes) long.

The wiring is simple, and clearly illustrated in the schematic diagram, Fig. 2 in which all instruments represented by symbols, carry exactly the same numbers and markings in the diagram as they do physically. All grid and plate leads are of bus-bar, in spaghetti where necessary, while all low-potential battery wiring is grouped along the center of the base, and is of flexible hook-up wire. After all wiring is done, the central group is cabled, or laced, using waxed shoemaker's thread. The Fahnestock clips are used for battery connections.

Testing and operating the set is very easy, and involves the use of standard accessories as listed below:

Two UX-112-A (CX-312-A) Tubes
One UX-201-A (CX-301-A) Tube
One UX-222 (CX-322) Screened-Grid Tube
One Western Electric Cone Loud Speaker
One 6-Volt A Battery
Three (or Four) 45-Volt Heavy-Duty B Batteries
Two 4½-Volt C Batteries

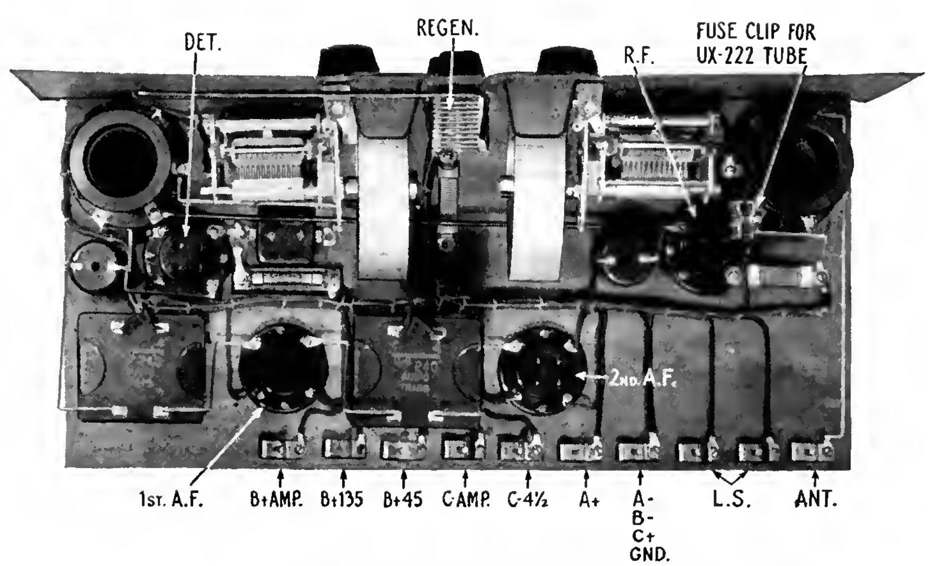
With the batteries connected and tubes in place, the rheostat should be turned full on, which will give 3.3 volts to the UX-222 tube under average conditions. With the midget condenser all in, the right-hand tuning dial should be rotated until a squeal is heard (every squeal is a station). The squeal should be tuned-in loudest by proper adjustment of the left-hand and right-hand drums. If the midget condenser is then turned out slowly, the squeal will disappear and the station program be heard. Volume may be controlled by the knob, adjusting R_2. In tuning for local stations, the regeneration condenser can be left set about one quarter in (far enough out so that no squeals are heard), but in tuning for distant stations it should always be turned in far enough to make the detector oscillate, and stations first picked up as a squeal, and then cleared up by turning the regeneration condenser out slowly to cut out the squeal and get the program. The set is most sensitive, the operator will find, with the regeneration condenser just barely out of the squealing condition.

The rotor in the antenna coil may be adjusted with the fingers to give greatest sharpness of tuning on the left-hand tuning dial. When set at right angles to the coil form, greatest selectivity and least volume will be obtained.

By using a 111D antenna coil and a 114D r.f. transformer in the coil sockets, the set will tune from 500 to 1500 meters (600-200 kc.). A 111E and a 114E coil will go from 1400 to 3000 meters (215-100 kc.). To operate below 200 meters (1500 kc.), the screened-grid r.f. amplifier is cut out entirely and the antenna connected to post 3 of the detector coil socket through a 0.0000-25-mfd. variable midget coupling condenser, such as the S-M 340. With this connection, using the right-hand condenser dial only to tune the regenerative detector, the three-tube set will tune from 70 to 210 meters (4285-1430 kc.), with a 114B coil, from 30 to 75 meters (10,000 to 4000 kc.), with a 114C coil; and down to about 18 meters (16,660 kc.) if the stator winding of another S-M 114C coil is cut down to four turns. It is not desirable to use the UX-222 r.f. amplifier stage below 200 meters, the three-tube portion of the set being amply sensitive for all short-wave reception.

It will be necessary to shunt the regeneration condenser with a fixed capacity of about 0.0001 mfd. to cause oscillation at the frequencies below the broadcast band.

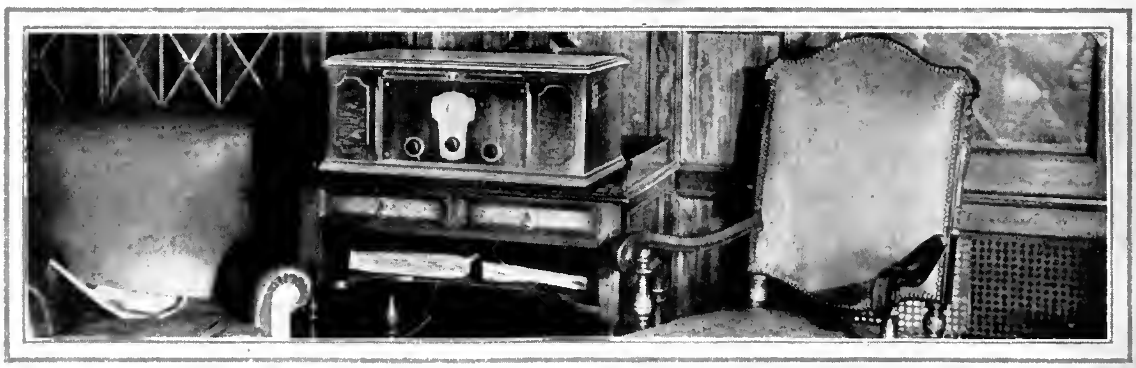
Of course, suitable A or B power devices may be used with the set, glow-tube equipped B units being most satisfactory.



SHOWING THE ARRANGEMENT OF APPARATUS ON THE BASEBOARD

Some New Loud

THE richness of its selected woods instantly distinguishes this beautiful Bosch receiver (shown to the left) from the commonplace. The model 87 is a seven-tube table type receiver having four stages of balanced radio-frequency amplification, a detector, and two transformer-coupled audio stages. Exceptional selectivity is possible, while provision is made for very exact and gradual control of volume. Needless to say, there is but a single dial for station selecting, and this is graduated in kilocycles. Engineering features make the receiver adaptable for all forms of power supply, while there is a switch on the front panel which not only controls the power for the tubes, but automatically turns on or shuts off the battery charger, B supply device, and all other power equipment. The model 87 is priced at $195.00

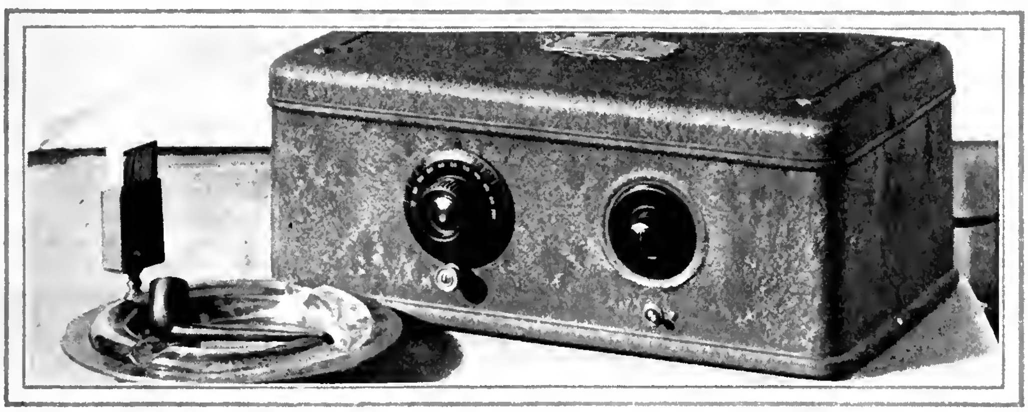


ANOTHER unique loud speaker by Amplion—the "Shield." The unusual lines and artistic appeal of the "Shield" lend charm to whatever surroundings it may be required to form a part of. The cabinet construction is entirely new in radio reproducer construction. The new-process embossed walnut panelling is attractively curved, and combines a grille front and back. The cone has a diameter of 16½ inches. Height, 22 inches. The Amplion "Shield" retails at $67.50

A NEWCOMER to the ranks of the electric set is depicted above—in the form of the Kolster 6J table type receiver. The new a. c. tubes make possible the 6J, which is a six-tube receiver employing three r. f. stages, and having built-in power equipment. All that is necessary to start the set operating is to insert the tubes, connect a loud speaker, antenna, and ground (or loop), and plug in to a light socket. Tuning is accomplished by means of a single control. The 6J retails at $250.00

Speakers and Sets

A BEAUTIFUL example of what Federal, Buffalo, is offering—the E45-60 "Ortho-sonic." While the price ($160.00) of the model shown is a little high for the average man's purse, it is worth while to remember that Federal has an equally attractive five-tube table model for only $100.00. The picture shows a completely a. c. operated six-tube receiver with a built-in loud speaker. Tuning is accomplished by means of a single knob, and the graduated scale is illuminated to facilitate tuning. Its remarkable selectivity is a feature claimed for the E45-60, but this is not obtained at the expense of tone quality. The height is 54½ inches, the depth is 17¾ inches, and the width is 30¼ inches. The cabinet is an original design in figured walnut with overlay of fiddle-back mahogany. The knobs and pendants are burnished.



THE new Atwater Kent a. c. receiver is shown in the illustration above. It is indeed a remarkable piece of engineering—a complete radio installation, with the exception of the loud speaker—in a metal cabinet 7¼ inches high and 17¼ inches long. The apportioning of the six tubes is as follows: Three r. f. stages, detector, two transformer-coupled audio stages. Single control tuning is featured, and the built-in power unit is shielded from the rest of the receiver. Absolutely no batteries are necessary for operation. The price of the Model 37 Atwater Kent a. c. receiver is $88.00

A WELCOME newcomer to the loud speaker field is pictured to the left. It is the "Air Chrome," a product of the Air-Chrome Studios, Irvington, New Jersey. Tests in RADIO BROADCAST Laboratory have shown this loud speaker to be capable of exceptional tone reproduction, while its efficiency is claimed by the manufacturers to exceed that of the best cones on the market. The "Air-Chrome" is not a cone loud speaker although in appearance it somewhat resembles one. The console model shown retails at $65.00, there being a choice of design in so far as the tapestry front covering is concerned. The loud speaker without cabinet is priced at $25.00

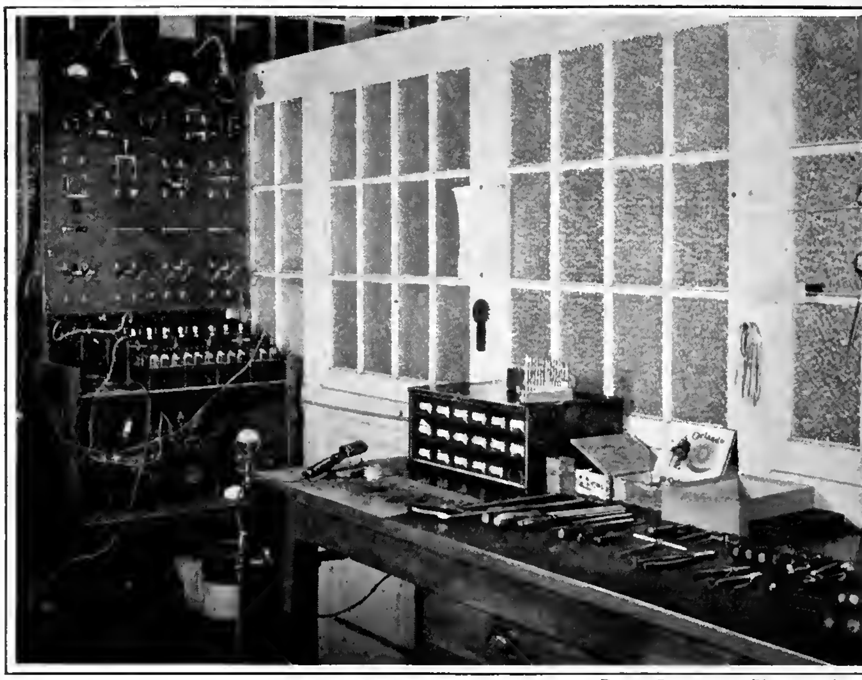
The Armchair Engineer

Keith Henney

Director of the Laboratory

TO THE RIGHT

This illustration shows a corner of the Radio Broadcast Laboratory. As the accompanying article explains, it is not necessary to have a laboratory or costly instruments at ones disposal to conduct interesting radio experiments. A piece of paper, a pencil, and a slide rule are sufficient to enable one to learn a lot about the design and operation of radio circuits, etc.



Radio Broadcast Photograph

THERE are several interesting and perhaps instructive investigations of receiver design that one may explore without a laboratory full of expensive apparatus. A slide rule, a pencil, and some paper, are all that are necessary.

For example, let us consider a conventional two-stage transformer-coupled audio amplifier with an output device to protect the loud speaker from the d.c. plate current of the last tube. There are two methods of connecting the loud speaker to this amplifier, as shown in Figs. 1 and 2. The turn ratio of the first audio transformer let us suppose to be T_1, and that of the second to be T_2; μ_1 and μ_2 are the amplification factors of the first and second tubes respectively. The detector of this set-up also secures its plate current from a common source, represented by the box at the left. In the first case the loud speaker is connected to the negative lead of the final amplifier tube. Now let us suppose that a 1000-cycle note comes into this system producing an a.c. voltage of 50 across the output choke, which, if it is very good indeed, will have an inductance of 40 henries, or an impedance at 1000 cycles of about 250,000 ohms. If the loud speaker has an impedance of only 4000 ohms at this frequency, most of the a.c. current will flow through the loud speaker, as is desired. This 50 volts across the choke is arbitrarily chosen, and the absolute value does not matter for our present discussion. Fifty volts is probably higher than is encountered in practice.

Fifty volts across the 250,000 ohms impedance of the choke will send through it a current of about 0.2 milliamperes which, to return to the filament of the last tube, must go through the B battery leads, through the 2-mfd. condenser across the plate supply unit, and thence to the filament. The 2-mfd. bypass condenser has an impedance of about 80 ohms at 1000 cycles (this may be found by reference to laboratory sheet No. 127, in the September, 1927, Radio Broadcast) and the voltage across it, obtained by multiplying the impedance by the current, is roughly 0.016 volts, most of which is impressed across the primary winding of the first audio transformer because of its high impedance compared to the plate impedance of the tube. This tone will go through the amplifier, and will be amplified accordingly, and if there are an odd number of stages securing plate voltage from this common source, say a detector and two audio stages, and if the transformer primaries are "poled" correctly, the final voltage appearing across the output choke will not only be amplified but will be in phase with the original voltage.

The problem is to find out how strong this voltage becomes by going through the amplifier. If the transformers are 3:1 each and the first tube has an amplification factor of 8, and the final tube (an UX-171 or CX-371) an amplification factor of 3, the maximum amplification will be the product of these factors, or 3 x 3 x 8 x 3, or roughly 200. In the plate circuit this voltage will divide, part being lost on the 2000-ohm plate impedance of the output tube and part appearing across the 4000-ohm output impedance (choke and loud speaker). As a matter of fact two-thirds of the voltage will appear across the choke so that the voltage finally appearing there will be 0.016 x 200 x $\frac{2}{3}$, or about 2.1. In other words, the original 50 volts which appeared across the output choke have returned in phase but have been decreased to 2.1 volts.

Now let us consider Fig. 2. Here all a.c. components in the plate circuit of the last tube must go through the plate supply before they can return to the filament of the power tube. The impedance of the choke is lowered by the shunt impedance of the loud speaker, say to 4000 ohms, and if the same 50 volts appears across this load impedance the a.c. current through it will be 50/4000 or 12.5 milliamperes, which will produce a voltage of 1.0 across the 2-mfd. condenser, and this finally appears as 1.0 x 200 x $\frac{2}{3}$, or 135, volts. Since this "feedback" voltage is greater than the original voltage, and may be in phase with it, an endless chain results and the amplifier turns itself into an excellent oscillator, singing at some frequency determined by the constants of the circuit, usually at the point where the maximum amplification of the audio transformers takes place, say about 5000 cycles.

This is exactly what happens in an oscillator; part of the output is fed back to the input so that it is amplified through the tube and again impressed across the output.

In the amplifier under discussion the feed-back is caused by the impedance of the plate supply unit which is common to all of the amplifier stages. If the bypass condenser is increased (which decreases the total impedance) the tendency to oscillate becomes less, since the feedback voltage impressed upon the input to the amplifier decreases with decrease in common impedance. In the Laboratory, a high-quality two-stage transformer-coupled amplifier with detector getting its plate supply from the same source as the amplifier sang terrifically when a resistance of 37 ohms was inserted in the negative B battery lead when the loud speaker was connected directly across the output choke-condenser combination. With one side of the loud speaker connected to the filament, a total of 670 ohms in the negative B lead could be tolerated before the amplifier sang.

Bypassing the common resistance with a 2-mfd. capacity, the tolerance in common impedance was increased, so that with the loud speaker across the output choke, 200 ohms did

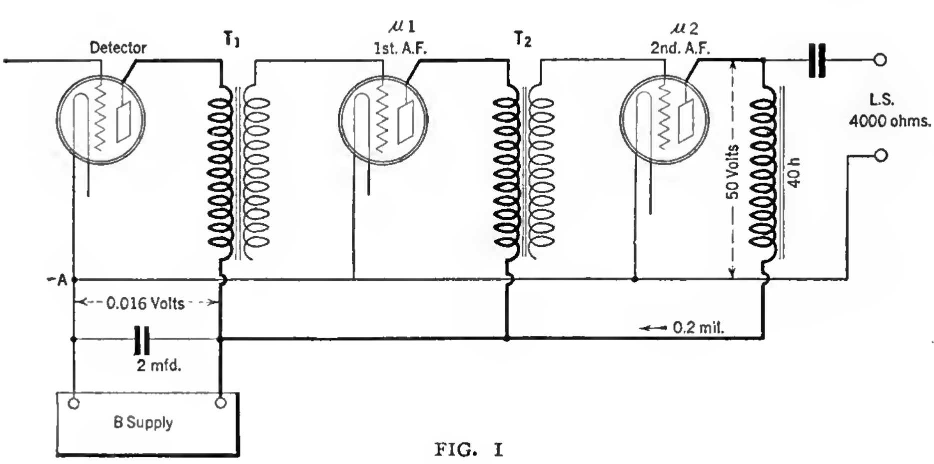


FIG. 1

not cause singing, and in the other case 2000 ohms could be tolerated.

This investigation indicates that, when a condenser-choke output device is used, the loud speaker should connect directly to the negative A, or to the filament center tap if a.c. operated, of the last tube. When an output transformer is used, corresponding to the case where the loud speaker is connected across the output device, and all of the a.c. components of the plate circuit must go through the plate supply, a large bypass capacity should be used. This is necessary when B batteries or plate-supply units are used, for the latter have a rather large a.c. impedance at all times, and the former have considerable a.c. impedance when they have been used for some time.

Now continuing our investigation, let us look at this two-stage amplifier again. Let us suppose that at some frequency the loud speaker represents a load to the last tube which takes as much power as a pure resistance equal to twice the impedance of the tube. This is an assumption easily satisfied, and since tube experts in England, and of the General Electric Company in America, have shown that the maximum undistorted output will be attained under these conditions, we shall start off on the right foot at least.

If the loud speaker impedance is twice that of the tube, $\frac{2}{3}$ of the total a.c. voltage appearing in the plate cicuit will be impressed across it.

Now the maximum voltage amplification of the amplifier, which we shall call A, is as follows, when T represents the turn ratio of the transformers and μ the amplification factor of the tubes:

$$A = T_1 \times \mu_1 \times T_2 \times \mu_2$$

and since two-thirds of this appears across the loud speaker, the voltage across the latter is:

$$E_{l.s.} = \tfrac{2}{3} \times A \times E_d$$

where E_d is the a.c. voltage available across the primary of the first audio transformer.

Actually the loud speaker voltage will be less than this figure, since the full transformer ratio, and amplification factor of the tube, cannot be realized, but good design will make it possible to approach this maximum voltage amplification.

Now, looking at a booklet on tubes, we note the maximum undistorted power output of a 171 type tube is 700 milliwatts, that the amplification factor is 3, and that the plate impedance is 2000 ohms. Then at the frequency chosen, the loud speaker impedance will look like 4000 ohms resistance to the tube, and since the power, W_o, into it is:

$$W_o = I^2 Z = \frac{(E_{l.s.})^2}{Z}$$

$$\text{or } E_{l.s.} = \sqrt{W_o \times Z} = \sqrt{0.7 \times 4000} = 53 \text{ volts r.m.s.}$$

where Z = loud speaker impedance, $E_{l.s.}$ = voltage across loud speaker, and I = current through loud speaker, we see that there must be 53 volts r.m.s. across the loud speaker to put 0.7 watts into it, and since this is but two-thirds of the total a.c. voltage in the plate circuit of the last tube, the total is $\frac{3}{2} \times 53$, or 79.5 volts.

Since the amplification factor of this tube is 3, $79.5 \div 3 = 26.5$ r.m.s. or 37.4 peak volts (since peak volts equals 1.41 times r.m.s. volts) which must appear on the grid of the power tube, so that when the booklet states that the grid bias should be 40.5 it shows that our calculations are not far wrong.

Now let us use a UX-201-A (CX-301-A) type tube as the first amplifier and two 3:1 transformers and calculate:

$$A = 3 \times 8 \times 3 \times 3 = 216$$

which shows that the maximum voltage amplification of the amplifier, from input to the first transformer to the plate circuit of the final tube, will be 216, and since we need 79.5 volts in the output tube plate circuit the voltage necessary across the primary of the first audio transformer will be:

$$79.5 \div 216 = 0.368 = E_d$$

This, then, is the voltage which the detector must supply to the input of the audio amplifier.

Now in place of the low-mu low-impedance tube in the output or power stage let us use a UX-210 (CX-310), which has a mu of 8 and an impedance of 5000 ohms, or a UX-112 (CX-312) which has the same characteristics. In this case we must use a step-down output transformer of 1.58 turns ratio ($\sqrt{10{,}000 \div 4000}$) so that our 4000-ohm loud speaker will look like 10,000 ohms to the power tube. Of course the same voltage will be necessary across the loud speaker to deliver 700 milliwatts to it, *i.e.*, 79.5, which, multiplied by 1.58, the turn ratio of the output transformer, gives 125 as the voltage which must appear in the plate circuit of the final tube.

In this case, however, the voltage amplification of the amplifier is increased to:

$$3 \times 8 \times 3 \times 8 = 575$$

and the detector output must be:

$$125 \div 575, \text{ or } 0.218$$

and the input peak volts to the last tube must be:

$$125 \div 8 = 22, \text{ approximately}$$

This calculation shows that the detector must deliver only 0.218 volts compared to 0.368 when a 171 type tube is used to furnish the same amount of power, 700 milliwatts, to the loud speaker. If, however, the detector can deliver to the input of the amplifier 0.368 volts without distortion, due to detector overloading, the power put into the loud speaker will be:

$$W_o = \frac{(E_d \times A \times \frac{2}{3})^2}{10{,}000} = 1.4 \text{ watts}$$

In other words the 210 type output tube will deliver exactly twice the power to the loud speaker as is obtained when a low-mu low-impedance tube is used. This difference is entirely due to the higher amplification factor of the tube.

The results of this simple comparison between output tubes are several. In the first place it means that the detector tube can be worked with lower input voltages, the r.f. amplifier need not be "geared up" so high, weaker stations may "load up" the amplifier, and it shows in some measure why more volume results when a UX-210 (CX-310) tube is substituted for a UX-171 (CX-371).

There is one more point which our computation may bring out—the reason why such high voltages are necessary for the plates of UX-210 (CX-310) type tubes. If 40 volts C bias is used on a UX-171 (CX-371) type tube, 180 plate volts are needed. This figure may be calculated by multiplying 40 by 3, the mu of the tube, and by what we may call a factor of safety of 1.5, or $40 \times 3 \times 1.5 = 180$. Now, when we use a UX-210 (CX-310) tube with a C bias of 22 the calculations say $22 \times 8 \times 1.5 = 263$ volts. If, however, the detector delivers 0.368 volts the C bias on the last tube must be 37.5 volts which, in turn, demands a plate voltage of $8 \times 37.5 \times 1.5 = 450$, and there you are.

Our little investigation into amplifier problems has not taken us from our armchair, and all we have needed to determine several interesting facts is a pencil, some paper, and if we possess one, a slide rule. We have learned that output devices, if choke-condenser affairs, should be so connected that the a.c. plate currents return directly to the filament of the last tube, and that if we use an output transformer, or if the a.c. currents do not return directly to the filament, we must bypass as heavily as we can afford the common impedance of the plate supply.

We have learned that we can estimate the maximum voltage amplification of an amplifier by multiplying the turn ratios of the transformers and the amplification constants of the tubes together, and that for distortionless amplification the loud speaker should have roughly twice the impedance of the tube. Under these conditions the voltage across the loud speaker is two-thirds of the total a.c. plate voltage in the plate circuit

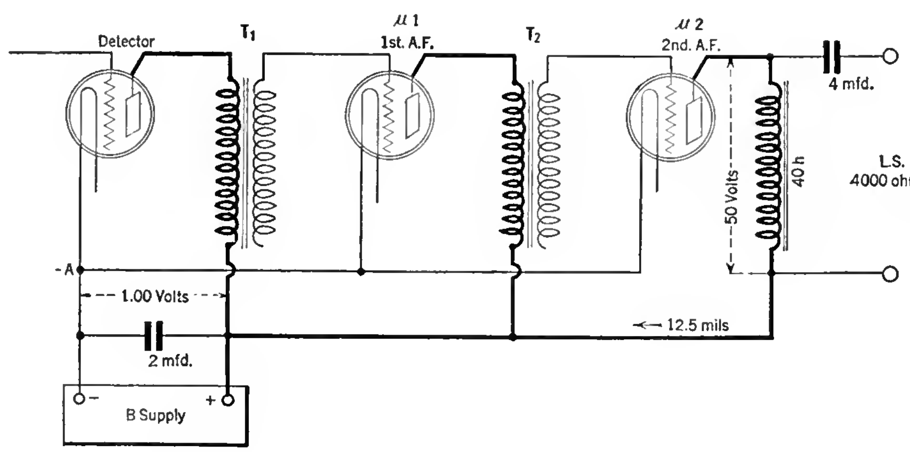


FIG. 2

of the last tube, and the detector output required may be calculated by dividing the a.c. voltage in the last tube's plate circuit by the amplification of the amplifier.

We have learned that a high-mu tube in the final stage of an audio amplifier delivers considerably more power, and requires considerably smaller input voltages to deliver the same power, compared to a low-mu tube. We have learned why such high plate voltages are required on power amplifiers using tubes with high values of amplification factor. Throughout this armchair investigation we have had to make certain assumptions that will make a "hard-boiled" engineer smile. We know but little of how a loud speaker looks to a tube, we have not bothered with vector voltages, we have not tried to be mathematically exact. But we have shown that with a slide rule, a pencil, and some paper we can delve into the subject of receiver and amplifier design.

CJRM, Pioneer Picture Broadcasting Station

By Edgar H. Felix

TO THE RIGHT
The illustration shows Mr. D. R. P. Coates, manager of CJRM, with his picture transmitting apparatus

THE series of articles in RADIO BROADCAST describing the Cooley Rayfoto system, have brought to its editors a surprising number of letters from experimenters who have already worked with telephotography of one kind or another. These, together with the thousands of letters, from those who plan to build Cooley recorders, make it appear quite certain that there will soon be a definite new experimental field—the making of radio pictures in the home. Indeed, we know of quite a number of Cooley outfits already in operation, even though, as we write, broadcasting is only spasmodic.

Perhaps the most interesting broadcasting experiment which has come to light is that of CJRM, of Moose Jaw, Saskatchewan, of which Mr. D. R. P. Coates is manager. An active Radio Picture Club, formed under his leadership, is already in existence, and a group of ardent workers are busy improving their existing picture reception apparatus. The Radio Picture Club is installing a Cooley picture receiving system but, in the meanwhile, is working with a somewhat more crude, picture system.

The transmitting apparatus, built by Mr. Coates, is a remarkable example of resourcefulness, for the facilities available are very limited. The transmitter is made with a cylindrical record phonograph as its basis. A copper plate is mounted on the drum, taking the place of the conventional record. On the copper plate, the picture to be sent is pasted in silhouette or outline form. A stylus passes over the copper drum and completes the circuit for an audio-frequency "howler," the output of which is used to modulate the transmitting carrier. A synchronizing signal, using the stop-start system, also used in the Cooley receiver, serves to re-check the synchronization at the beginning of each revolution.

Reception is simply a reverse of the transmitting process. A stylus makes a continuous black line by pressing on carbon paper laid over a sheet of white paper, on a revolving cylinder. When the "howler" signal comes in, the stylus is lifted, thus giving a positive silhouette. Nothing simpler than this system can be imagined, but Mr. Coates tells us it was widely used by the Germans during the War for transmitting military information.

Owing to the fluctuations in drum speed, the synchronization is not good. The difficulty lies in the fact that the phonograph motor is brought to a full stop by the synchronizing system and it does not always resume speed at the same rate when released by the synchronizing control.

Naturally, the Radio Picture Club looks forward to the receipt of its Cooley recorder equipment because that will overcome these difficulties. An ingenious clutch and locking arrangement makes good synchronization easy with the Cooley system, and it is independent of the operation of the phonograph motor. The Cooley stop-start system, and the mechanical unit which is a part of it, is so built that the load on the phonograph motor does not change when the light aluminum drum is stopped at the end of each revolution by the stop-start mechanism. A clutch allows the motor and the turntable to continue revolving, so that there is little or no speed variation.

A PREDICTION

IT IS pleasing to see such enterprise in far-away western Canada. A rather interesting point in Mr. Coates' letter is his point of view with regard to the broadcasting of pictures:

"The present position of the radio picture art reminds me very much of the position of radio seven or eight years ago. I believe that we shall find amateurs dabbling in it for a while and that this will gradually evolve until receiving apparatus is improved and popularized. If we are to follow the line that was taken by broadcasting, we must go ahead and put pictures on the air, no matter how simple and elementary, so that people will be encouraged to build apparatus for the purpose of reproducing the pictures. The fact that there is no one around here yet able to reproduce the pictures does not deter me at all, because I remember broadcasting years ago when our audience was very limited indeed. If we had waited for a big audience before going ahead with broadcasting, we would not be very far advanced at the present time."

Not only do we find that American stations have a similar point of view, but inquiries have come from broadcasting systems, even as far distant as New Zealand, desiring to put Cooley pictures on the air so as to give experimenters an opportunity to develop the picture receiving art.

Mr. Coates is the originator of a system of broadcasting "pictures" of the constellations as an aid to the study of astronomy. He terms these "stellagraphs." The stellagraphs were broadcast by coöperation with a local newspaper which printed a graph paper suitably marked up so that any position on the paper could be given by two reference numbers. A third number in the code indicated the intensity of the star so that a lecturer on astronomy could enable his radio listener to illustrate and draw out the principal constellations of which he was speaking.

The precedent set by Mr. Coates, in suggesting the formation of a radio picture club, is one which should be encouraged. An individual experimenter may hesitate to spend a hundred or a hundred and fifty dollars to go into picture experimentation, but, if five or six club together, the individual cost is small and the experimenters have the benefit of their combined facilities and ingenuity. The Cooley system is sufficiently well developed that it can hardly be termed a hazardous experiment and the amount of special equipment required is not particularly great. We have been advised that a number of substantial prizes will soon be offered for the best Cooley picture reception, through the courtesy of a large radio manufacturer who believes in the future of picture transmission and reception. Naturally, the leaders and pioneers who have the greatest experience, are the most likely to be successful in such a contest.

"Our Readers Suggest—"

"OUR Readers Suggest. . ." is a regular feature of Radio Broadcast, *made up of contributions from our readers dealing with their experiences in the use of manufactured radio apparatus. Little "kinks," the result of experience, which give improved operation, will be described here. Regular space rates will be paid for contributions accepted, and these should be addressed to "The Complete Set Editor,"* Radio Broadcast, *Garden City, New York. A special award of $10 will be paid each month for the best contribution published. The prize this month goes to Fred Madsen, Chicago, Illinois, for his suggestion entitled "A.C. Tube Operation Without Rewiring"*

—The Editor.

A Distortion Indicator

THE average loud speaker is blamed for a multitude of sins which really should be laid at the door of other parts of the receiving circuit. It is not generally understood that a rattle almost identical with the mechanical rattle of an overloaded loud speaker can be caused by a distorting amplifier. The sound of the strain, depending upon the extent of distortion, reproduces in a manner quite deceiving to other than experts, all the various forms of blasting experienced in faulty loud speakers.

If you are experiencing difficulties of this nature, it would be well to investigate the characteristics of your amplifier before discarding your loud speaker as defective. The procedure is simple, as the following illustrations indicate.

A milliameter capable of carrying the current to the power tube (a zero-to-25 milliamperes meter is about right) can be inserted in the plate circuit of any tube, providing a fairly reliable indication as to whether or not that particular tube is introducing distortion. The circuit is shown in Fig. 1.

Any deflection on the meter scale with incoming signals is evidence that the tube in the plate circuit of which it is included is rectifying, *i. e.*, distorting. This distortion can be eliminated by proper biasing. If the needle kicks down, more C battery should be used. If the needle kicks up, the C potential should be lowered. If the C bias is correctly adjusted no movement whatever should be noticed in the needle when a signal of moderate strength is being received. Any movement, up or down, indicates distortion, and the C battery should be adjusted in an endeavor to stabilize the needle.

Quite naturally, every tube has a maximum distortionless output with a given plate voltage, and when this limit is exceeded by applying too powerful a signal to the grid, rectification and distortion will result, regardless of the grid bias. It will be at a minimum, however, if the grid battery is correctly adjusted. If more than a slight flicker of the needle is indicated at the desired volume, a higher plate voltage or a power tube of greater handling capacity should be employed.

The correct biasing of every tube in the audio-frequency amplifier can be effected in this manner. As the grid swing applied to other than the last or power amplifier stage is relatively small, however, a rough adjustment (that is the application of approximately the bias recommended by the tube manufacturer for the plate voltage used) will be sufficient in these preceding stages.

Philip Riley
Cincinnati, Ohio.

STAFF COMMENT

MR. RILEY'S distortion indicator is of particular utility when the plate voltage is obtained from a B power-supply device. The voltage supplied by such an arrangement varies with the load, and it is always more or less indeterminant. The correct bias changes with variations in plate potential, so an arbitrarily designated bias voltage rarely affords the maximum distortionless output.

Still more undistorted power can often be obtained from a given amplifier-loud speaker combination by the use of an output device

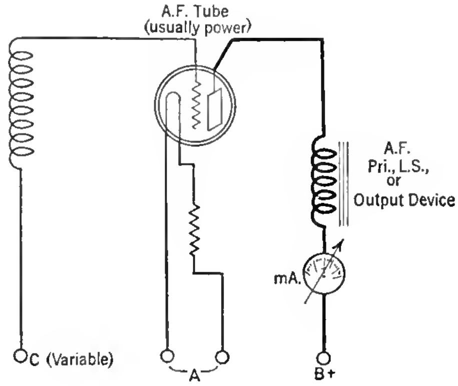


FIG. 1
A simple hook-up to indicate distortion

connected between the loud speaker and the power tube, because the relatively high d. c. resistance of the loud speaker lowers the actual voltage on the plate of the tube, and the use of an output device therefore results in a greater potential being applied to the plate. The loud speaker should never be placed directly in the plate circuit when there is a current of more than 10 mils. flowing. Aside from the relatively powerful current surges, which may damage the delicate windings, the steady direct current tends to draw the armature toward one of the pole pieces, causing the mechanism to hit and rattle on loud signals. There are several commercial output devices which may be instantly connected between loud speaker and power tube. Such filters are manufactured by the National Company, Silver-Marshall, Muter, Ferranti, General Radio, Samson, and Federal, etc.

"Motor-boating"

I HAVE a seven-tube set which employs one stage of resistance-coupled audio amplification and I have been trying for some time to find a B supply device that would not "motor-boat," but without success. It was quite costly to operate the set with a 171 power tube with B batteries so I conceived the idea of using a combination of B battery and B device. It is well known that the r. f. stages and the power tube take most of the B current, so I use the B device on those taps and the battery on the resistance coupled tap. This arrangement is very satisfactory and is giving fine results. The drain on the B battery is small, hardly noticeable in fact, while the B device operates the tubes drawing the heavy current. Fig. 2 tells the story. The negative of both B supplies are common.

C. R. Yarger
Shenandoah, Iowa.

STAFF COMMENT

THE method suggested by Mr. Yarger hits directly at the very source of "motor-boating," *i. e.*, a common B supply circuit through which coupling may be effected. The arrangement suggested by our correspondent will probably be effective in the most violent cases of "motor-boating."

Unfortunately, the purpose of B battery elimination is more or less defeated in this scheme. The current drain on the B battery is, as Mr. Yarger points out, nevertheless very slight.

The connection of an Amrad Mershon electrolytic condenser across the high-voltage and negative terminals of the power supply of a motor-boating receiver, will, in the majority of cases, be equally effective in eliminating this disturbance.

A glow tube, connected according to the directions given in "Our Readers Suggest" for February 1928, is also effective.

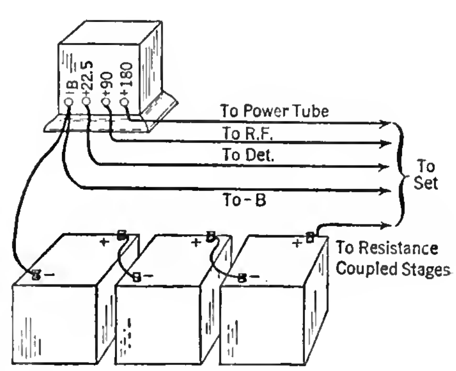


FIG. 2
A simple way of eliminating "motor-boating" in all circuits. The troublesome circuit is fed from a separate plate source

A. C. Tube Operation Without Rewiring

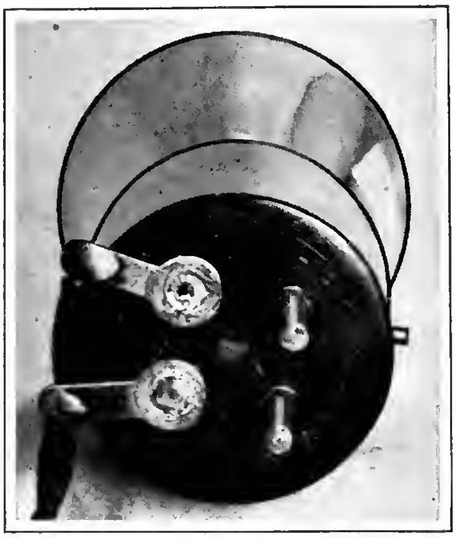
IN THE November, 1927, issue of RADIO BROADCAST, "Our Readers Suggest" department gave directions for the rewiring of a standard radio-frequency receiver and an Atwater Kent 35 for the use of Arcturus alternating-current tubes.

This rewiring necessitated changes in the filament and radio-frequency circuits of such nature that many comparatively experienced fans would hesitate to make. It is extremely difficult to gain access to the wiring of many commercial receivers, and some enthusiasts, adept with the soldering iron and pliers, are reluctant to tamper with a ready-made job.

I have an Atwater Kent 35 receiver which I desired to adapt for a. c. operation without touching the actual wiring of the receiver. I succeeded in doing this along the lines suggested in Fig. 3, and in the accompanying photograph. Arcturus a. c. tubes, which are of special construction, being used for the purpose. The arrangement, briefly, requires the sawing off of the two heater prongs from the a. c. tube bases and soldering lugs in their places, to which the heater connections are made.

The mechanical changes are clearly illustrated in the photograph. Though the prongs are sawed off at the bottom of the base, sufficient metal remains for firm soldering of the lugs. The prongs should be carefully tinned before the lugs are soldered to them in order to insure perfect connection with the heater leads. See that the leads from the elements within the tube are not sawn off when the prongs are removed. They should be firmly soldered to the remaining prong stubs.

The original sockets in the receiver hold the tubes with sufficient rigidity by means of the plate and grid prongs, which remain unchanged. Flexible Braidite is recommended for use in the rewiring of the heater circuits. This can be obtained in different colors facilitating consistent heater connections. The same side of every heater (as determined by their relationship to the pin on the tube base) should be connected together throughout the circuit. Looking at the bottom of the base with the pin toward you, the left-hand prong is filament plus on a d. c. tube. On the Arcturus a. c. type tube it is a combined heater and cathode connection. It is good practice to wire these prongs with red Braidite, using black for the other heater leads. Both leads should be twisted, as shown in the photograph. A separate wire is brought out from the cathode of the detector tube to which B minus, C plus, and D minus are connected. The expression "D" refers to the special biasing battery necessary for the detector tube, the grid of which is made positive. The fundamental diagram is shown in Fig. 3.



WITH HEATER PRONGS REMOVED

An accompaning contribution explains how the Atwater Kent model 35 receiver may be arranged for a.c. tube operation. The main mechanical change requires that the two heater prongs be sawed off and replaced with soldering lugs

An Electrad Royalty 200,000-ohm resistor, shown, in Fig. 3, in dotted lines, must be connected across the secondary of the first audio-frequency transformer where it functions as a volume control. This volume control is mounted externally. The only change actually made in the receiver itself was a slight alteration in the detector grid circuit. The grid leak was removed and a piece of heavy wrapping paper inserted in the prong toward the back of the receiver. A small piece of copper foil, to which a flexible lead was soldered, was laid on top of the wrapping paper so that no connection was made to the prong. The copper foil, however, makes contact with the cap of the grid leak when inserted. This lead was brought out along with the other wires and marked "D" plus 4.5 volts. This operation automatically opens the connection between the grid leak and the center of a resistance which exists across the filament of the detector in this model of the Atwater Kent receiver.

The tubes were placed in the sockets and the set was ready for operation.

Minus 1.5 volts of C battery were connected to the ground post and minus 22.5 volts of C battery were connected to the power tube. If it is possible to tap off between 4.5 to 9 volts on your first B battery or from the B supply device, the D plus lead from the detector grid leak may be lead directly to such a tap, otherwise it will be necessary to insert a 4.5-volt battery, plus to the grid leak and negative to the B minus.

A plate potential of 90 volts is applied to the plates of the radio-frequency and first audio tubes and 180 volts to the plate of the power tube. Arcturus type A-C 28 tubes are used in the first radio-frequency amplifier and in the first audio amplifier. An Arcturus detector type A-C 26 tube is employed in the detector socket and a power tube type A-C 30 in the power stage. The A plus and A minus leads from the original Atwater Kent receiver are short circuited. Fifteen volts a. c. is applied across the twisted heater wires. This is obtained from an Ives type 225 step-down transformer.

The arrangement as applied here can be adapted to practically any circuit with very few changes.

FRED MADSEN
Chicago, Illinois.

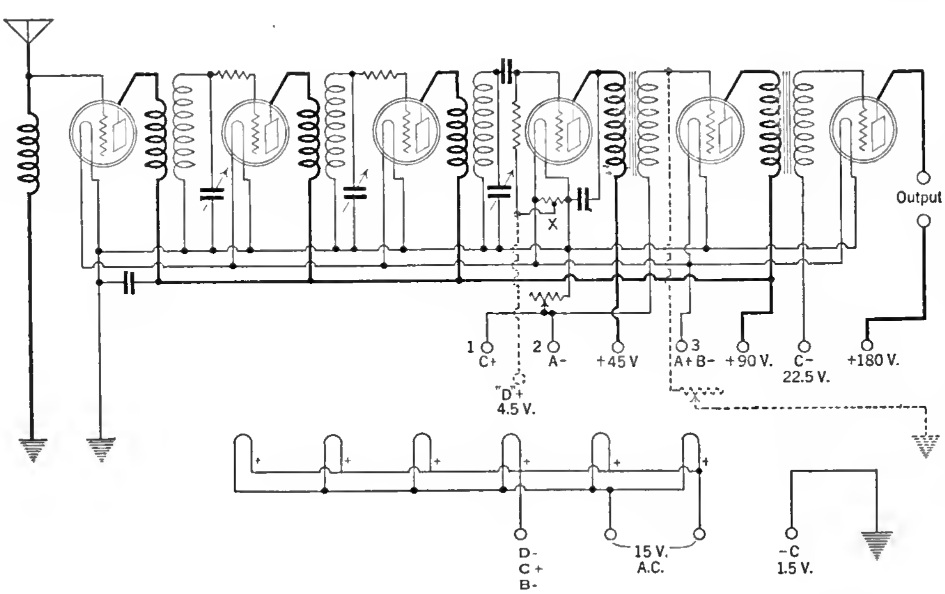


FIG. 3

Adapting the Atwater Kent Model 35 receiver for a.c. tube operation without making any major changes to the wiring of the receiver itself. The detector grid leak return is broken at X, and brought down, according to the dotted line, to the special "D" plus lead. Dotted lines also show the position of the volume control. The wiring below shows the external wiring to the heaters of the tubes. Posts Nos. 1, 2, and 3 are short-circuited, and no connections whatever are made to them

STAFF COMMENT

THE arrangements suggested by Mr. Madsen are quite practical. As he suggests, there are doubtless many instances where the "harness" system is preferable to actual set changes. Commercial "harnesses," which are very similar to the arrangement described, are being placed upon the market to adapt various receivers to different types of a. c. tubes.

In some receivers the prongs of the tube are inserted in metal eyelet holes which protrude a fraction of an inch or more above the surface of the sub-panel. The presence of these eyelets, which are connected electrically to some part of the circuit, will make the receiver inoperative unless care is taken to see that the sawed off prongs or the soldering lugs do not touch them. This is easily accomplished by the use of a pasteboard disk cut to size and punched with two holes to pass the grid and plate prongs.

In some instances it will be more desirable to control volume by means of a zero to 500,000 ohm Electrad Royalty or Centralab resistor connected across the radio-frequency secondary preceding the detector tube. Not all variable resistors of the required ohmic value will work in this arrangement due to the relatively high capacity of several makes.

The Listener's Point of View

IF YOU LIKE GOOD MUSIC LISTEN THIS WAY

By JOHN WALLACE

WE HAVE utilized this department before, in fact as recently as last January, to make tearful entreaties to the radio lords to furnish more straight instrumental music. If we may be said to have any platform, that is its principal plank.

In one of these articles we advanced the point that listening to symphonic music via the radio has at least one distinct advantage over listening to the same in a symphony hall, namely: the orchestra cannot be seen. With none of the modesty proper to the father of an idea we aver that the point is an excellent one and well worth dragging out again.

The universal custom of lighting up concert halls with a dazzling effulgence of electric light has about as much to recommend it as would the equipping of art galleries with a fire siren and a ship's bell beside each picture. It is our occasional custom to attend the Friday afternoon concerts of the Chicago Symphony Orchestra, frequented presumably, by the very cream of Chicago's music lovers. Here, as elsewhere, the blaze of light system prevails. In the course of the concert, a surprisingly large proportion of the audience may be observed to be taking advantage of this lavish pyrotechnical display in any one of three ways: (a) reading their programs, (b) embroidering, (c) sitting on the edge of their chairs better to watch the conductor. Anyone who can thus disport himself before Brahms or Beethoven, or even Tschaikowsky, and then later claim that he "heard" the music is either a physiological phenomenon or a prevaricator.To follow honestly the development of a piece of music requires so high a degree of concentration that it is absurd to imagine that an attention divided between the eye and the ear is sufficient. We have essayed the more or less successful subterfuge of slumping down in the seat with one or the other hand before the eyes, but this lays us open to the suspicion of our neighbors that we are (a) a silly fellow feigning intense absorption, (b) asleep. Extinguishing the lights would solve the problem, but this the persons who run concert halls will not do.

To attack the reading of program during a concert is a ticklish proposition. It is "done" by our very best people. Tell them they are demonstrating their ignorance of music by so doing and they will look at you aghast.

It is perfectly possible to look at, and enjoy, a picture without knowing a thing about the painter's life, in fact without even knowing who painted it. This is done constantly, even by connoisseurs. Music, a purer art than painting, is even more independent of its composer and he may be even more easily ignored.

Or it may be protested with still more vigor that "you have to watch the conductor really to 'feel' the music unfolding!" This likewise is pishposh. The gesticulations of the conductor, however graceful or dramatic they may be, have little to do with the music as music. They exist for the purely technical purpose of evoking the proper sounds at the proper time, and the technique of putting the thing across is no more your business than would be the trade name of the pigments your artist used in his painting.

Perhaps we seem to wax too wroth and to be making a mountain out of a mole hill in our vehemence against optical assimilation of music. But our fury is aroused by the fact that the people who so insult good music in the concert halls are supposedly the very topmost strata of music lovers—the highbrows, no less! If the highbrows of the nation don't know how to listen to serious music what about the masses?

It would seem, perhaps, that the case we are making out for proper concert listening is no very happy one, and that we would place it on the same tedious and exacting plane as listening to a class-room lecture on philosophy or astronomy. This is not entirely true. Certainly we have to concentrate just as much—a symphony by Brahms has just as much meat in it as any four chapters from Kant's *Critique*—but the concentration can be entirely effortless.

Herein, as we have said before, lies the advantage of radio. Given a good receiver and a symphony orchestra properly "picked up" and transmitted and you are all set for a concert

EUNICE WYNN OF KFWB

Miss Wynn is a regular artist of the Hollywood station of Warner Brothers, KFWB. Cute songs, she sings, according to the station

which may nine times out of ten be more enjoyable than one in a mazda-equipped concert hall. You can don your slippers, turn off the lights and park in an easy chair—three separate counts wherein "second hand" radio has it over the first hand thing! With your own private stage thus set you are in an ideal position really to "hear" the music with a fullest possible realization of what it really has in it.

A popular delusion exists that music should caress the listener and lull him into a pleasant state of lethargy, and that he need do nothing but just "set" and let the vague tides of sound wash over him soothingly. The answer to this is age old: the artist can go only half way.

The reward for going half way is the surprising discovery that there are tasty bon-bons waiting at the half-way point whose existence was never even suspected.

Now our point is that it is easier for the neophyte to cultivate an understanding of serious music by listening to it on the radio than by going to concert halls—simply because he can do it with less distraction.

Devious and many are the ways suggested for learning "how to appreciate music." Most of them involve too much work (they are the best ones). Others go in too much for the technical and intellectual, which after all is only half the content of music at most. We are going to suggest a short-cut method—one which requires no preparatory work at all.

HOW TO LISTEN TO GOOD MUSIC

DOUBTLESS this system of learning how to follow music has been suggested before—though we have not run across it. It may be objected to as an unscientific method, as an unintellectual method—in short as a too strictly emotional method. But it is, a practical method.

Sit yourself before the receiving set in the afore-mentioned slippered condition when there is some first rate symphonic orchestra program going on (we hope you can find one!). Turn off the lights and the oil burner and otherwise exclude all conceivable distractions and then concentrate on the sound issuing from the loud speaker as though you were entombed in a mine waiting for the faint ring of a distant pick ax. Or strain your ears as though you were trying at three in the morning for 2LO. Things will immediately begin to happen. Surprising things. A host of sounds will begin to emerge that were formerly just lost in the shuffle. Pick out one of the thinnest and feeblest of these sounds and follow it through the maze like a bloodhound pursuing little Eliza through the forest. Keep on its trail and see what it does—and what some of the big bullying noises do to it. Then for a change pick out some little transitory tune—perhaps only five notes long—wait for it like a cat before a mousehole. Presently it will appear again, perhaps in a different key or on a different instrument, or even disguised with false whiskers. But you will recognize it, and with a glee quite equal to that of the cat when the mouse finally emerges from its burrow.

Next try listening to two tunes—or two instruments—at once. Watch how the two tunes sneak along side by side, some times drawing together and shaking hands; other times running off on by-paths and making faces at each other. Watch them intertwine and overlap and disappear and emerge again with a new suit and their hair combed on the other side. Search out some little insignificant orchestral effect that seems to be buried obscurely away at the bottom of the heap of noises. Watch it while it pussy-foots around the corner and gets itself a drink. Watch it start to swell and swagger and toss its hat around. Presently the snifter does its stuff and it is strutting around bombastically. Before you know it, it is running the whole works, the other noises fleeing, terrified, to shelter.

In such wise, listening to the symphony orchestra becomes a grand game with yourself just as much a participant as the orchestra. It has much in common with football: there are long end-runs and fake plays and intercepted passes and trick formations; there is team work and tripping, signalling, and shifts, even "time out" where a rest occurs in the music. And both the football game and the symphony are divided into quarters.

The analogy to football is not quite complete. What happens in a football game is largely subject to chance (as we found out just before we swore off betting last season). But what happens in a symphony, far from resulting from chance, results from perfect organization.

Herein our proposed method of learning how to listen fails. It will not reveal to you the organization of the music. That would be asking too much. However, the method we suggest will at least demonstrate to a listener that music is not simply a blur of sound, and will enable him to recognize the elements out of which music is organized.

This will be a first step. Furthermore it will be fun—which is the only excuse music has for existence anyway.

For Program Directors Only

WRITES Paul Hale Bruske, of Detroit: My friend Jimmie is blessed with one of those urbane baritone voices that pleasantly vibrate so many loud speakers in the sun rooms and front parlors of our broad land.

Yes! He's a radio announcer. More than that, he's also a program director. On his shoulders rests the responsibility of seeking, interviewing, choosing, auditioning, hiring, scheduling and rejecting various features of alleged entertainment and enlightenment. His station is a good one.

Jimmie does little if any seeking for talent. He does a microscopical amount of hiring. At interviewing he shines. His waiting room is usually full of folks who believe they have a Mission and a Message. Male and female—blondes and brunettes—old and young—artists and artistes—they are all grist for Jimmie's mill. Auditions occupy a good share of his day. He always takes the name, address and telephone number, and gives them a sweet promise to let them know.

One might think that, with all this wealth of willing workers on call, the programs from Jimmie's station would be replete with variety, and fertile in surprise, as the theatrical notices say. Such is not the result. Far from it. Tune-in on him any evening and here is what you are pretty sure to get:—

> 6:00—7:00—Dinner concert from the Herculaneum Room of a good hotel. Gwan to Bed dope for the kiddies.
>
> 7:00—8:00—News Bulletins, Hot Stuff for Farmers, Organ Recital from a Cinema Palace.
>
> 8:00—9:00 (Commercially Tainted Hour)—Somebody's Antiseptic Carolers in solos, duets and quartet numbers. Somebody's Realestate Minstrels in comic songs and dialog.
>
> 9:00—10:00 P. M.—(Big Station Feature); —Baby Grand Philharmonic Orchestra in classical and semi-classical numbers, with guest artist soprano or tenor.
>
> 10:00 P. M. and on:—Jazz Bedlam from some cabaret or night club.

On Sundays, Jimmie broadcasts church services. In midsummers, he gives us band concerts from the parks. He occasionally hands us a sporting event. He has a weekly silent night. More so than seems usually the case, Jimmie enjoys quite a free hand. His boss is rich, a radio bug and has no personal propaganda to get over—not enough, at any rate, to make it obnoxious.

Some months ago I began to razz Jimmie a bit on the striking lack of originality in his programs. He insisted that he was every bit as good as his competition, and I had to admit it. With him, it was purely a matter of beating competition on one common ground. Jimmie's rut was too deep. He couldn't see over the top.

But one day I got a barb under his hide. Perhaps the boss had just asked about the applause letters. For Jimmie turned on me defiantly.

"What would you do if you were in my place?" he challenged.

That was surely a quick pass of the celebrated buck but, after all my raillery, I couldn't dodge.

"Well," I stalled, "I'd first try to analyze a bit. Here you are, competing for public attention with from four to forty other stations, depending on reception conditions. You want folks to be tuning you in and then letting the dials alone for a while. You want them to think of you when they think of radio—to talk about your station and your programs. You want more applause letters. You'd even prefer knocks to the present silence. You crave personal glory. You could endure a bigger check in your pay envelope."

"Yes! And how?"

"Shut up; I'm analyzing.

"The main offering of all radio stations is music. On that you've gone about the logical limit. Vocally, instrumentally and in combination, you fellows have probably tried about all the tricks there are. I doubt if there is any new musical dodge which would create more than a ripple of interest. And what we want is a tidal wave.

"But there are at least two channels of approach to your dear invisible audience. The one that isn't music is speech. Let us admit, therefore, that the method you will use in getting folks to talking about your station is the spoken word."

"No chance!" yelled Jimmie. "The dullest thing that comes over the air is a speech. The minute one starts here, I can just feel the people tuning-out. There are only three kinds of radio speeches. There's politics. There's platitudes. And there's propaganda. Each is worse than the other. I'd like to pass a rule that would absolutely prohibit all speeches from this station.

"Why you've no comprehension of the speechifiers we turn down right now," Jimmie continued. "There isn't a public official in town who doesn't think he'd be the hit of the season, if he could only get on the air. Every convention that comes here tries to get time for its Grand High Cockalorum. The ladies with pet charities can't understand why we don't put them on oftener. The boy scouts litter up the place with officers that have a message. Speeches? Take a swift jump into the lake!"

"Wait a minute Jimmie," I begged. "Don't get me as any friend of your three P's. They're even more terrible than you say. But there must be such a thing as interesting talk. The newspapers get it."

Jimmie picked a fresh edition from his desk. Clear across the front, in glaring 72-point, screamed the legend, "MRS. BANCROFT WEEPS ON STAND."

It was just the current divorce case and not much of a case at that— no shooting, no violence of any kind, hardly any real scandal. But both parties were socially prominent. The gentleman was rich. The lady alleged he was cruel and neglectful. The children also socially prominent, took sides. The case was good food for tea-table gossip, so the papers were playing it strong.

Jimmie and I looked at the headline. It seemed suggestive.

"She weeps, Jimmie," I said. "And the people read about it. Wouldn't it be better if they could really hear her weep?

"If you could schedule her to weep into your mike to-night, would they tune-in?"

"You're whoopin' they would," admitted Jimmie.

"Then go get her," I insisted. "Tell her she's got a Mission. Explain that what's happened to her is only a sample of what's happening to thousands of other women. Get her to tell these others what to do. Let her put her case to the whole world, with her own voice and freed from any cross-examination or other rules of any kind. I'll bet she'd jump at the chance. Give those listeners of yours something worth listening to."

"Gosh!" commented Jimmie.

"Then next night, give the same privilege to Mr. Bancroft. Let him talk to the husbands. Have him tell what a real life partner should do. Let him say anything within reason about these wives who spend their days in clubs, and don't have time to cook a dinner for the family. Play him as the outraged American husband, and let him counsel others who feel bad with him. Then let the household arguments rage. Every time the case is mentioned, folks will think of your station and wonder what next."

"Well, that's a good question. What next?"

"Next will come the poor boob who's just been sentenced to life in the hoosegow for murder of his sweetie's friend husband. Give him a last chance to say farewell to the world. What a cinch it will be for you to write his speech! To-night, he's a man and has a name. To-morrow night, and until he dies, he's nothing but a number. And who's to blame? The woman, of course! And then the moral. All this in his own voice, with the handcuffs rattling every time he turns a page.

"Gruesome? Sure, but will they listen?

"As for me, Jimmie, I've always had a longing to know just what happens at a hospital during a good, major operation on the human torso. I'd rather hear you describe such a thing than get your fresh-from-the-ringside word picture of a good prize fight. That's only a sample of what you can do when you once get your mind on really interesting topics. But let that pass.

"Watch the front pages. They're the best bet. Grab those features hot, give 'em a good, moral, uplifting line of talk, rehearse 'em, and turn 'em loose with their own voices to give us listeners honest-to-goodness heart throbs in the raw. If you're too busy to add this department's duties to those you carry now, hire Pat Montgomery, our old city editor, and put it up to him. Yellow up—and that only means make your stuff interesting."

Jimmie had been getting more pop-eyed with every word. Temporarily, at least, I had him sold. But he cooled off just as quickly. Eventually he admitted that there was something in this idea and promised he'd think it over.

"But no murderers! And no gory operations, either," he declared. "Something controversial, maybe. That's perhaps the secret of making speech interesting. And I may be able to do something with decent celebrities of the day."

A few days later, Jimmie's station announced the first controversial event. It was a debate. On one side was the mayor. Opposed was one of his appointees who had the courage to think for himself. The debate itself wasn't so much. But before it started, right in Jimmie's studio, the mayor fired the appointee, and the latter announced the fact in his address. Jimmie's station got a lot of good publicity, and he was greatly elated.

For several weeks thereafter I was out of touch with Jimmie and with radio. Back in town again I bumped into Jimmie.

"I'll bet I've been missing some hot stuff," I remarked. Jimmie looked blank. Actually I had to remind him of the big idea.

"Oh! We've got something a lot better than that," he boasted. "We've joined a big chain and get our programs right from New York." And then he went on to tell how much better his chain was, on every count, as compared to the others.

However, comma, there are other stations and other cities. Every city has a newspaper, and that newspaper must have a front page. Somewhere, I doggedly insist, there will bob up a program director with the necessary nerve to watch that front page and do what every successful newspaper does—get circulation by being interesting.

AS THE BROADCASTER SEES IT

BY CARL DREHER

How a Famous Artist Broadcasts

THE scene is in the large "B" studio of the National Broadcasting Company at the building on Fifth Avenue in New York City. The room, thirty-six by fifty-two feet, and two stories in height, holds an orchestra of sixty-five men recruited from the New York Philharmonic, with Fritz Busch conducting. The musicians are all in evening dress; their white shirt-fronts gleam in the light streaming down from six giant electroliers. It is a General Motors hour on a Monday night, a somewhat formal occasion, as broadcast features go. About a hundred spectators are grouped around the orchestra, most of the ladies seated, the men standing. I lean against the wall, an idle spectator for the moment, interested, even so, in the effect of the presence of this good-sized crowd on the acoustic characteristics of the room. A concert manager stands on one side of me, and a very famous baritone on the other. We are all looking toward Fritz Busch, who stands, with his baton upraised, in an attitude of commanding tenseness, and at another man who faces the microphones a few feet to one side of the conductor. This man is of a notably handsome and virile aspect; his body is that of an athlete; his features might be those of an intelligent and sensitive business man, but at the same time something of the actor and artist is easily discernible. His head is about three feet from one of the microphones of a double set-up. He stands with his legs well apart and his arms folded across a broad chest. This is John Charles Thomas, the tenor. He is about to sing an aria from Verdi's "The Masked Ball." Interested in the outward manifestations of his technique, I watch the artist carefully.

Fritz Busch now swings his arm downward with an emphatic gesture, and the orchestra begins to play the introductory bars. As the moment for his first note approaches, Thomas raises his left hand and cups it behind his ear. He does this in order better to hear the tones as they reach the microphone, for a man hears his own voice both through the air and through the bones of his head, while others hear him only through the air. His other arm the singer holds across his chest in a rather cramped position, which does not concern him, for he is singing with only moderate volume and does not, for the present, require the full capacity of his lungs. Nevertheless, he is ready for exertion, he has his coat off, and incidentally he is not, like most of the others in the room, in evening dress, but wears a business suit and a blue shirt with soft collar.

He rounds his lips carefully for the notes and sways a little in time with the music. His attitude is one of mingled nonchalance and the greatest circumspection. On the one hand you see a man with every natural advantage for his part, with a reputation made early and securely based on experience; and yet this same man realizes that to sing beautifully is never easy, and that it is only too easy to deviate from the pitch, if only a little, or to falter in the time, if only for a fraction of a second, or to mar a phrase with a breath that is only a little awkwardly drawn. So, seen in one aspect, John Charles Thomas sings effortlessly, and from another angle, he is working as hard as any man in any trade cares to work. The expression of his face changes, sometimes in consonance with the music, but at times, because he is singing more for the audience which cannot see him than for the hundred spectators, he seems frankly to use his facial muscles to aid his larynx. And again, when a note does not suit him precisely, he frowns critically, engrossed in his own private world of tonal creation. As Thomas maneuvers through a difficult succession of transitions, the concert manager nods approvingly, while the baritone on my right, when I glance at him, is watching the singer with critical professional admiration.

Interesting Highlights this Month

—How John Charles Thomas Performs Behind the Microphone.
—Matters Which Make Life Hard for the Broadcaster.
—Where to Get New Information on Human Speech Constants.
—Sources of Helpful Printed Information from Manufacturers.

The aria is nearing its end. As he approaches the forte passage at the close, Mr. Thomas moves his right arm down from his chest and lets out something near his full volume. He is much too good a microphone performer to go all the way; it is interesting to see how nicely, without knowing a transmission unit from a kilocycle, he unconsciously compresses his volume range within approximately the 40-TU-width allowable in radio telephone transmission, leaving the control operator little to do. Having had considerable experience singing for the radio and phonograph, and, presumably, having heard the performances of others in the same mediums, this artist has adjusted his technique, when he sings for the air, to the requirements of that particular machinery. Therein you see one of the reasons for his success. The difference between the artist who goes well over the air and the one who is a flop in the broadcast field is as often one of adaptive intelligence as a matter of voice characteristics. That adaptive intelligence may be intuitive rather than quantitative, but the results are the same, whether reached through the vocal feeling of the artist or the calculations of the engineer—better, in fact, when the artist does the editing himself. So, at his climax, Mr. Thomas roars formidably, but not so recklessly as to cause consternation at Bellmore, where the transmitter technicians are keeping an eye on the modulation peaks. Nor does he walk into the microphone; he gestures somewhat with his free right hand, but his feet remain rooted to the spot where he originally took up his position.

The last fine notes ring out, and for a second the artist stands, still in his part, looking somberly at the microphone, as if, behind its unrevealing diaphragm, he saw, across hill and plain and river, on farms and in cities, the several hundred thousand of his countrymen whom he has held entranced for those few minutes. Then, turning, he smiles broadly at the conductor, and, as the announcer speaks his lines, Thomas walks off-stage, or what amounts to off-stage in a broadcast studio, puts on his coat with a gesture curiously reminiscent of a football player struggling into his blanket as he retires to the sidelines, and looks over his next song before he is once more called before the transmitters.

Note for Lexicographers

IN THE December, 1927 issue, under the heading "Radio As An Electro-Medical Cure-All" we recounted the claims of a quack imbued with the conviction that he is curing the assorted ailments of the populace by saturating them with his own brand of radio waves. The word "stob" occurred several times in the healer's description of his paraphernalia, and, failing to find it in my Webster's Collegiate, a very good dictionary for its size, I was at a loss as to its meaning, except that the context indicated that it was some sort of metal ground stake. Mr. H. G. Reading of Franklin, Pennsylvania, clarifies the subject in the following communication:

"Thinking it queer that there could possibly be a word 'not in the (New Standard) Dictionary,' I looked for 'stob' and find it having several meanings, one of which is 'a long steel wedge' used in coal mines. Doubtless the Doctor wielded the pick for a living at one time."

Mr. Reading's conjecture may possibly have hit the mark. If so, the electronic magic worker in question abandoned a socially laudable profession. We may hope that his adventures in the healing arts, having led him to the conclusion that he can remedy the lesions of a man a mile away by modulating the output of his battery-operated radio transmitter with the stutterings of his "oscilloclast," will end by putting him to work with a pick again, although perhaps not in a coal mine.

Speech Constants

ON PAGES 753–754 of Morecroft's *Principles of Radio Communication* (Second Edition), published by John Wiley & Sons, Inc., there is a useful summary of the results of the research work on speech carried on in telephonic laboratories during the past decade. Most of the figures have already been given in this department in the past, but Morecroft adds one or two new ones gleaned from his reading.

(1) The frequencies encountered in human speech are within the range of 100 to 6000 complete vibrations per second.

(2) The energy contained in speech is carried almost completely by frequencies below 500 but the quality and intelligibility of speech is determined very largely by the frequencies higher than 500.

(3) The average power output of the average normal voice is about 75 ergs per second or 7.5 microwatts.

(4) The average male voice exerts a pressure of about 10 dynes per square centimeter at a distance 3 centimeters from the mouth of the speaker.

(5) The human ear can detect sounds, at a frequency of about 1000 cycles, if the sound pressure is as low as 0.001 dyne per square centimeter. If the pressure exceeds about 1000 dynes per square centimeter at this frequency, the ear is practically paralyzed in so far as sound is concerned and the sensation is one of feeling rather than hearing.

(6) The ratio of peak power in the voice (accented syllable) to average may be 200 to 1. Thus an average voice of 10 microwatts shows peaks of 2000 microwatts.

Professor Morecroft gives references to two articles in the *Bell System Technical Journal* which have not been specifically mentioned in this department. One is the article on "Speech, Power and Energy" in the October, 1925 issue of the *Journal*; the other is a paper on speech analysis by Harvey Fletcher in the July, 1925 issue of the same publication. Both discussions are of direct interest to broadcast technicians.

Catalogs and Commercial Publications

THE number of commercial publications of interest to broadcasters is increasing. Three may be mentioned this month. The Sales Department of the Radio Corporation of America (233 Broadway, New York City, with district offices in Chicago and San Francisco) is distributing to its dealers a leaflet entitled *Average Characteristics of Receiving Radiotrons.* [This leaflet, listed as No. 69 in our "Manufacturers' Booklets Available List, appearing in the back pages of this magazine, may be secured by our readers by using the coupon indicated.—*Editor.*] Some of the tubes described, such as the UX-210 (7.5 watts oscillator rating) are used in the lower power stages of broadcast speech amplifiers, while others are commonly employed in field equipment. The tubes are classified as "Detectors and Amplifiers"; "Power Amplifiers"; "Rectifiers" and "Miscellaneous." The data given is, first, general physical and electrical information, such as the type of base, outside dimensions, special circuit requirements, possible filament supplies, voltages, and currents. For detection purposes the proper grid return, grid leak, "B" voltage, and plate current are specified. Under "Amplification," for various plate and corresponding bias voltages, the plate current, a.c. plate resistance, mutual conductance, voltage amplification factor, and maximum undistorted output in milliwatts, are included. The alternating current filament and a.c. heater type radiotrons are listed, and the whole list is a useful page to be added to the broadcast engineer's notebook.

J. E. Jenkins & S. E. Adair of 1500 North Dearborn Parkway, Chicago, have issued their *Bulletin No. 4,* dealing with a "Complete Input System" installed at the 1927 Chicago Radio Show. This equipment was used during the entire week of the show, feeding a network of some thirteen of the local broadcasting stations, and a public address system the output of which supplied 22 eighteen-inch cone speakers in the Coliseum. The "Broadcast Amplifier" portion of the apparatus was mounted on a frame 72 inches high by 25 inches wide, which supported the following units: meter panel; a monitor panel, employing a W. E. 205-E or R. C. A. UX-210 tube to feed a loud speaker; an output level indicator; a three-stage broadcast amplifier; a microphone mixing panel; and a telephone jack panel for the broadcast pairs and order wires. The amplifier was the "Type A" described in Jenkins & Adair's *Bulletin 1A,* comprising two stages of amplification using W. E. 102-E or R. C. A. UX-240 tubes, and an output stage for a 205-E or UX-210. A 350,000-ohm wire-wound gain control afforded 11 values of amplification, with equal TU-increments. The 500-ohm output of the amplifier was connected to the level indicator, the monitor amplifier, and the jacks for the outgoing broadcast pairs. The maximum undistorted output available is stated to be 0.8 watt, on a plate voltage of 135 for the small tubes and 350 for the output stage, secured from heavy-duty dry batteries.

The power amplifier portion of the equipment was mounted on a frame only 19 inches wide, but the same height as the broadcast frame (72"). Current was supplied from a generator capable of giving 150 milliamperes at 1200 volts and 10 amperes at 12 volts for the plates and filaments, respectively, of the power tubes, which consisted of two fifty-watters in a push-pull circuit. The actual plate potential was 1000 volts, and separate grid bias batteries enabled each tube to be adjusted to draw 60 milliamperes. Each tube also had a 0–100 milliammeter in the plate circuit, and a quarter-ampere fuse. The push-pull amplifier was fed from a 5-watt stage, which in turn received part of the output of the three-stage broadcast amplifier previously described. A level indicator panel for the P. A. system was also included in this frame, the input being directly connected to the output of the large amplifier with a high resistance in series to reduce the voltage. This instrument gave a check on the volume of the loud speakers, incidentally showing up irregularities in the 3000 feet of line connecting up the loud speakers. The broadcast and P. A. frames, set up with a desk between them, made a neat lay-out. All the parts used in building the units with the exception of such items as tube sockets, etc., were manufactured by J. E. Jenkins & S. E. Adair.

A more elaborate publication is *Samson Broadcast Amplifier Units,* issued by the Samson Electric Company, of Canton, Mass. This is a pamphlet of 24 eight-and-one-half-by-ten pages describing Samson parts for broadcast amplifiers and associated equipment, and incidentally going quite deeply into design considerations. It is not intended for general distribution, but may be obtained free of charge by broadcasters writing for it on their letterheads. Microphone-to-tube transformers are first described, with some advice regarding connections and care of carbon microphones. There appears to be an error on page 5, where the d.c. of a 200-ohm microphone is given as 200 milliamperes per button, instead of 20. The difference is serious! Following there is a discussion of multiple microphone (mixer) operation, but the pamphlet argues that "this practice (using more than one transmitter for pick-up) should be avoided unless it is imperative." The point is highly debatable, but at any rate, as the Samson people sell mixer transformers, it is refreshing to see them state what they believe to be true, regardless of a little economic advantage. Tube-to-line and line-to-tube transformers, as well as other matching devices, interstage impedances and transformers are described in following pages. The discussion of impedance relations in audio circuits, direct current design considerations, and the use of center-tap connections, including devices for obtaining a center tap electrically where the actual winding midpoint is unavailable, is quite thorough. The last seven pages are devoted to "General Considerations"—Interference Level, Gain, Volume Control, Attenuation Networks or Pads, and Pad Design. The Samson Electric Company's engineers have turned out a valuable publication.

The A. C. "Bandbox"

By JOHN F. RIDER

A SHORT time ago, the writer had occasion to visit a friend who maintains a hunting lodge in the Berkshires—in the northwestern part of Connecticut. We spent the day in a virgin forest, chopping trees and hauling timber, for the stock of wood fuel required to heat the lodge had to be replenished. There were five of us at the camp and, at the day's end, after our evening meal, we would gather around the fire and listen to the radio.

Say what you will of the radio in the city, the welcome cheer which it imparted to us up in the woods created a deep impression in our minds. To the woodsman habitually isolated many miles from the city it must indeed be a blessing. Imagine the interior of a rough shack, snowflakes beating against the window panes which are almost hidden by sweeping drifts of snow, a merciless wind screaming through the tree tops, and a temperature of "three above" outside. The stillness within the shack is broken by the crackling of the blazing log fire, and by the deep breathing of the woodsman inhabitant, who sits deep in thought—a few well worn books his only companions. His nearest neighbor may be miles away; it would be useless to try and reach him during the several days the storm rages. And what a different state of affairs exists at this neighbor's. Outwardly there is little to choose between the two shacks. They are both lost in the depths of the snow. Each has its blazing open fire of logs, and in each lives a solitary woodsman. But there is also a radio in the second one, and what a transformation it has wrought. Were you to knock at the door for shelter, you might enter to the strains of a Strauss waltz, a Berlin melody, or perhaps even, some politician may be monopolizing the attention of the blustering fellow who admits you. He'll discuss the Waldorf Astoria orchestra as if he were accustomed to dine there and listen to it almost every day, and will talk with you of Mr. Coolidge's choices almost before the President even chooses. Or he'll demonstrate how Gene got in the winning punch, compare Damrosch's rendition of Beethoven's "Fifth" with Mengelberg's, talk of the merits of the four-wheel brakes on Dodge Brothers "Fastest Four," and match the "Silver Slipper" orchestra with that of the "Twin Oaks." No, he's never been to New York. He was born up in the woods Rarely sees an automobile. Yes, lots of the men now have radios up here. Don't need them in the summer. Too much to do outside, and plenty of people around, anyhow. No, neighbor Joe hasn't got one. He's an iconoclast (a word he picked up on the radio). Never knows what's going on in the big cities. He himself wouldn't be without a radio.

THE "BANDBOX"

THE receiver that we used at the lodge in the Berkshires was a Crosley "Bandbox." Reception was good, volume adequate, and the quality of reproduction, excellent. After listening to a concert from Springfield, we tuned-in WGY, with the usual result—periodical fading. This phenomenon provoked a discourse by one of the party—Jones, a medical man. He knew all about receivers, although medicine was his forte. His was an analytical mind, and he had grasped the fundamentals of radio. It was simple. He was an old timer. His interest dated back since the day WOR commenced operations.

The discussion finally centred upon the receiver at hand. He was the radio authority. The receiver seemed to work well, but——. Yes, it was selective, but——. The volume was good, but——. Well, he had a ten-tube receiver at home, which he had constructed; it comprised five stages of tuned radio-frequency amplification, push-pull audio amplification, a variable grid leak, etc., etc. In sum and substance, it was a "wow." He hoped that some day we would have the opportunity to listen to his pet receiver!

At this point the writer timidly explained his connection with the radio industry. Fine—just the man he was looking for. Could I explain to him wherein the Crosley differed from any other receiver? Would I point out to him the engineering features of the "Bandbox?" How could this receiver be a scientific receiver, and still sell at its low price? As far as he could see, all manufactured receivers were alike; he would never buy a finished product anyhow. Would I tell him something about the new a. c. operated "Bandbox," which is fundamentally similar, so far as the circuit constants are concerned, to the battery-operated "Bandbox" we were using up in the Berkshires?

The fact that highly scientific design and highly scientific production were absolutely necessary to produce a successful inexpensive receiver never entered his mind. He overlooked the fact completely that an accurate study must be made before even the apportioning of the tubes is made, or before the engineering staff can decide upon how many stages of radio-frequency amplification should be employed. The fact that the receiver is sold at a low price cannot influence the staff to make haphazard decisions. In this particular instance, I told him, the selection of three stages of radio-frequency amplification was a compromise of the sales division and the engineering staff to produce and sell a radio receiver at a reasonable cost for a given amount of radio-frequency amplification and stability. That is to say, calculations were made to determine how much radio-frequency amplification was necessary to provide a certain amount of sensitivity, with a reasonable stability factor. After a study of the sensitivity factor, selectivity was the next consideration. Would the three stages which afford sufficient sensitivity be selective enough? This could be determined mathematically, but it was also determined experimentally. This determination is extremely important in the design of a radio receiver. A low sales price and a high degree of efficiency will immediately "make" a receiver, but low sales price will not compensate deficiency in design.

In view of the demand for single-control receivers, there was much discussion as to what arrangement could be used in the "Bandbox" to permit efficient single tuning control. The receiver has but one major tuning control, and in order to accomplish this, it was necessary to incorporate into the design of the receiver, a circuit arrangement which provided for the different electrical characteristics of various antennas. This was essential in order that true single control be obtained, otherwise a vernier control would be necessary for the input circuit. Under normal conditions, different antennas, with different electrical constants of capacity and inductance, would alter the setting of the first tuning condenser. In the a. c. "Bandbox" the antenna stage has been left untuned. The remaining stages are tuned, and are isolated from the antenna stage. Hence the settings of the tuning condensers remain uniform regardless of the height or length of the antenna used. A radio-frequency choke is connected across the grid-filament circuit of the first tube. The antenna and ground are connected across the choke, and the action of this latter is to cause the radio-frequency signals induced in the antenna circuit to be impressed across the grid-filament circuit of the tube. The choke must be one with very

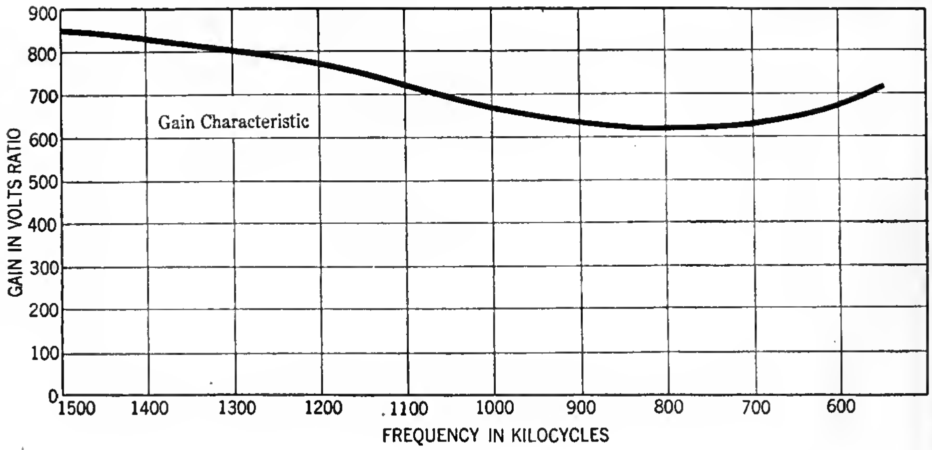


FIG. 1

little distributed capacity, since inherent capacity would afford an easy path for the radio-frequency signals to ground. By reducing the effect of the choke, the magnitude of the signal applied across the grid-filament circuit of the first radio-frequency tube can be reduced, hence the Crosley engineering department immediately visualized an excellent volume control. This is found in the variable resistance which shunts the radio-frequency choke in the antenna circuit. This resistance is non-inductive, free of capacity and, when varied, reduces the impedance of the choke. By reducing the impedance of the choke, its effect is reduced, and the signal input is decreased. Thus we have a volume control, which does not display any effect upon the selectivity of the receiver.

Receivers which oscillate and at the same time perhaps radiate an interfering signal, are not very popular, hence the radio-frequency stages are neutralized—by means of the Hazeltine system. The manner of neutralization gives the system an excellent radio-frequency amplifying characteristic, and helps overcome the usual falling characteristic on the longer wavelengths. Fig. 1 shows the radio-frequency response curve of the system. This graph is graduated from 200 meters (1500 kilocycles) to 545 meters (650 kilocycles). The maximum difference is about 25 per cent., and the minimum point of sensitivity is around 320 meters. The amplification rises on both sides of this point. The maximum gain is found at 200 meters, but even at this frequency, it is not a sharp peak. At no place on the curve is there a sharp peak or depression. Contrary to usual design, the amplification increases as the wavelength setting is increased above 320 meters (940 kc.), the low amplification point of the system. At 350 meters (545 kc.) the difference between its level and the maximum is approximately 16 per cent. These differences are small, and are not noticeable in actual operation. The radio-frequency transformers are single-layer solenoids with bifilar primary windings; that is to say, they have two primary windings. One winding is the regular primary and the other small winding is the inductance utilized in the neutralizing system. The inductance value of the secondary of these transformers is 190 microhenries and the capacity of the tuning condensers is approximately 430 micro-microfarads (0.00043 mfd.). The excellent radio-frequency response characteristic is attributable to a very large extent to the design of the primary winding of each radio-frequency transformer, its position with respect to the secondary winding, and to the coil utilized in the neutralizing system. A close study of the wiring diagram,

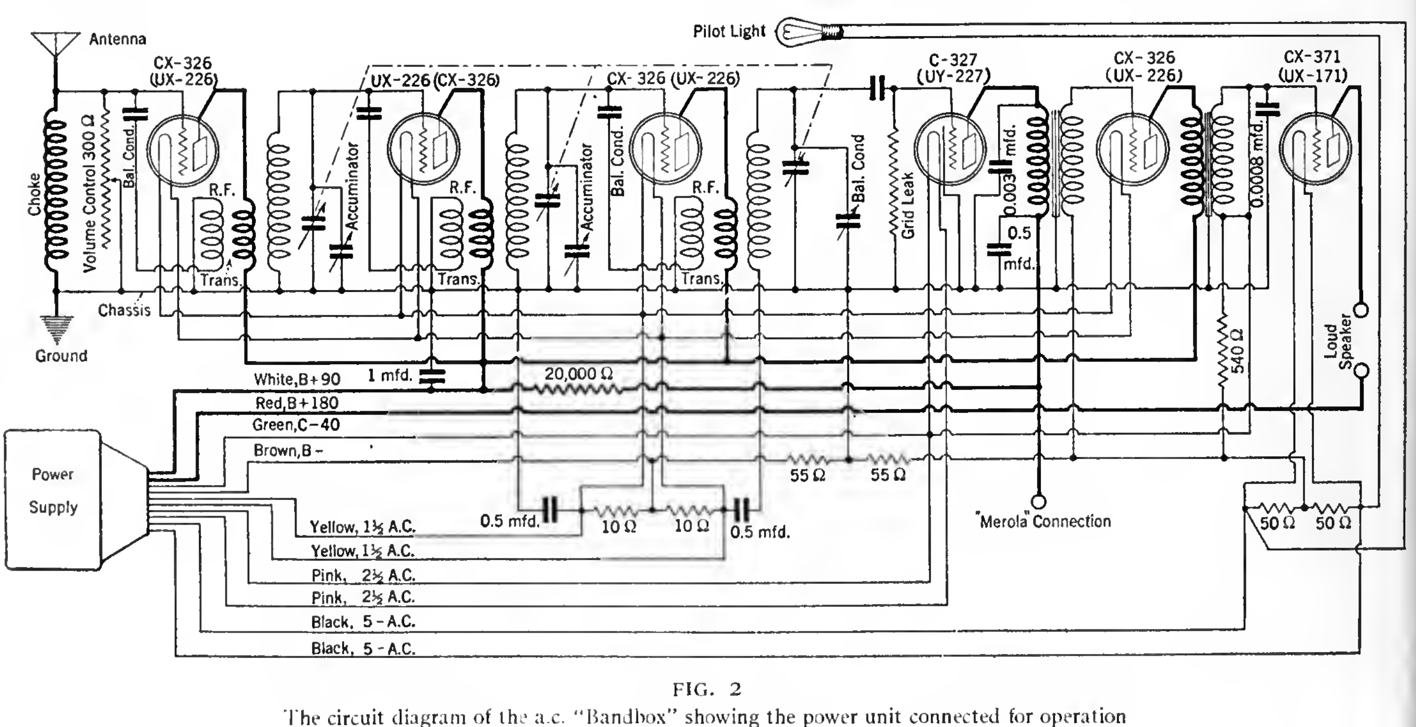


FIG. 2

The circuit diagram of the a.c. "Bandbox" showing the power unit connected for operation

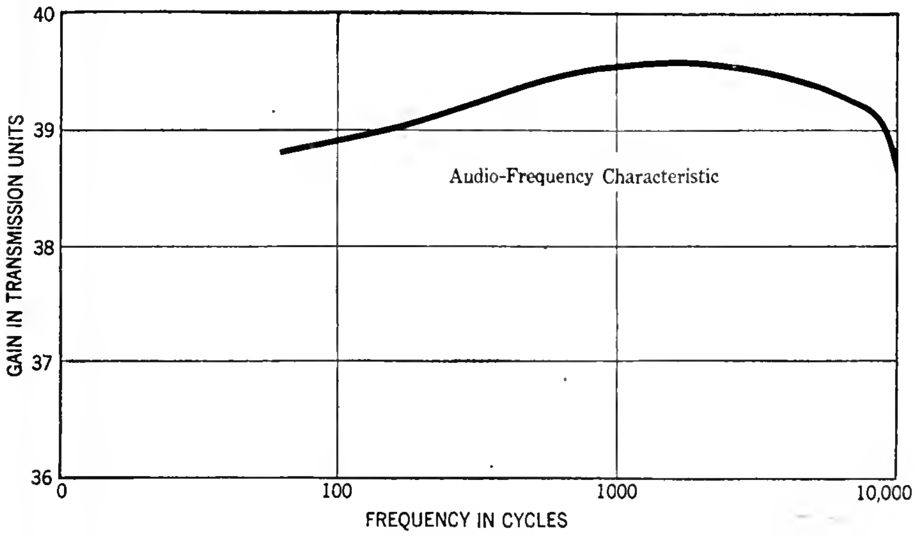


FIG. 3

Fig. 2, will bring to light the fact that this system is different from the conventional split-primary neutralizing arrangements. It is just these little differences which make for the variances in design, and necessitate extensive research, in order that the final result be meritorious and worthy of recognition.

An examination of the receiver shows thorough and complete shielding of all the units, including condensers, coils, and transformers. This is a sound piece of engineering, since it practically isolates the receiver from all external influences. Very often, a. c. operation with the power supply unit adjacent to a receiver utilizing unshielded transformers results in the induction of an interfering hum from the power equipment into the receiver audio-frequency transformers. Shielding the units eliminates all possibility of external interfering influences. Sheet iron, cadmium plated, is used as the shield for the condensers, of which shield the chassis also forms a part. Copper cans are used for the shielding of the radio-frequency transformers. These shields facilitate elimination of coil interaction and external influences, and also tend to increase stability. By selection of copper shields, the design of the coils, and placement of these latter with respect to the shields, the effect of the shield upon the radio-frequency transformer is kept at a very low value, so much so, that its detrimental effects are negligible so far as sensitivity and selectivity are concerned.

THE AUDIO SYSTEM

With respect to the audio system, two stages of transformer coupling are utilized and the operating curve is shown in Fig. 3. A study of the curve shows a variation of less than one half of a transmission unit through a frequency spectrum of from 60 to 10,000 cycles. At first glance, one is apt to imagine an operating characteristic very much akin to the majority of two-stage audio units. Upon closer observation, however, the small variation becomes apparent. The gain of the audio channel is low, but with the amplifying powers of the radio-frequency system, the combination affords a very satisfactory overall response. The absence of a definite peak on some audio frequency shows the result of careful study of the leakage reactance factor in transformer design.

A study of the curve shows an overall frequency range of from 60 to 10,000 cycles, with about equal amplification on 60 and 10,000 cycles. The curve rises between 60 and 900 cycles, is fairly flat between 900 and 3000 cycles, falls gradually to 8000 cycles, and then drops abruptly between 8000 and 10,000 cycles.

OTHER FEATURES

Being, at the time of my sojourn in the Berkshires, conversant with the features of the a. c. operated "Bandbox," the writer was able to communicate all the above information to Jones, whose mind, strangely enough, was gradually allowing itself to be changed to look upon the manufactured receiver in more favorable light.

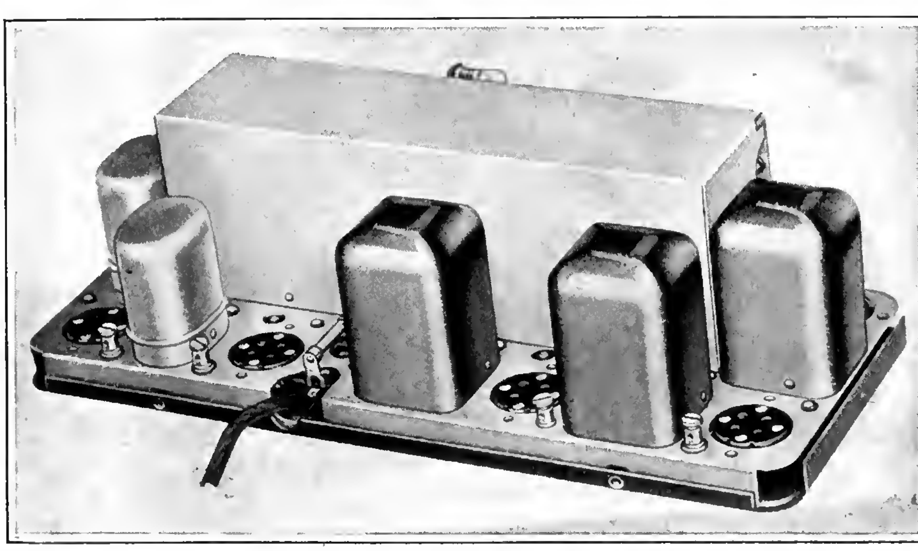
THE POWER UNIT
Its compactness is evidenced by the photograph on page 369

By this time the other members of the group had evinced interest. Some had read the advertisements describing the receiver, and commenced hurling questions: "What were the accuminators?" "Were there any other interesting features?" The appearance of the accuminator controls deceived the "expert." He was certain that they were resistances or potentiometers, by means of which the grid bias voltages were altered. He was much surprised to hear that they were small vernier condensers, one in shunt with the third radio-frequency stage input tuning condenser and the other in shunt with the detector tuning condenser. These are visible in the wiring diagram and their function is to permit more accurate tuning.

The chassis is of $\frac{3}{16}''$ iron and is grounded so that all ground connections of the receiver may be attached to it. The radio-frequency transformers used in the receiver are tested on radio-frequency bridges to within 2 per cent. and are matched with condensers which are also tested at radio frequencies. No coil or condenser combination of a set of three varies more than 1 per cent. from the rated values. In other words, the coils and condensers are sorted into groups and are matched so that the resonance points are identical in the various tuned stages. The grid returns for the untuned and tuned stages are at ground potential and obtain the various bias voltages through resistances, which carry the plate current. The voltage drop across these resistances is utilized as the grid bias.

The tubes in the three stages of radio-frequency amplification of the a. c. "Bandbox" are of the CX-326 (UX-226) type, and this tube is also used for the first audio stage. The detector is a C-327 (UY-227) and the output audio tube is a CX-371 (UX-171).

The electrical balance in the various filament circuits is obtained by means of mid-tapped resistances connected across the filaments, instead of resorting to the use of mid-tapped transformers. The plate voltage applied to the radio-frequency tubes and also the first audio tube is 90 volts. The 90-volt lead also connects to a 20,000-ohm resistance in the set, and is thus dropped to supply the required detector plate voltage. In other words, only two positive plate-voltage leads are available from the unit supplying the receiver. These are the 180-volt lead for the power tube and the 90-volt lead for the



A REAR VIEW OF THE "BANDBOX" CHASSIS

other tubes. A separate 45-volt lead is not provided in the manner usually employed. The power unit also has a negative grid bias 40-volt lead, and the regular B minus lead. The resistances which supply the radio-frequency and detector tubes with grid bias are in series with the B minus.

All of the cx-326 type tubes are connected in parallel and are fed from individual low-voltage filament windings. The midpoint in the filament circuit is obtained by means of a 20-ohm mid-tapped resistance in shunt with this filament circuit. A mid-point is not required in the filament circuit of the c-327 tube since it is of the heater type. The mid-point for the 171 tube filament circuit is obtained by means of a 100-ohm mid-tapped resistance. The filament heating transformer in the power unit supplies three distinct voltages from three distinct windings. These are for the 1.5-volt tube, the 2.5-volt tube, and the 5-volt tube. The cx-326 tubes require 1.5 volts at 1.05 amperes for normal filament operation. The c-327 requires 2.5 volts at 1.05 amperes, and the cx-371 requires 5 volts at 0.5 ampere.

The "Merola" connection indicated on Fig. 2 is the contact point for a phonograph pick-up unit, should it be used. "Merola" is the trade name for a pick-up made by Crosley.

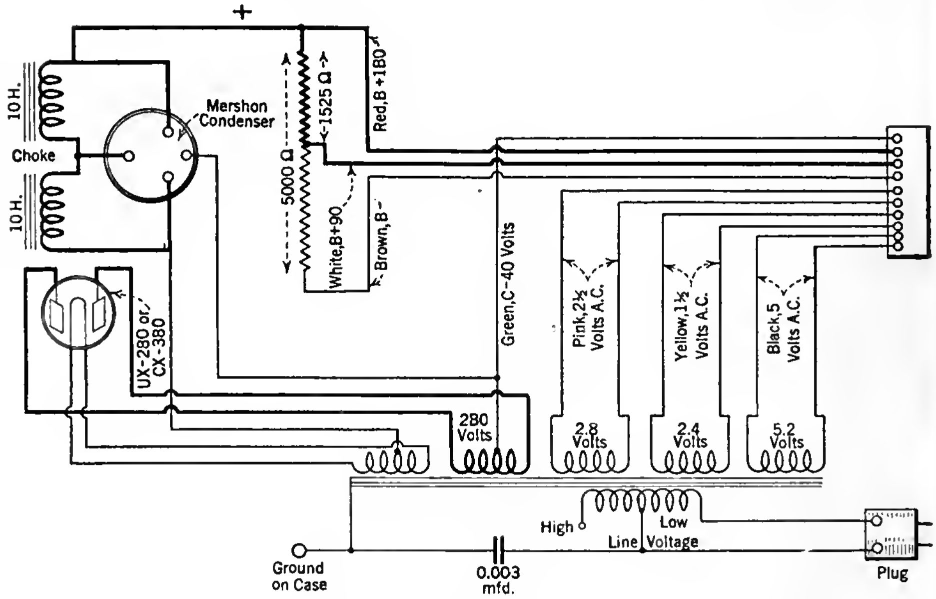


FIG. 4

The circuit diagram of the power supply unit of the a.c. "Bandbox"

THE POWER UNIT

THE power unit differs in several respects from the conventional. It is obtainable in two forms, the first being suitable for a 60-cycle supply and the second for a 25-cycle supply. The latter may also be used for 60 cycles.

A ux-280 type full-wave rectifying tube is employed, as can be seen in Fig. 4. A well-designed two-section filter is employed and the chokes are of 10 henries inductance each, and have a high current rating. This is important, since filtration is improved when the choke is operating below the maximum current rating.

The condensers in the filter network are of 10-mfd. each, three being used in the form of a single Mershon condenser. The voltage reducing resistance has a total resistance of 5000 ohms, tapped at 1525 ohms. With 280 volts input across the two anodes of the rectifying tube, the total voltage across the output is 220 volts. The rectified voltage is, therefore, sufficient to supply the required negative bias of 40 volts. The transformer contained in the power unit has six individual windings. The primary is tapped for low and high line voltage. The rectifier tube filament voltage is obtained from one secondary winding, the rectifier plate voltage from another, while a winding of 2.8 volts is used to supply the 2.5-volt filament of the detector tube.

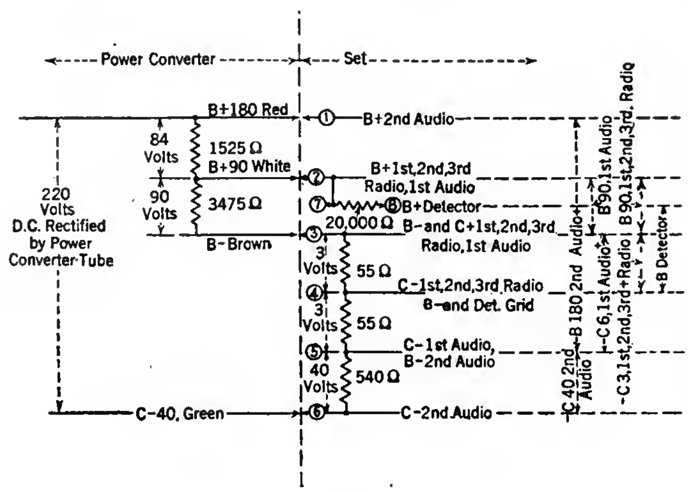


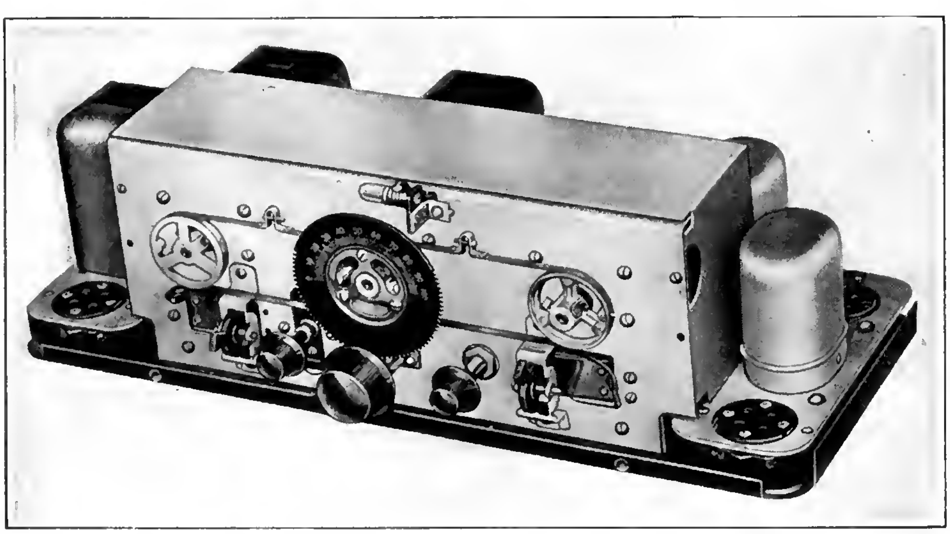
FIG. 5

This diagram shows how the grid voltages are obtained

The excess voltage is an excellent feature because it provides for a reasonable voltage drop in the receiver filament circuit. This phase of a. c. tube operation has been the cause of the greatest amount of annoyance. With the high current consumption of low-voltage tubes, the voltage drop in the average receiver circuit, when five or six tubes are used, is sufficient to reduce the available filament voltage to a value below the requirements of the vacuum tubes. The current drain of six or eight cx-326 or c-327 tubes is quite high, and even a small amount of resistance in the feed line will cause an appreciable voltage drop.

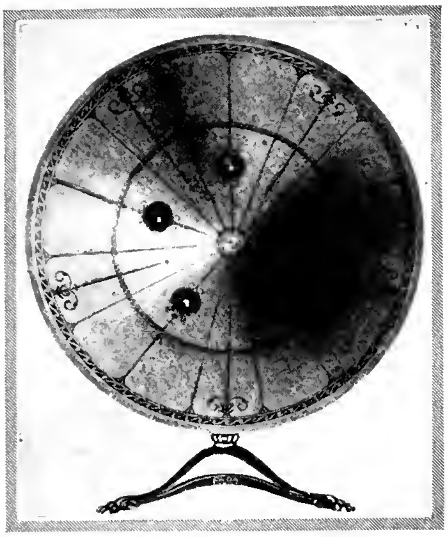
The voltage output of the winding of the power transformer which supplies the 1.5-volt tubes is rated at 2.4 volts, and the voltage output of the winding which supplies the 5-volt power tube is 5.2 volts.

An idea of how the various grid bias voltages are obtained can be gleaned by a study of the wiring diagram of the receiver Fig. 2, and Fig. 5. The three resistances which produce the C bias voltages for the various tubes are shown in both drawings. The main wiring diagram shows the actual position of these resistances, as located in the receiver. The small wiring diagram, on the other hand, shows a much simpler arrangement, such as would be found were these resistances located in the power unit. The first 55-ohm resistance results in a voltage drop of 3 volts. This is the bias applied to the three radio-frequency amplifiers and to the detector grid. The next 55-ohm resistance, in series with the first, produces a voltage drop of 6 volts, which is applied to the grid of the first audio-frequency tube. The 540-ohm resistance produces the voltage drop of 40 volts required for the second audio tube, which, in this case, is a cx-371 (ux-171).



WHAT THE "BANDBOX" LOOKS LIKE WITH THE CABINET REMOVED

Interesting Loud Speakers and Power Equipment



THE FADA 22″ CONE

ALTHOUGH this picture illustrates only the table model, the 22″ cone is obtainable also in pedestal form at $50.00, and for hanging on the wall at $25.00. The table model shown lists at $35.00. Fada also has a 17″ cone which retails (the table pattern) for $25.00

THE BOSCH A UNIT

WHICH has been designed to supply A current to a receiver employing from four to ten tubes. The unit makes use of a Tungar rectifier tube. The price of this A supply is $58.00, and it is produced by the American Bosch Magneto Corporation, Springfield, Massachusetts

IF YOU HAVE AN ATWATER KENT RECEIVER

YOU will find this Atwater Kent B supply especially suitable for use in conjunction with it. The B supply may, however, be used with other receivers. It delivers up to 135 volts, and is for sets consuming not more than 40 mils. An automatic relay is incorporated within the unit, and there is a receptacle in the front for trickle charger plug. Price $39.00

A NEW DYNAMIC LOUD SPEAKER

THE movable coil principle is featured in this attractive new loud speaker, which retails at only $65.00. Two of its connections go to the A battery, but a minimum of current is consumed. The loud speaker (with step-down transformer) without cabinet retails at $17.50. Jensen Radio Manufacturing Company, Oakland, California

TWO MAGNAVOX LOUD SPEAKERS

THE popular R-4 unit is shown to the left. It is a moving coil electro-dynamic loud speaker retailing for $50.00. It should be used in conjunction with a baffleboard. The model to the right lists at $120.00. In addition to being a loud speaker, it also combines a B supply unit and power amplifier. A 210 type tube is used for the latter, while a 216 type tube is employed as the rectifier

A NEW WESTERN ELECTRIC CONE

THE Western Electric 540 AW cone loud speaker has been the standard of comparison for so long that considerable interest is bound to follow the announcement of a new cone by this company. The 560 AW, as this new instrument is known, is a 25″ cone, and it lists at $35.00. The decoration in red and dark brown, is more striking than that on the 540 AW

New Records

Short Reviews of Recent Releases by Victor, Brunswick, and Columbia—A List of Some New Record Albums—Rimsky-Korsakov's Scheherazade *Suite Obtainable in Complete Form*

WE ARE celebrating the four-month birthday of this department by climbing out of our rompers and taking a big step. Henceforth we shall aim to be a guide to all the best phonograph records. You cannot read all the books published each year in order to choose the best volumes, so you consult book reviews and guides. Neither can you while away the hours in your favorite music store listening to the new—and old—offerings of the very active phonograph companies. When you buy records the chances are you act on the advice of the music salesman, or take the word of a friend, or if you happen to be on the mailing list of a music store, you check over the catalogue and select the most likely sounding titles. Any one of these methods is precarious and the element of chance is large in each.

When this department was mapped out in the editorial mind, the word went forth that these two pages were to be devoted to a general review of phonograph records which had been produced by artists who were familiar to listeners-in as broadcast performers. Now we will extend the field to include the records of all artists whether or not they play the dual rôle. Some of the recordings will be briefly reviewed, others will merely be mentioned, and each month there will be a list of records which we consider well worth hearing, and buying, if the spirit moveth.

WHAT HAVE WE HERE?

AFTER inspecting the current supply of records we find that it contains the following ingredients: The usual popular vocal numbers by the usual popular vocal artists; an array of good dance numbers with one outstanding success, *Dream Kisses*; several old favorites rendered superbly by such distinguished artists as Sophie Braslau, John Charles Thomas, Charles Hackett, and Maria Kurenko; seven minutes of very beautiful choral singing by the Metropolitan Opera Chorus; and an album of Rimsky-Korsakov music, of which, more anon. These ingredients have been highly seasoned with the sentiment which, we are led to believe by song writers, song singers, and phonograph companies, the public cries for, and they have been expertly mixed, and sifted, spread on the discs by the new electrical recording method, and served hot to the public, for prices ranging from seventy-five cents to ten dollars. Taken as a whole there can be no question of the general excellence of the output. Our chief complaint is that it is too sweet for our taste. Is our taste peculiar or are there others who do not clamor for sentiment as the pervading flavor in their musical diet? Would they, too, like a little humor in their daily slice of song?

Don't Miss These

Scheherazade Suite (Rimsky-Korsakov) played by the Philadelphia Orchestra under Leopold Stokowski (Victor).
Cavalleria Rusticana-Gli Aranci Olezzano and *Immeggiamo Il Signor* (Mascagni) sung by the Metropolitan Opera Chorus, with Orchestra (Victor).
Rigoletto: La Donna E Mobile (Verdi) and *Cavalleria Rusticana: Siciliana* (Mascagni) sung by Charles Hackett (Columbia).
Liebestraum (Lizt) and *Sheep and Goat Walkin' To Pasture* and *Gigue* (Bach) played by Percy Grainger (Columbia).
Among My Souvenirs and *Washboard Blues* played by Paul Whiteman and His Concert Orchestra (Victor).
Dream Kisses and *Among My Souvenirs* played by the Ipana Troubadours and Ben Selvin respectively (Columbia).
My Lady and *Two Loving Arms* played by Cass Hagan and His Park Central Orchestra and The Cavaliers respectively (Columbia).
A Shady Tree and *There Ain't No Land Like Dixieland To Me* played by Ernie Golden and His Hotel McAlpin Orchestra (Brunswick).
Back Where the Daisies Grow and *Lonely in a Crowd* played by the Park Lane Orchestra (Brunswick).
Liliue and *Hanohano Hanalei* by the South Sea Islanders (Columbia).

More or Less Classic

Cavalleria Rusticana—Gli Aranci Olezzano and *Cavalleria Rusticana—Inneggiamo Il Signor.* By Metropolitan Opera Chorus with Orchestra. (Victor). An expert recording of two of the most melodious of the choruses of Mascagni's opera, sung with great beauty and restraint.

(a) *Sheep' and Goat Walkin' to the Pasture* (Guion), (b) *Gigue* from *First Partita* (Bach), and *Liebestraum* (Liszt). By Percy Grainger (Columbia). Here is variety itself: a humorous tale, a lively jig, and a romance all on the same record, and each feelingly interpreted by this master pianist.

Hungarian Dance No. 1 (Brahms-Joachim) and *Slavonic Dance No.* 2, in E minor, (Dvorak-Kreisler). By Toscha Seidel (Columbia). Two lusty dances played with too mechanical vehemence to suit us.

Lucrezia Borgia: Brindisi (Donizetti) and *Come to Me O Beloved!* (Bassani-Malipiero). By Sophie Braslau (Columbia). We prefer the rollicking joyousness of the drinking song to the heavy solemnity of the cantata but that is a matter of opinion. The rich contralto voice of this artist handles both expertly.

Love's Old Sweet Song (Molloy) and *The Sweetest Story Ever Told* (Stults). By Sophie Braslau (Columbia). Miss Braslau digs way down in the bag and brings up some of the old tricks. But she sings beautifully.

Rigoletto: La Donna e Mobile (Verdi) and *Cavalleria Rusticana: Siciliana* (Mascagni) by Charles Hackett (Columbia). So convincingly does this glorious tenor sing Verdi's surprise number that one is almost ready to agree that woman *is* fickle! Well, were it necessary, we would agree to anything for the privilege of listening to Hackett's singing.

Coq D'Or, Hymn to the Sun (Rimsky-Korsakov) and *Song of India* (Rimsky-Korsakov) By Maria Kurenko (Columbia). We would like the first selection better were it minus a few coloratura frills. As for the S. of I. we said what we had to say about that years ago. However, it *is* beautifully sung.

Smiling Eyes and *Roses of Picardy*. By John Charles Thomas (Brunswick). Why turn this fine baritone voice loose on such shop-worn ballads as these?

"Popular"

Among My Souvenirs and *Washboard Blues* by Paul Whiteman and his Concert Orchestra (Victor). Whiteman at his unique best. You can't dance to these but who wants to? It's music worth *hearing*.

Dream Kisses by the Ipana Troubadours (Columbia). At last we have something different in dance numbers! A soothing, insinuating rhythm built for dancing and played for dancing

Interesting Record Albums

Beethoven: *Symphony No. 9, in D minor (Choral)*	ALBERT COATES AND SYMPHONY ORCHESTRA	*Victor*
Beethoven: *Concerto in D major. Violin*	FRITZ KREISLER AND STATE OPERA ORCHESTRA, BERLIN	*Victor*
Brahms: *Symphony No. 1, in C minor*	LEOPOLD STOKOWSKI AND PHILADELPHIA ORCHESTRA	*Victor*
Schubert: *Symphony No. 8, in B minor (Unfinished)*	LEOPOLD STOKOWSKI AND PHILADELPHIA ORCHESTRA	*Victor*
Tschaikowsky: *Casse Noisette (Nutcracker Suite)*	LEOPOLD STOKOWSKI AND PHILADELPHIA ORCHESTRA	*Victor*
Chopin: *Sonata in B minor, for Pianoforte, Opus 58*	PERCY GRAINGER	*Columbia*
Brahms: *Sonata in A major, Opus 100, Violin and Piano*	TOSCHA SEIDEL AND ARTHUR LOESSER	*Columbia*
Ravel: *Ma Mère l'Oye (Mother Goose) Suite for Orchestra*	WALTER DAMROSCH AND NEW YORK SYMPHONY ORCHESTRA	*Columbia*
Dvorak: *Symphony No. 5, "From the New World"*	SIR HAMILTON HARTY AND HALLÉ ORCHESTRA	*Columbia*
Berlioz: *Symphonie Fantastique, Opus 14*	FELIX WEINGARTNER AND LONDON SYMPHONY ORCHESTRA	*Columbia*
Beethoven: *Symphony No. 5, in C minor*	WILHELM FURTWAENGLER AND PHILHARMONIC ORCHESTRA, BERLIN	*Brunswick*
Beethoven: *Symphony No. 7, in A major*	RICHARD STRAUSS AND THE ORCHESTRA OF THE STATE OPERA, BERLIN	*Brunswick*
Handel: *Concerto for Organ and Orchestra No. 4 (Op. 4)*	WALTER FISCHER OF THE BERLIN CATHEDRAL WITH ORCHESTRA	*Brunswick*
Mozart: *Jupiter Symphony, No. 41 Opus 551*	RICHARD STRAUSS AND ORCHESTRA OF THE STATE OPERA, BERLIN	*Brunswick*
Richard Strauss: *Ein Heldenleben*	RICHARD STRAUSS AND THE ORCHESTRA OF THE STATE OPERA, BERLIN	*Brunswick*

The records in the above groups are to be had only in album form. The list is by no means complete but serves to indicate a few of the most interesting complete recordings which are available. The Rimsky-Korsakov *Scheherazade Suite* (Victor) is reviewed elsewhere on this page.

by S. C. Lanin's Toothpaste Boys. On the reverse is *Among My Souvenirs*. Ben Selvin makes as good a dance record out of this as Whiteman did a set piece.

A Shady Tree and *There Ain't No Land Like Dixieland To Me* by Ernie Golden and His Hotel McAlpin Orchestra (Brunswick). Two more hot numbers from the orchestra under the direction of the gent who has musical "it."

Yep! 'Long About June and *Blue Baby* by Ray Miller and His Hotel Gibson Orchestra (Brunswick). The first is a lively down-east-barn-dance sort of number that will make your feet very restless; the second, only another dance tune. Both smoothly played by this excellent Cincinnati orchestra.

Back Where the Daisies Grow and *Lonely in a Crowd* by the Park Lane Orchestra (Brunswick). After hearing these two numbers you will add the P. L. to your list of best orchestras.

Ooh! Maybe It's You and *Shaking the Blues Away* by Ben Selvin (Brunswick). Not quite up to the Selvin mark but you won't want to sit still to either number.

Barbara and *There's a Cradle in Caroline* by Ben Bernie and H. R. Orchestra (Brunswick). Just another disappointment.

Together We Two and *What'll You Do* by Isham Jones Orchestra (Brunswick). Isham has certainly been in seclusion long enough to have dug up better numbers than these for his return engagement.

My Lady by Cass Hagan and His Park Central Orchestra. Simply swell! *Two Loving Arms* by the Cavaliers. A grand waltz. (Columbia).

Are You Happy? and *Kiss and Make Up* by Vincent Lopez and His Casa Lopez Orchestra (Brunswick). Answering the question: No more so than if we'd never heard this record.

Together We Two by Fred Rich and His Hotel Astor Orchestra. (Columbia). Only moderate. *Baby Feet Go Pitter Patter* by Harry Reser's Syncopators. Won't you give just a little something for a decent funeral?

Where Is My Meyer? by Eddie Thomas' Collegians (Columbia). A good nonsense song from the *Chauve Souris* sung by Frank Harris with an orchestral background and a little yodeling for good measure. *Clementine* by Don Voorhees and His Orchestra is only fair.

A Lane in Spain and *There Must Be Somebody Else* by Van and Schenck (Columbia). A very good vocal duet aided by guitar and piano.

Watching the World Go By by Ford and Glenn (Columbia). Why shouldn't it? This isn't enough to stop for. *Are You Thinking of Me To-night?* by Elliott Shaw. Insomnia must be prevalent among song writers.

There's a Cradle in Caroline and *I'll Be Lonely* by Frank Bessinger and Ed Smalle (Brunswick). Good sentimental singing.

I'm Coming, Virginia and *Just a Memory* by the Singing Sophomores (Columbia). Leaves us cold.

Twiddlin' My Thumbs and *The Pal You Left At Home* by the Whispering Pianist (Columbia). Good rubber wasted on tripe.

Liliue and *Hanohano Hanalei* by the South Sea Islanders (Columbia). Good Hawaiian music magnificently played.

My Blue Heaven and *The Song is Ended* by Jesse Crawford (Victor). If you know anyone who wields a better movie organ than the organist at the Paramount Palace we would like to hear of him. Jesse Crawford is at his very best on these records.

Are You Lonesome To-night? and *Under the Moon* by Lew White (Brunswick). But the Roxy organist isn't far behind.

Estrellita and *Mi Viejo Amor* by Godfrey Ludlow (Brunswick). Good violin solos by the well-known staff artist of the National Broadcasting Company.

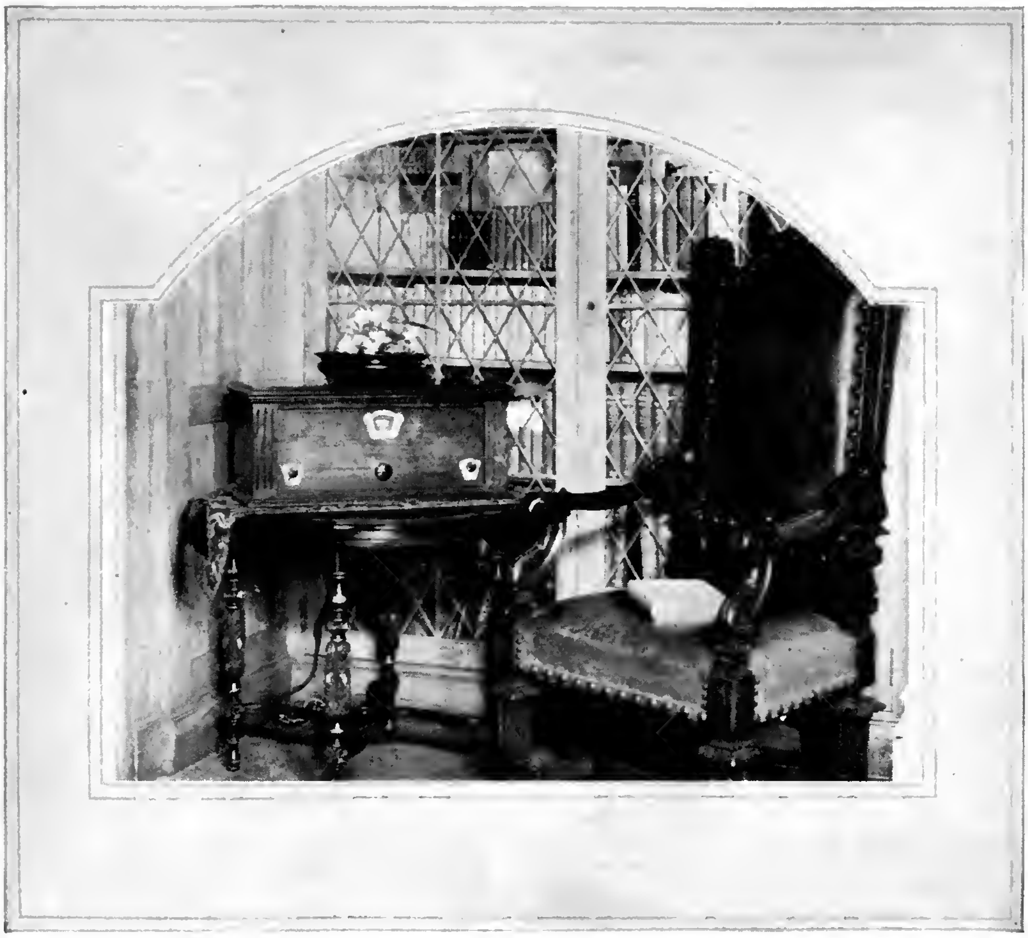
A COMPLETE SYMPHONY

Scheherazade—Symphonic Suite (Rimsky-Korsakow). By Leopold Stokowski and the Philadelphia Orchestra. Complete on five double-faced Victor records.

When the Russian composer Rimsky-Korsakov called this music the *Scheherazade Suite* he did not mean to imply that he was telling, musical word for spoken word, the story of the Sultan Schahriar, who so distrusted women that he vowed to put each of his wives to death after the first nuptial night; and of Scheherazade, the Sultana, who caused him to forsake his vow by entertaining him with fascinating tales for one thousand and one nights, at the end of which time it is to be presumed that he had regained his faith in women. Rimsky-Korsakov merely used the title as a hint to his listeners that the suite was "an Oriental narrative of some numerous and varied fairy tale wonders," told by some one person to her stern husband.

Take the hint of leave it. If you take it you can easily pick out the voice of the stern husband with which the first movement, *The Sea and the Vessel of Sinbad*, opens. It is a bold phrase played in unison by the trombone, the tuba, horns, woodwinds, and strings in their lower range. Then the sweet, timid voice of Scheherazade, in the high trembling notes of the violin, with the harp in the background. Then we hear the long roll of the sea translated into music by the violins. Now and then the lapping of the waves on the vessel. In the second movement, *The Tale of the Prince Kalender*, you can certainly identify the figure of the fakir prince in the now sad, now comic, notes of the bassoon; and there is no mistaking the wild violent dance of the Orient in which brasses, woodwinds, tuba, trombone, bassoon, and strings combine. The third movement tells a love story of *The Young Prince and the Young Princess*. The romance is plainly indicated in the simple tender melodies. And lastly there is *The Festival at Bagdad*, music full of the color and sinuous rhythm of the East. Queer minglings of sounds, seductive strains, call to mind beautiful veiled maidens, snake-charmers, swaying camels, spicy odors, perfumes of the Orient. Then suddenly we swing back again to the sea, this time not the calm, rolling sea of the first movement but a turbulent, treacherous sea, in which the vessel of Sinbad finally sinks, after a mighty crash on the rocks. And as the waters close over the ship the voice of the Sultan, now subdued, tells us that the tale is over and he is pleased, and the Sultana goes back to the opening theme of the strings for her finale.

Beautiful music, rich, colorful, varied—dealing with weird and wonderful events but always essentially human. Played by a master orchestra directed by a master hand—a feast to suit the palate of the most discriminating of music lovers.



RADIO BROADCAST Photograph

A RECEIVER EMBODYING NEW R. F. PRINCIPLES

This six-tube Stewart-Warner receiver employs the features of r.f. design which are described in this article

Designing an R. F. Amplifier

By Sylvan Harris

PERHAPS the most important problem that remains in connection with the design of radio receivers is that of controlling regeneration and the tendency toward self-oscillation. The patent situation in the radio industry to-day accentuates the importance of this matter, but aside from this, and considering only the technical aspect of the problem, there are certain important points concerning which the layman's ignorance is appalling and on which many engineers are doubtful. The most important of these is, perhaps, the magnitude of the amplification which a radio-frequency amplifier can furnish under the most favorable conditions.

This problem will not be discussed here; it will suffice for the present to state that the greatest amplification that a radio-frequency amplifier, having regeneration, will furnish, is determined by the electrical characteristics of the circuits, and takes place when the decrease in amplitude of the feed-back current from stage to stage becomes less than equal to the natural amplification in the opposite direction. That is, a voltage established in the plate circuit of the last amplifier (r.f.) tube, is decreased in each stage looking in a direction toward the input of the amplifier.

In the opposite direction we have the signal voltage passing from stage to stage, but being amplified at each step. When the decrease in amplitude in the direction of feed-back becomes small enough, oscillations are established, and it is at the instant that these oscillations are established that the greatest amplification is obtained.

The maximum possible amplification that can be obtained from the system under given conditions can be computed. A method of making this computation was shown some time ago by Dr. A. W. Hull, in his paper on the shielded-grid tube in the *Physical Review.*

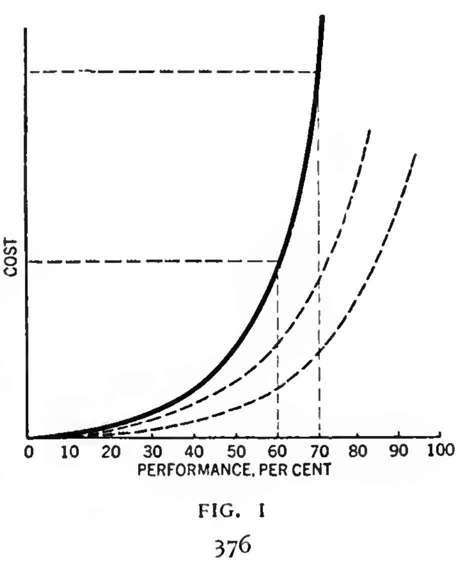


FIG. 1

It can be shown that, using the usual tubes, and under the usual average circuit conditions, it is not possible to obtain a gain per stage of more than about 10 or thereabouts, in the broadcasting spectrum, assuming reasonable values for the circuit elements and the 201-A type tube characteristics. Furthermore, the amplification naturally drops off as the frequency increases because of several complicated tube and circuit factors. The amplification we are referring to is the *maximum* amplification obtainable, keeping the adjustments such that the system is always on the verge of oscillation.

This brings to our attention a particular phase of the problem, *viz.*, that of keeping the overall gain of the amplifier constant over the broadcasting frequency range. Since the amplification is naturally greater at lower frequencies than at higher, the only way in which to make it uniform is to operate very close to the point of oscillation at high frequencies, and not so close at low frequencies. On account of difficulties encountered due to the stabilizing elements (grid resistors, etc.), we have many sets which operate well at

300 meters but are "dead" at 500 meters, and many of which are rather "wild" below 300 meters.

On the other hand, due to absorption in metal panels, additional attenuation introduced by neutralizing condensers, etc., we often encounter the condition where the set is "dead" at the higher frequencies also. Of course, these terms are merely relative; it is clear that under any circumstances the design of the receiver, especially when it is intended for production in large quantities, must provide for sufficient tolerance in this matter of operating close to the oscillation point.

Another point which is of paramount importance, especially as regards the production of radio receivers in large quantities, is that of the relation between the performance of a receiver and its cost. Let us call the "performance" of our ideal receiver 100 per cent. and the performance of the receiver which will not work at all, 0 per cent. As regards the cost, let us say we can build a receiver whose performance is zero per cent. for practically nothing. On the other hand, as we improve the performance of our receiver in uniform steps, the cost mounts up and up at an ever-increasing rate, until it would cost an infinite amount to produce the ideal receiver operating at a performance of 100 per cent. The relation between the performance and the cost of a receiver is probably an exponential one, and may be something like the curve of Fig. 1. Thus, we can design and build a receiver having a "performance" of 60 per cent. at a reasonable cost, but when we attempt to improve the performance by 10 per cent. more, we drive the cost way up. Of course, the curve of Fig. 1 is purely qualitative; it is intended merely to illustrate the idea.

The receiver described in these articles has been designed with these ideas in mind; at the same time it must be remembered that there are certain circuit arrangements which are more flexible than others, making it possible to build a better receiver at the same cost, so that actually Fig. 1 should be a family of curves, each curve applying to a different type of receiver. As to the merits of the receiver to be described here, it will be well to leave these to the judgment of the reader rather than run the risk of laying oneself open to criticism.

It is well known that the presence of inductive reactance in the plate circuit of a radio-frequency amplifier tube results in regeneration. Furthermore, if that reactance exceeds a certain critical value, oscillations will be established in that stage, and further, the critical value varies with the frequency. Many different methods have been tried for keeping this reactance below the critical value, such as varying the coupling in the resonance transformers simultaneously with the tuning condenser. The method used in this circuit is unusual as applied to r.f. amplifiers, although a similar arrangement has been used for controlling regenerative detectors.

Fig. 2 illustrates the fundamental idea of the

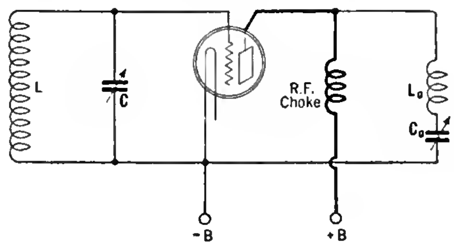


FIG. 2

circuit. The coil L and the condenser C constitute the tuned input circuit. In the plate circuit of the tube there is the usual primary coil of a resonance transformer, L_0. This inductance L_0 is of such value that the circuits would ordinarily oscillate; in other words, L_0 is greater than the critical positive value.

In order to stop the oscillations the condenser C_0 is introduced in series with L_0; the condensive reactance furnished by C_0 is negative in sign, so that the net positive reactance in the plate circuit of the tube is reduced, depending upon the value of the capacity of C_0.

It is clear that the net reactance can be made almost anything we desire by this means. We may so proportion L_0 and C_0 that X_0 may be positive and greater than the critical value, equal to or slightly less than the critical value, or, we may even make X_0 equal to zero, or make it negative. When X_0 is positive and greater than the critical value, the circuits will oscillate; under any other condition it will not oscillate. The special case where X_0 equals zero is known as the "zero reactance plate circuit," and will be discussed later on. The case where X_0 is negative (or capacitive) is not of interest here, for under such conditions the circuit becomes very inefficient, due to the absorption of power at the input of the tube. These conditions have been discussed by J. M. Miller in *Circular No. 351 Bureau of Standards.*

It would evidently be very cumbersome to operate two condensers in each stage of the radio-frequency amplifier, a three-stage amplifier requiring seven condensers, three "twins" and one "single." The obvious thing to do, therefore, is to operate them all together. The problem remains then, to so proportion the inductance and capacity in the plate circuits so that when C_0 is varied at the same rate as C (the tuning condenser) the net plate circuit reactance will be slightly below the critical value at all frequencies.

The first problem in the design was, therefore, to determine whether C and C_0 could be varied at the same rate; this amounts to the same thing as determining whether the plates in the two condensers could have the same shape. In order to determine this, as well as to determine other things that were to follow, a system of measuring the amplification or "gain" per stage was set up, a description of which was presented by the writer in *The Proceedings of the I.R.E.*, July, 1927.

The complete circuit of the receiver is shown in Fig. 3. Each stage is completely shielded, originally in copper cans, but later in aluminum cans. A laboratory set-up was made, in conjunction with the measuring system mentioned above, "single" condensers being used in the receiver, with leads coming out of the cans to which separate plate condensers were connected. Each condenser was individually controlled.

With a constant-frequency signal impressed on the input of the receiver, the condensers in the plate circuits of the r.f. tubes were gradually and simultaneously increased from zero upwards, in steps, their capacities being always kept the same, and measurements of the gain were taken at each step.

At a high frequency, say 1500 kilocycles, a curve similar to that marked f_1 in Fig. 4 was obtained. At the upper limit of the curve the circuits broke into oscillation. Having completed this curve, a similar curve was obtained for a slightly lower frequency, say 1750 kilocycles, illustrated by curve f_2 of Fig. 4. So, a family of curves was obtained, each curve for a different frequency; sufficient curves were obtained so that the operation over the entire broadcasting range of frequency could be studied.

It will be noted that there is an inflection in each of these curves near the upper limit where oscillations begin. Above the point where the inflection begins the system is very critical, so it was evident that the greatest gain per stage that could be utilized with safety at any given frequency is at this point. In Fig. 4, therefore, the points a, b, c, d, represent the greatest amplification that can be obtained with the particular tubes, coils, etc. Through these points a curve can be drawn, marked AB, from which can be taken values to plot a curve of C_0 against the frequency, or against C, which is the information which was required. It was found that on plotting C_0 against C, the curve obtained was very nearly linear, indicating that it was per-

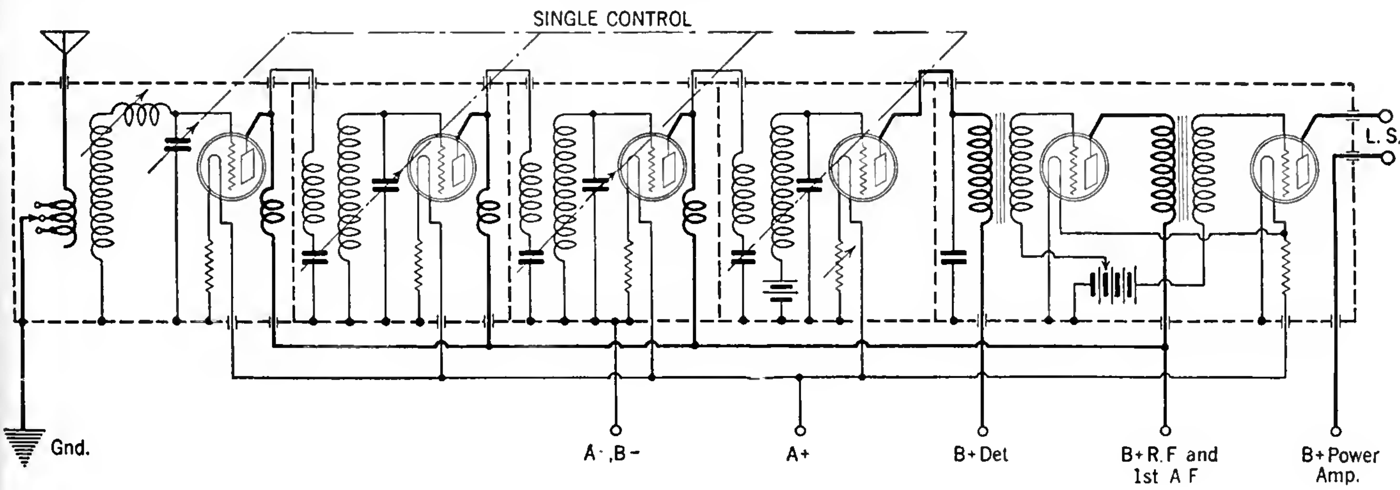


FIG. 3

fectly feasible to vary C_0 at the same rate as C, and that the two condensers may have plates of the same shape and may be driven by the same dial.

It is evidently desirable to have the same shape plates in the two condensers, in the interests of economy as well as simplicity. It was also found that with the given coils, the capacity required in the plate circuit (represented by the points a, b, c, d, of Fig. 4) at various frequencies was very

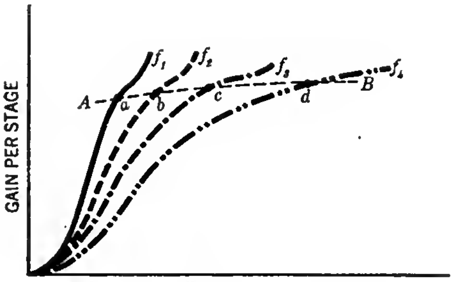


FIG. 4

close to that required in the tuning condenser C at each frequency. This relation can be adjusted at will, by simply changing the design of the resonance transformer; it was thought advisable, however, to keep both sections of the "twin" condenser the same, as this would facilitate factory inspection, permitting the inspection of both sections, by the same operator and on the same testing "jigs."

Upon setting up a model of the receiver, it was found, that, whereas the amplification was considerable at lower frequencies, it dropped off very rapidly as the higher frequencies were approached. This was very noticeable when the receiver was tried "on the air;" the ability of the receiver to "perform" at wavelengths shorter than about 350 meters was practically *nil*. The problem then remained to increase the sensitivity of the receiver at the shorter wavelengths, leaving the sensitivity at the longer wavelengths the same.

The means used for doing this is, as far as the writer is aware, a new one; it is new, not in the sense that it has never been used before, but in the sense that it has been done intentionally and with a definite purpose. There is plenty of coil capacity in plenty of receivers, but as far as the writer has been able to find out, no one has heretofore attempted to put this coil capacity to a good use.

Up to this point in the work the primary coils of the resonance transformer were wound in a single layer at one end of the secondary, separated from the secondary by about one-quarter of an inch. The idea occurred that by introducing a slight amount of capacity coupling in the resonance transformers, in addition to the magnetic coupling, the regeneration at the higher frequencies would be slightly increased, and the desired increase in amplification would be thereby attained.

Consequently, the primary coil of one of the resonance transformers (that preceding the detector) was wound on a short tube and slipped *inside* the secondary. When tuned to a short wavelength (or high frequency), the response of the receiver would gradually increase as this primary is moved up into the secondary further and further, until oscillations begin. This point is located, and the primary coil is then fixed in place slightly below it. Besides the advantage gained by increasing the amplification at the higher frequencies and thus solving the greatest problem which was encountered, there is an additional and important advantage gained by making the primary adjustable at the factory. It is possible by this means to insure uniform production of receivers with regard to sensitivity.

The effect can be explained qualitatively by means of Fig. 5. The curve AB is supposed to represent the amplification curve of a stage of the r.f. amplifier before the coil capacity has been introduced. On introducing the coil capacity the curve rises at the right-hand side, resulting in the curve AC. On the first trial a considerable depression was found in the curve at a frequency of about 850 kilocycles. It was found, however, that by properly adjusting the self-inductance of the primary as well as its location within the secondary, this depression could be made to disappear almost, and the amplification was thus made practically uniform over the entire broadcasting spectrum.

The resulting receiver proved to be very sensitive and selective. No difficulty was experienced in separating the local broadcasting stations in either New York or Chicago, and it was possible in many cases to even tune-in stations between the locals.

There are several other additional features of this receiver which are worthy of mention. One of these is the location of a separate filament resistor in the negative lead of each tube filament of the r.f. amplifier.

By this means a negative bias is placed on each grid, with the result that the receiver is very economical with respect to the B supply. The maximum plate current is about 27 milliamperes, and on receiving local concerts, sufficient volume for ordinary sized homes is obtained with the volume control "just on," and the set drawing only about 10 milliamperes. This latter statement holds also when receiving some powerful stations at fair distances.

Another feature of the receiver is the C battery detector. This type of detector was used instead of the grid leak-grid condenser type on account of its ability to rectify more powerful signals before overloading occurs. It also cuts down the costs by eliminating the grid condenser and leak, and necessary inspection were they used. The difference in sensitivity between the two types of detectors is of secondary importance in this receiver on account of the great sensitivity of the r.f. amplifier.

The input stage of the amplifier is tuned by a "single" condenser, and, in addition to this, has a portion of the secondary winding of the antenna transformer variable. There are also three taps on the primary or antenna coil, so that by means of the taps and variable portion of the secondary, the input stage is made very efficient. The constants of this stage, however, are so chosen that no matter on which of the three points the switch may be set, it is not possible to "pass over" any except the *very* weakest signals when varying the condensers.

Another feature of the receiver is the absence of bypass condensers in the r.f. amplifier. The only place where a bypass condenser is used is in shunting the primary of the first audio transformer. The general wiring of the receiver makes it unnecessary to use them, the only avenue of exit for the r.f. currents outside of the grid and

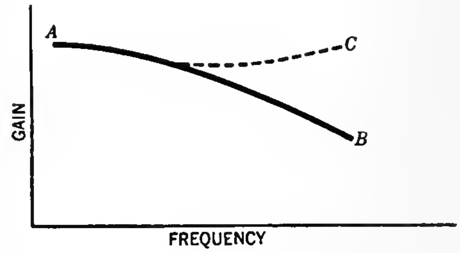


FIG. 5

plate leads being the B supply lead, which is blocked by an effective r.f. choke coil.

The greater part of the wiring is in the metal of the receiver—the aluminum cans and base. The ground accommodates the A minus, B minus, and C plus, making the entire wiring job a very simple one indeed. A "matched unit" construction is used, the four cans and their contents being identical in many respects. The first stage differs from the rest only in the coil and single condenser, and the fourth can (the detector stage) differs only in having an individual filament control. This was deemed necessary, or at least desirable, on account of the varying characteristics of electron tubes. But when once this rheostat is set for a particular tube, there is no further necessity of adjusting it.

The mechanical arrangement of the receiver is also novel. The separate cans are easily removable, for servicing purposes, by simply loosening the screws on the backs of the cans which hold the terminal lugs fastened on to the four or five leads connecting to the can. All the battery supply leads are cabled along the rear of the set outside the cans. Likewise the audio amplifier, of the transformer type, is removable as a unit, in the same manner. There are four "twin" condensers and one "single" condenser in the receiver, all of which are driven by the same mechanism. To facilitate the "matching" of condensers while the lids of the cans are in place, the front steel panel on which the condensers are mounted is slotted, so that the stators of the condensers can be rotated through a small angle and then clamped in place.

The great sensitivity of the receiver described here is due to several things; first the primary self-inductance is a little greater and the coupling is slightly closer than in the usual resonance transformer employed in r.f. amplifiers. Furthermore, it is possible to adjust, and to maintain the adjustment closer to the oscillation point than is usually the case. Next, there is the reduction of grid losses due to the grid bias on each r.f. amplifier tube, and finally there is the tuned input stage.

Suppressing Radio Interference

Some Recently Investigated Sources of Interference—Trouble from High-Tension Lines and Distribution Systems—General Hints on the Location of Sources, the Arrangement of a Patrol Car, and the Receiver to Use—Procedure in Patrol Work and the Many Misleading Clues

By A. T. Lawton

WHEN we consider that a little spark, say one-sixty-fourth of an inch long, can cause severe radio interference, it becomes obvious that almost any piece of electrical apparatus in ordinary commercial use is a potential source of trouble. This does not mean that all electrical accessories do actually give rise to disturbances. On the contrary; considering the expansion of the electrical industry and the universal use of electrical equipment, we may well marvel that the noise level of the average city is so low.

When looking around for the possible cause of interference, however, nothing in the electrical line should be overlooked. It may help a little if we detail some of the sources located recently in following up interference complaints:—

(1.) Printing office linotype motor; normal operation, no fault. Cleared up by method (a) Fig. 1.
(2.) Clippers in barber shop. Normal. Cleared up by method (a) Fig. 1
(3.) Same source as above. Abnormal—commutator grooved. Used method (c) Fig. 1
(4.) Cream tester in dairy plant. Normal. Used (a) Fig. 1
(5.) Battery charger, vibrating reed type. A 1-mfd. condenser across contacts eliminated trouble.
(6.) Same source as above—different manufacture. Required method (a) Fig. 1
(7.) Refrigerator, home type artificial refrigeration. Used method (a) Fig. 1
(8.) Battery Charger, rotary rectifier. Obstinate case. Used method (c) Fig. 1
(9.) Woolen mill, static neutralizer. Defective plug connection. Repaired.
(10.) Brass foundry, lighting wires crossed and sparking, concealed. Confusing, as corresponded with vibration of large motor which was shaking floor. Motor supply cut abruptly but radio interference died gradually with slowing down of motor giving clue to the trouble, which was located and fixed.
(11.) Voltage regulator in a power station. Case still pending.
(12.) Chattering circuit breaker in power plant operated by thermocouple. Breaker readjusted and interference disappeared.
(13.) Washing machine motor, defective. Repaired.
(14.) Thermostat, mounted on wall subject to abnormal vibration. Bad clicking radio interference. Changed location of thermostat to solid wall.
(15.) Constant-current transformer in power station. Case pending.
(16.) Noisy grid leak in complainant's radio set. Referred to service man.
(17.) Elevator in apartment house. Under investigation.
(18.) Bakery oven. Thermostats to regulate heat and operate gas lighting jump sparks. Case pending.

Many other cases of interference reported in the same period had their origin in apparatus already discussed in previous sections while an additional number arose from defects on power lines, all of which were located and rectified.

HIGH-TENSION LINES

IN THIS category we include primary distribution systems operating on from thirty thousand to one hundred and ten thousand volts a.c.

We must frankly admit that the data on interference from this source are far from complete. Difficulties of a practical nature are responsible. Thirty or more towns may be served by say, a 110,000-volt three-phase system and to cut this line the required number of times for test purposes is out of the question since all towns depending on it for electric power would be interfered with to a prohibitive extent.

UNDER the title "Suppressing Radio Interference" the author has printed three previous articles in this series, all of which deal, in an enlightening and comprehensive fashion, with the different forms of interference with which the radio listener may have to cope. Each article in the series is complete in itself, and should be read by all radio men whether they are troubled by man-made static or not. Mr. Lawton's articles cover a period of two and a half years' research made in more than 130 different cities. The first article appeared in the September, 1927, Radio Broadcast, *and dealt with interference caused by oil-burning furnaces, electro-medical therapeutic apparatus, X-Ray equipment, and dental motors. The November article dealt with interference from motion picture theatres, telephone exchanges, arc lamps, incandescent street lamps, flour mills, factory belts, electric warming pads, and precipitators. In the January, 1928,* Radio Broadcast, *the following sources of interference were dealt with: Farm lighting plants, railway signals, land line telegraph and stock tickers, radio receivers, and electric street railways. The present article is of especial interest to radio clubs and organizations contemplating the construction and operation of interference locating equipment.*

—The Editor.

Also, when suspicion to any piece of apparatus in connection with such a line arises and arrangements can be made to have it investigated at a close range, the line must, of course, be cut prior to detail inspection. Complications enter; foreign matter, deposited at such points as to be a possible cause of the trouble, is burned up by the surge produced on cutting the line. The investigator, not noting any apparent defect, and no spitting of current being possible for an audio check, often removes the source of the trouble unconsciously.

Where several possible sources are observed all must be rectified at once in order to get the line back in operation as quickly as possible, so even if elimination of interference is secured the exact source is not definitely established. Piece-meal elimination is a theoretical idea—desirable from a scientific standpoint but impractical.

It is probable that a slightly leaky insulator on a 110,000-volt line will cause radio interference though certain observations point to the contrary. For instance, a six-petticoat suspension insulator which was spitting vigorously over three petticoats caused absolutely no radio interference on a three-tube regenerative receiver located thirty feet distant. Possibly this caused a disturbance farther out on the line but other disturbances at the same points complicated the determinations.

If a high-tension conductor on a pin insulator is not fastened down securely, audible hissing is usually the result, but it gives rise to no radio interference. Two defective wall bushings on a 12,000-volt line showed considerable spitting, which gave an audible noise, but there was no indication of radio interference on a "patrol" receiver in the vicinity. Out on the line half a mile or so it was impossible to tell whether these constituted material sources or not; if anything, the "mushy" noise usually associated with high-tension lines was slightly augmented.

We must not assume that because a line, d.c. or a.c., produces audible noise, it necessarily gives a corresponding radio interference. Take the case of a d.c. line operated at 700 volts and carrying thirty thousand amperes. The "lines"

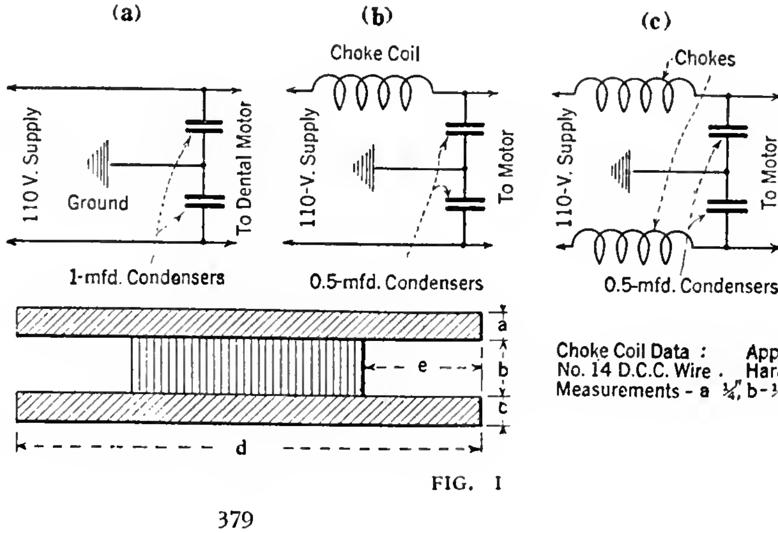


FIG. 1

in this case were composed of several hundreds of wires or, rather, rods, bound together at intervals and were mechanically noisy but variations of this heavy current caused no radio disturbance.

When two separate conductors are used as one on a high-tension line, running close together and attached to the same insulators, there will likely be audible hissing although the voltage at any given point is equal on both wires. Prevailing interference could not be definitely associated with lines of this nature.

It is worth noting that the smelting arcs fed by the thirty-thousand ampere d.c. line referred to above do not set up any serious disturbance beyond about one hundred yards. Even within this distance we are inclined to think that some of the interference noted on test had its origin in associated apparatus because in the near vicinity of three a.c. arcs, operating on 22,000 amperes, reception from station WGY, 300 miles distant, was possible with the receiver within 60 feet of the arcs.

The charging of h.t. lightning arresters sets up heavy interference. Charging is done twice daily as a rule, each operation requiring only a few seconds. Where there are many sub-stations in a restricted area it is usual to arrange to have the arresters charged at 2 A.M. and 2 P.M. instead of during the more significant broadcasting hours.

Thick snow falling between the horn gaps is pretty sure to cause considerable snapping and the interference, being vigorous, is propagated for miles.

Surprising as it may seem, the normal interference field of a 110,000-volt a.c. line has much in common with a 600-volt d.c. trolley feeder. Within fifty or sixty feet of either, reception is doubtful, but an abrupt cut occurs here, and a few feet farther away normal reception is possible, a condition which would seem to indicate magnetic coupling rather than a pick-up through direct radiation.

A.C. lines of fifty-thousand volts or so can, of course, set up currents of very high potential in parallel systems. We know that enough energy is transferred by induction to the overhead ground wire of a 100,000-volt line to supply lighting power to small communities, and advantage is taken of this in many localities for the purpose mentioned. It is obvious then, that where h.t. lines and part of the city distribution system run parallel at close range, any irregularity of the high-tension line will transfer a vigorous surge to the city system—a surge of sufficient initial amplitude to carry it all over the distribution and create widespread interference. The source in a case of this nature was recently located seventeen and a half miles from the town affected.

It has been noted in a few cases, that h.t. systems having telephone lines on the same poles or towers appear to be the greater offenders. Further research is required here and must be carried out with the full coöperation of the line engineers and their qualified assistants. All h.t. switches are not set with a cycle counter although they really should be, and any investigator who happens to be touching bare metal parts of the parallel line telephone installation when the h.t. line is cut will probably have good reason for remembering the incident.

In the case of noisy h.t. lines we do not know of one exception to the following: In sub-zero weather, interference is very bad; in mild weather, it is slight; in rainy weather, when all the insulators and cross arms are dripping wet, it is practically nil. Offhand, we are inclined to believe that this notorious trouble originates, not at any one specific point, but is the result of thousands of small brush discharges all over the system. Incidentally, we hope that we are wrong; the outlook for elimination is indeed poor if our diagnosis happens to be correct.

DISTRIBUTION SYSTEMS

JUST what percentage of a city's total interference originates on the local distribution system is a difficult question. One thing is certain; any interference occurring here is serious because of its proximity to the broadcast listener and its wide range. One loose primary cutout on a 2200-volt line can propagate severe interference for two miles in one direction and every wire running parallel picks up the disturbance by induction and spreads it all over the district. Now there are two primary cutouts used in connection with every transformer, except in the case of banked units, and if there are three hundred transformers in the city we have roughly six hundred potential sources of trouble from this agency alone.

Primary cutout interference represents about seventy-five or eighty per cent. of the total trouble caused by power lines in any city at any time. We should remember that this means no material loss of energy to the power company; such faults will not necessarily affect power consumption or even cause the house lights to flicker. For the sake of the good will of the public, however, it is in the interest of the operating company to give this particular accessory careful attention.

Interference from this source takes the form of a hard buzzing. It may be steady or intermittent; gusts of wind shaking the pole may start or stop it and heavy trucks passing along the road will do the same thing. Several cutouts buzzing intermittently will give the effect of wireless telegraph transmission and is easily confused by persons unfamiliar with the code.

A systematic check with a radio receiver should be made of such sources at least twice yearly. In one city, 146 transformers were checked and 41 loose cutouts giving rise to radio interference, were found. In another city the relative figures were higher.

The next fault, in the order of frequency of occurrence, is that of primary leads (2200-volt) spitting to the transformer case, guy wires, or crossarm braces. Severe buzzing results in the first case—practically the same characteristics as primary cutout interference—and it doesn't matter whether the transformer is grounded or not. Spitting to an insulated guy wire gives rise to a heavy clicking interference rather than buzzing. Where the primary lead is scraping on a brace the disturbance is not unlike that produced by the home type violet-ray machine but may, under varying conditions, take a different form.

Tree grounds are next in order. The intermittent "zip" from this source is very annoying. Even a little green twig waving on a bare 2200-volt feeder can set up enough "chirping" to bother reception. Tree trimming is the obvious remedy here but property rights, etc., come up, and much difficulty is often experienced in getting action. It might be as well for tree owners to reflect on the fact that copper has a bad effect on tree growth and if a copper spike be driven in the base of a healthy tree the tree will perish. Chemical analysis of branches, grooved and burned by 2200-volt lines, showed a deposit of copper, not only at the point of contact, but also a short distance either way, just as though the sap were absorbing this fine deposit and spreading it through the tree system.

Interference from the next source, loose splices, is not common. When such faults are present they give rise to heavy clicking. Generally speaking, poor splices or connections are the result of winter jobs, done in zero weather when the lineman's lot is no sinecure.

It is not usual to find cracked or leaky bushings in transformers. There are instances, of course—a few bad ones—but they are rare. Also, in a thousand odd transformers checked, only one had loose inside connections, and there were three of them in the one transformer. This particular source wiped out reception in two adjoining towns.

LOCATION OF SOURCES

WHILE access to a properly equipped radio patrol car is desirable, much good work in the location of sources of radio interference has been done with an ordinary loop receiver and standard automobile.

In order to get an idea of the area covered by any given interference, it is usual to telephone various radio fans throughout the city and find out if interference coinciding in time and character with your own case prevails at the distant points. The distant observer should bring his loud speaker near the house telephone so that you may be able to check the noise from his set and your own at the same time. Another method is for the various observers to keep a log of the characteristics and periods of activity of the trouble under investigation. Synchronized watches should be used here.

Knowing the general location, use is then made of a loop receiver carried around in an automobile. Any good super-heterodyne or radio-frequency receiver with a volume control is suitable.

Once in a great while some use may be made of the directional properties of the loop; for the present, disregard this feature for it is misleading.

Prop the loop in a fixed position, not too close to the side of the car, and drive around the affected district. At some point where the interference is strong, cut down the volume control so that the noise is just audible. Then repeat the patrol. It is probable that another point will be found where the noise comes up slightly; cut down the volume control further and keep lowering it at every increase in the intensity of the disturbance until there are only one or two points on the patrol route where the noise is audible.

An inspection is then made, watching out for garage battery chargers, transformer cutouts, chiropractors' offices, etc., etc. If the trouble seems to be in any way connected with the lighting or distribution system it should be referred to the power company for action.

The foregoing gives a general idea of the method followed in running down radio disturbances. In view, however, of the growing interest and activity along this line, it might be of help to those organizing patrols on a large scale if we go into a little more detail.

THE CAR

THE car should be a six-cylinder one; complicated interference requires that the receiver volume control be cut down until the disturbance is a mere whisper and any mechanical rumbling noise is a detriment to the patrol.

The car body, above the waist line anyway, should be of wood, facilitating inside loop reception. Metal bodies shield an inside loop and weaken the signals in addition to distorting the wave direction.

Measures are taken to prevent the ignition interference unduly affecting reception. No standard method, applicable to all cars, can be recommended, but one of the following methods, or a combination of them, should be effective:

(1.) A one-microfarad condenser across the battery circuit; attach one side to the ammeter terminal and the other under any convenient nut in contact with the chassis. Paint or enamel causing imperfect contact should be scraped away.
(2.) Duplication of method (1.) except that connection is made at the coil primary instead of at the ammeter.
(3.) Seventy-five turn choke coil, enclosed in a metal box, inserted in the lead from the dash switch to the coil primary.
(4.) Complete box screen of fine mesh wire gauze over cylinder head clamped around engine block and covering spark plugs, distributor, and ignition cables. Removable side gate is fitted giving access to the enclosed parts.

Where trouble is experienced from the generator a one-half or one-microfarad condenser from the positive brush to the chassis will help, and if the tail light cable is carrying a surge another condenser will be required here.

All low-tension wiring should be of armored cable but copper braid over the high-tension leads, while it clears up the interference, is objectionable since it tends to founder the spark energy.

It is not desirable to wipe out the ignition click completely; leave a slight trace of it to act as a pilot signal for the receiver.

The layout of interior fittings, *i.e.*, desk, cupboards, etc., will depend on the size of the car and the scope of the patrol. Convenient racks for record books, etc., should be fitted; it is very necessary to have a place for everything and equally necessary that the interior of such a car be kept, at all times, in first-class order.

THE RECEIVER

FOR official patrols, a good stable superheterodyne receiver is desirable. We specify stable because so many "supers" burst into oscillation under the conditions of patrol—especially near high-tension lines. In this case the "mushy" note of oscillation and the normal h.t. interference are almost identical, and accurate determinations are not possible.

Any make of tube known to be microphonic should be ruled out without further consideration. It is not necessary to take the precaution of mounting the sockets on rubber. A volume control of some nature is essential but throwing the set out of tune to accomplish this is not recommended.

The loop is mounted on a swivel base, allowing at least ninety-degree rotation and the three leads to the set should be sewn in a flat strap leaving a distance of three-eighths or half an inch between each wire. A storage A battery and dry cell B batteries are connected to a receptacle which is fixed permanently at some convenient point on the desk front. The corresponding plug and cable is, of course, attached to the "super." A neat box containing spare A and B batteries should also be carried, and should be fitted with a receptacle similar to the desk one.

Where metal body cars are used the loop is mounted outside, on the car roof, the handle for rotation coming down through a special weatherproof fitting.

It is obvious that in the course of extended patrol the receiver will get some rough usage so it is important that very careful attention be paid to all connections and steps taken to make the equipment as rugged as possible. Nothing can be more exasperating than to have this gear fail at a critical moment when tests involving much prearrangement are being carried out.

Condenser bearings must be set up fairly tight so that vibration of the car does not alter the tuning. Mechanically unbalanced condensers, mounted in a vertical plane, which move ever so little through jolting of the car, can throw a patrol into complete chaos. Frequent observation of the filament ammeter is important; a slight drop in filament current after the first intensity observations have been made can cause considerable confusion.

Inclusion of a loud speaker in the equipment is not recommended since this instrument tends to suppress the finer characteristics, harmonics and overtones, of specific interferences, rendering determination of their origin more difficult. Headphones, exclusively, are used on standard patrols.

PATROL WORK

SUCCESSFUL patrol work is largely a matter of experience. Given a suitable car and the necessary receiving equipment, the beginner is apt to become discouraged at his failure to secure immediate results—a condition which will probably last until he learns some of the wiles of the elusive interference and knows the pitfalls to avoid.

In the first place, the directional properties of the loop are practically valueless in city work; its plane for maximum sensitivity will, in every case, be parallel to the adjacent street wiring and instead of pointing toward the source, may point in any direction away from it. There is just one circumstance in which a rotating loop can be of value and it is simply to cover this one condition that we recommend the swivel base.

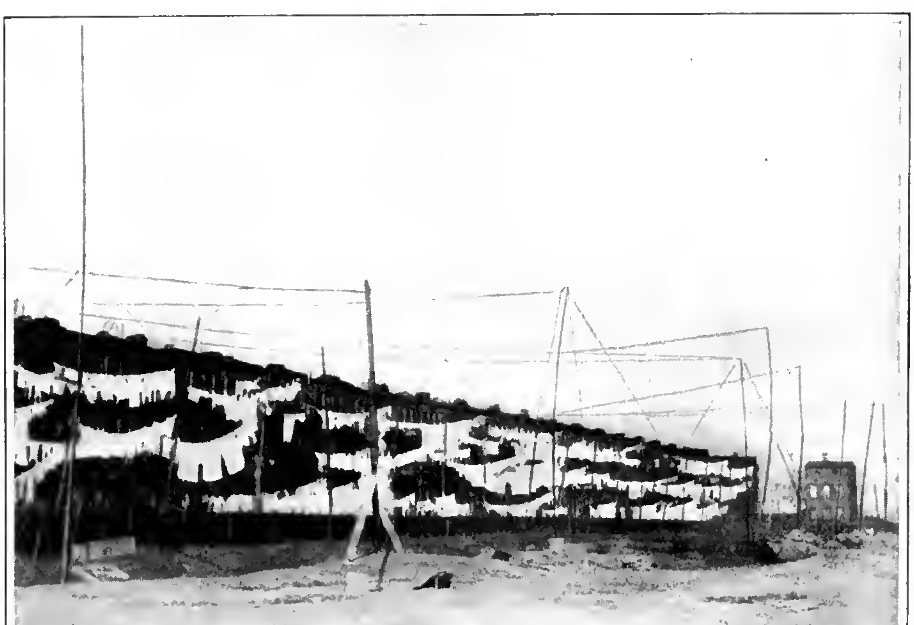
If the patrol is parked at the corner of intersecting streets where distribution wiring runs, say, north and south on one street and east and west on the other, it is sometimes an advantage to know on which set of wires the interference is stronger. The loop may be turned through ninety degrees while the car is parked directly under the intersection of the wires and a determination arrived at. The system showing the greater disturbance is then followed up.

It is popularly supposed that, at its source, interference is very loud, and that its intensity tapers gradually to zero as we move away. This is only partly correct. As a matter of fact, one often finds that actually at the source, interference is much weaker than, say, fifty feet away. Suppose, however, we start patrol in the vicinity of a source where the noise is very loud. On moving away, say, 250 feet, the disturbance falls to zero; at 500 feet it is up again very strong. At 750 feet it has died again; at 1000 feet it comes up, and so on for a mile or more of straight patrol. We can see that this trouble is a case of forced oscillations creating standing waves on the distribution system and the varying intensities plotted out take the general form of a sine curve.

In contrast to the sine curve, however, successive "bumps" or peaks of intensity will be slightly weaker than the preceding one, that is, when we are moving away from the source. The reverse is true when we approach the source from a distance.

By cutting down the volume control to bare audibility in the vicinity of the heavy bumps it is possible to narrow down the trouble to a small area, since nothing will be heard where only a slight bump prevails. The audibility control should have a knob and pointer rather than a dial; it is desirable to be able to switch on to full volume at intervals but we must know, accurately, the original setting to which to revert. Failure to note this renders comparisons with previous observations inaccurate.

Now, in the course of this patrol, certain complications will probably enter. We are assuming that the disturbance is strongest near the source —if not directly at the source—and, naturally, are watchful for the strongest "bump." In ordinary reception, say, from some broadcasting station, a difference of half a mile or so in distance between the station and receiver makes very little difference in signal strength. A few feet, however, can make a big difference in the intensity of radio interference being guided by city wiring; simply moving the patrol set over to the other side of the street may make as much



WHERE RADIO COMPETES WITH THE WASHING

The owner of these tenements in Long Island City, New York, does not permit construction of antennas on the roof, with the result that a forest of back yard poles at crazy angles support the necessary antennas. Interference from improperly operated receivers is frequently acute in such congested areas as 40 per cent. reduction or increase as the case may be. For this reason it is desirable always to keep the same distance from the curb when patrolling, so far as this is possible, and occasional observations should be made to see that the line is still on the same side of the street being patrolled. If it has crossed over at an unobserved point and continued on, on the other side of the street, misleading checks may result.

Every wire, directly connected or not, in the vicinity of a vigorous source of radio interference, will pick up the disturbance and radiate it in different directions; trolley wires, being much nearer the loop than the power wires, will give a heavy indication even when the trouble is not in any way connected with the car system.

Service wires running low across the street will also produce a false peak and, incidentally, give a bogus direction if directional properties of the loop are being counted upon.

Potheads and pole ground wires are notorious misleaders of the unwary. At these points the overhead wiring is brought right down to us and we will get a heavy bump of the noise when passing the pothead or ground wire although the source may be half a mile or more away. The bump here may even be stronger, so far as effect on the receiver is concerned, than at its loudest point near the source.

In the affected area, nearly every street corner or intersection registers a number of confusing bumps. This is due to abrupt physical changes in the circuits, free radiation probably, since high-frequency surges dislike going around sharp corners.

A rise in the disturbance intensity will be noted at each transformer passed during patrol but when the car is running over an iron bridge with side supporting girders, interference will drop practically to zero although the source may be nearby. A peak will be registered at dead ends and circuit stops also, whether the wires are alive or not. Dead wiring is just as effective in propagating radio interference as live wiring and under certain circumstances the actual source may be on a system which is not energized except by induction from some other line. If a dead circuit having on it a partial ground, parallels a high-tension line, the voltage induced in the former is sufficient to cause a spit-over at the imperfect contact, resulting in severe disturbance.

Where complicated interference is being investigated on streets on which electric cars are run, much time will be saved by carrying out the work between the hours of 1 A.M. and 5 A.M. In fact, these are the best hours for radio patrol work up to the point of location to a given pole or residence. Daylight inspection is then necessary. During the early morning hours street car activity is at a minimum and traffic conditions are ideal for concentrated patrol.

One thing to be religiously avoided is any tendency to jump at hasty conclusions; an investigator cannot be too careful on this point. Literally hundreds of reasons, each with a story behind it, can be cited to show how very necessary it is for the patrol man to attack his problem with a perfectly open mind. One example selected at random, may be of interest. Reception over a fairly wide area in a certain town was being spoiled by a strong buzzing interference. The "buzzes" came at one-second intervals and kept up for days at a time, stopping for a few hours or a day, as the case might be, and then starting off again. It was narrowed down to two buildings—a large factory and an electrical power plant. Generator interference close to the plant swamped the disturbance being investigated, but it was learned here that the "static ground detector" on the factory supply lines (2200 v.) showed an intermittent ground on one phase. The factory electrician had checked everything in detail and insisted there were no grounds on his end of the business; the power company did likewise. Service was not impaired in the least but still the radio interference corresponded exactly with the swinging of the ground indicator, and such a ground on the 2200-volt system would account for our trouble.

We might say that there was absolutely no reason whatever for suspecting this meter; it was a standard instrument made by a very reliable firm. Nevertheless one of the condensers in it had broken down and constituted the source from which our radio interference originated. The trouble was eliminated with despatch.

It must be obvious from what has been said that the location of the source of any given disturbance is not always an easy matter. The work is doubly difficult in the case of intermittent interference or that which periodically alters its intensity. Where several sources are active at the same time, the resultant confusion demands close concentration on the part of the investigator.

On all standard patrols a five- or six-pound sledge hammer is carried. If the characteristics of the interference indicate power line trouble, patrol is carried out until the source is confined to half a block or less on one street. Then the suspected poles are tapped with the sledge and any loose connection of any nature whatever will immediately show up on the patrol receiver, usually as a violent buzzing. Loose primary cutouts, defective lightning arresters, partial grounds, bad splices—all show up definitely and at once.

Care is taken not to hit the pole too hard; an inexperienced investigator can cause damage here. If looking for loose splices, the pole should be tapped in the plane of the overhead wiring since right-angle tapping does not always send the vibration along the wires. A moderate tap in the plane of the wiring will show up defective splices five poles distant.

Literally, thousands of transformer poles have been checked in this way and we know of only three instances in which the method failed. In these instances the cutouts were jammed mechanically solid and could not vibrate but at the same time they were making poor electrical connection. Such cases are extremely rare, the point is worth noting however, in view of a possible recurrence.

Poles giving an indication of severe interference on the first tap are not jarred a second time, since the loose cutouts are liable to fall and disrupt the service.

When a lineman is setting up loose cutouts it is desirable to check with the sledge hammer and radio set, tapping the pole while the lineman is still aloft. A cutout in proper order for lighting or power purposes may, at the same time, be a source of radio interference because of some apparently insignificant internal sparking.

We might say, in passing, that a good many faults have been found in perfectly new line accessories and constructions; new installations are checked just as carefully as old constructions.

COMPLAINT RECORDS

THE method of handling complaints, adopted by public utility companies and other organizations engaged in radio interference elimination work, varies according to the services performed and the area covered. The questionnaire system finds favor in certain quarters. Its application, however, is limited, and where work is being carried out on a large scale the questionnaire is worse than useless.

Details of the recording system for taking care of nationwide patrols with which the author is associated would serve no useful purpose here; it may be remarked, however, that the central authority diagnoses every complaint, and, on the information given, endeavors to fix its source. If this can be done, appropriate remedial measures are recommended; if not, the nearest patrol car is ordered to the location and trained experts take over the case, reporting to the division headquarters on completion of the work.

Here, the information is classified and recorded together with other data relative to the particular location, *i.e.*, previous cases cleared up, specific sources, general noise level, local patrol facilities, radio clubs, etc., etc. In this way a fairly accurate check is kept on the general interference situation, which facilitates the laying out of future patrol work for the staffs engaged.

In reviewing the radio situation generally and from direct contact with thousands of broadcast listeners, we are forced to the conclusion that the greatest need in the radio game to-day is a concentrated and determined effort to rid every town and city of all preventable interference.

The suppression of every source is a practical impossibility, but it is obvious that the noise level of any given centre can be considerably reduced. Much work along this line has been done by different private corporations and various governments, and we hope that the day is not far distant when every city will have its specially equipped radio patrol car to run down interfering disturbances and give radio the chance that it deserves.

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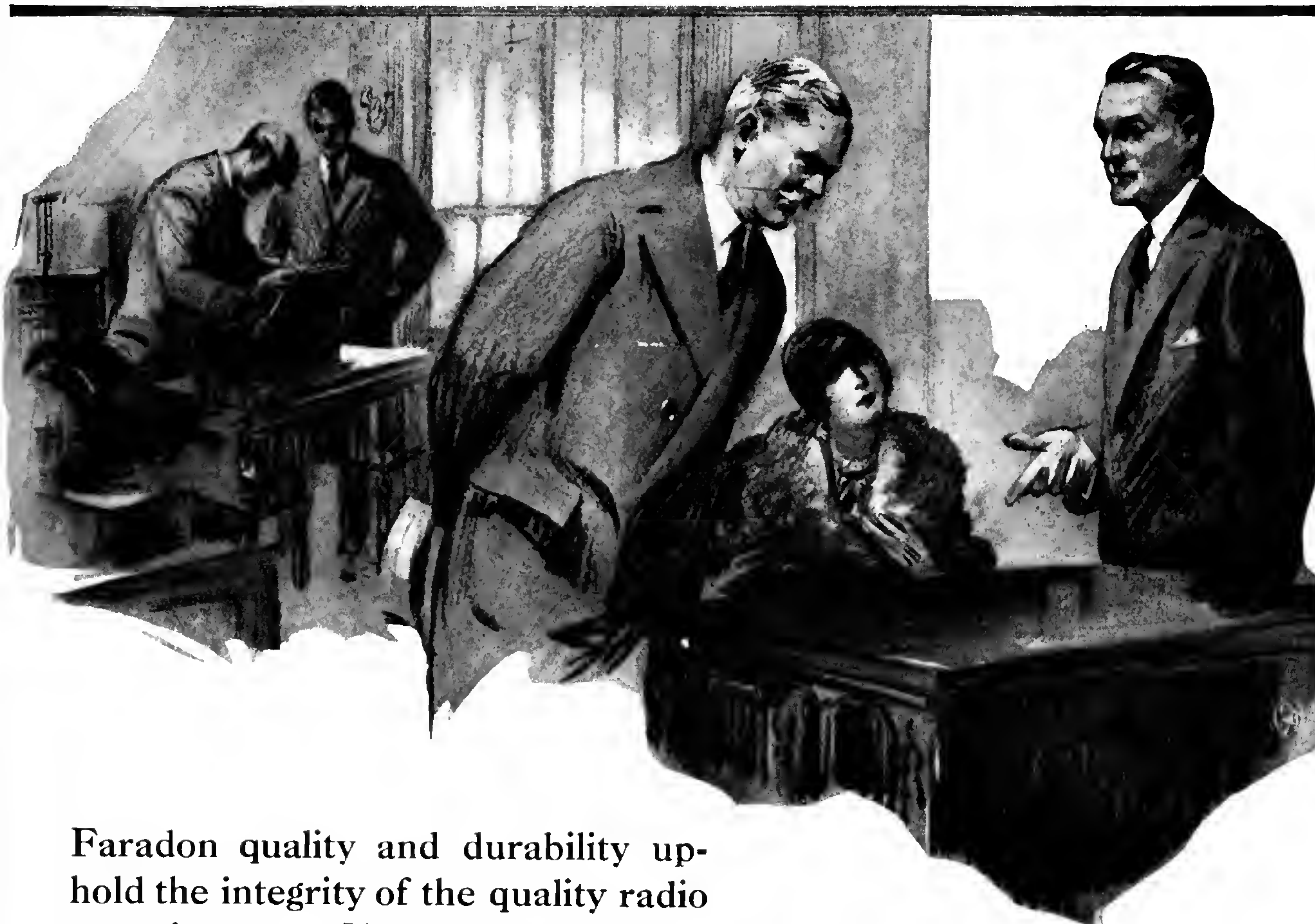

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The *Radio Broadcast*

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. In July, 1927, an index to all Sheets appearing up to that time was printed.

All of the 1926 issues of RADIO BROADCAST are out of print. A complete set of Sheets, Nos. 1 to 88, can be secured from the Circulation Department, Doubleday, Doran & Company, Inc., 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 occur, a new Laboratory Sheet with the old number will appear.

—THE EDITOR.

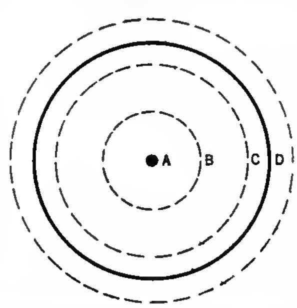
No. 169 RADIO BROADCAST Laboratory Information Sheet March, 1928

Data on the UX-222 (CX-322)

CONSTRUCTION

THE new UX-222 (CX-322) screened-grid tube is designed especially for use as a radio-frequency amplifier and when used as such it is capable of giving greater amplification than can be obtained from other tubes. A receiver using these tubes does not have to be neutralized. This Laboratory Sheet gives details regarding its construction.

The arrangement of the elements as we look down on a UX-222 (CX-322) tube is indicated in the drawing on this Sheet. At the center is the filament, A, consisting of a single straight wire. Surrounding the filament is the control or signal grid, B. The plate, D, is located between C and E, which are two comparatively coarse "screen grids." The filament terminals, the plate terminal, and the extra grid terminal (grids C and E are connected together inside the tube), are brought down to a standard four-prong base. The signal grid, B, is connected to a small brass cap on top of the tube.



The amplification constant of this new tube is of the order of 200 to 300, the mutual conductance is about 300 micromhos, and its plate impedance is around one megohm. These values will vary widely, depending upon the voltages. The amplification of the tube in an r. f. circuit may average about three times that possible with a 201-A type tube. Three times as much amplification in the r.f. stage is equivalent to 81 times as much power in the loud speaker.

When a 201-A type tube is used as an r. f. amplifier there is a strong tendency for it to oscillate, due to feed-back through the grid-plate capacity. The plate of the UX-222 (CX-322) is shielded from the signal grid by the screen grid C-E, and the tendency toward oscillation due to feed-back through the tube is practically nullified.

The general characteristics of the tube, and the correct voltages to employ when it is used as an r. f. amplifier, are given below:

Filament Volts 3.3
Plate Voltage ....90 to 135
Screen-Grid Voltage .....+45
Signal Grid Bias −1 to −1.5 volts

No. 170 RADIO BROADCAST Laboratory Information Sheet March, 1928

Selectivity and Sensitivity

DESIRABLE CHARACTERISTICS

THE ideal receiver should be as selective as is possible; that is, it should receive a channel of frequencies 10,000 cycles wide (or only 5000 cycles wide in the case of single side-band transmission) equally well, but should not receive other frequencies at all. A receiver for reception of broadcast programs cannot be made any more selective than this without impairing the quality of reproduction. When a receiver is this selective, it will offer a barrier to all frequencies except those lying in the channel to which it is tuned.

The ideal receiver should not need to be any more sensitive than is necessary to amplify interfering noises to more than tolerable loudness under conditions of least interference. When the interference is greater, the sensitivity should be cut down to keep these noises from becoming objectionably loud. In summertime the interfering radio waves manufactured by nature are generally the strongest.

Assuming that an ideal radio receiver is available, there is only one way left (other than the invention of a static eliminator or reducer) to reduce interference to any further extent and thereby increase the distance over which satisfactory reception is possible. This second method of reducing interference is through the use of increased power at the transmitting station. If the signal strength at any given location is increased, the ratio between the signal and the static is thereby increased and reception in this way made freer of interfering noises. Just as in the case of land wire telephony, however, we will probably never be able to put enough power into the ether to give good transmission across the continent in spite of bad interference.

In so far as sensitivity and selectivity are concerned, the super-heterodyne type of receiver is probably the most desirable. These characteristics in a receiver of this type depend, however, in large measure on the design of the intermediate-frequency amplifier. This amplifier can be designed only to amplify a very narrow band of frequencies (a good design for reception of code signals), or, by the use of band-pass filters, the equal amplification of a band of frequencies can be accomplished (a satisfactory design for the reception of ordinary broadcast signals).

No. 171 Radio Broadcast Laboratory Information Sheet March, 1928

The CX-312 (UX-112) and CX-371 (UX-171)

FURTHER COMPARISONS

THE two types of power tubes best adapted for medium B voltages are the CX-312 (UX-112) and the CX-371 (UX-171). The former tube, introduced first, came into immediate favor, and for a time was more popular than the CX-371 (UX-171). This initial preference was due to several factors, the most important ones being, first, the fact that the voltages required by this type were identical with those required by type CX-301-A (UX-201-A) tubes, and therefore, the tube could be substituted without battery changes. Secondly the horn type loud speaker, generally more sensitive than the cone loud speaker, was still popular, and there was less necessity for the greater power output given by the CX-371 (UX-171). A third factor was the misapprehension about battery voltages, many not realizing that although the CX-371 could be used to best advantage at the maximum voltage of 180 volts, the quality of reproduction was equally good at 135 volts, and the volume ample for average home service.

During the current season the standing of the two tubes is rapidly being reversed, the CX-371 (UX-171) assuming the leadership, partly because of the large number of new receivers for which the tube is specified, and partly because of better facilities for using the tube to its best advantages. As improvements in audio amplification and in loud speaker design are made, the advantage of using this type of tube becomes increasingly apparent. The higher frequencies are usually reproduced satisfactorily by any type of output tube, but to secure full undistorted reproduction of low frequencies, or the bass notes, a tube having low internal resistance, such as the CX-371 (UX-171), is required.

In installing the CX-371 (UX-171), the first precaution with which the user has to become familiar is the use of a high grid biasing, or C, battery voltage—from 16½ to 40½ volts, depending upon the B voltage used. With general-purpose tubes, which the power tubes replaced, the use of a C battery was to a large extent optional with the user, although the fact that better quality was obtained with this battery was generally recognized.

Laboratory Sheets Nos. 161 and 162 gave some interesting data and curves on the type 112 and 171 tubes. The 210 type tube was also covered in these latter sheets.

No. 172 Radio Broadcast Laboratory Information Sheet March, 1928

A Simple Wavemeter

CONSTRUCTION AND CALIBRATION

A WAVEMETER is a very useful asset to the laboratory of any radio experimenter. A coil of wire and a condenser, connected together properly, are all that is required to make this instrument.

The circuit diagram of a wavemeter is given on the curve published herewith. It is evident from the diagram that the coil is simply connected across the condenser. The coil should preferably be a solenoid wound on a piece of tubing so that it will be able to withstand some abuse without any alteration in its inductance, and should have sufficient number of turns to cover the frequency band it is to be used on.

The construction of the wavemeter presents no problems. The method of calibrating it and plotting a calibration curve may, however, require some explanation. The procedure is as follows:

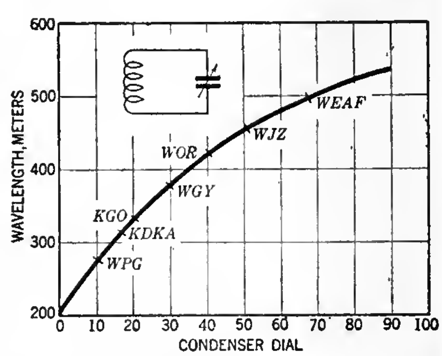
(1.) Set the wavemeter at a distance of about two feet from your radio receiver.

(2.) Take the lead from the antenna and wrap one turn around the coil of the wavemeter and then run the antenna lead over to the regular antenna post on your receiver.

(3.) Turn on the receiver and tune-in the signals of some station. Now slowly revolve the dial on the wavemeter and at some point on the dial the signal output of the receiver will decrease. Note the reading on the wavemeter condenser dial which cuts out the signal most completely. Make the same test on some other stations.

(4.) Now draw the curve, using the data obtained, in a manner similar to that indicated on this Laboratory Sheet. The wavelengths, or frequencies, on which the various stations are transmitting can, of course, be obtained from any list of broadcasting stations.

Such a wavemeter aids materially in the identification of stations heard on a receiver which is not calibrated.



No. 173 Radio Broadcast Laboratory Information Sheet March, 1928

The Regulator Tube

WHY IT IS USED

THE voltage regulator tube, or glow tube, as it is sometimes called, has found rather wide use in the design of B power units, making them capable of delivering a voltage output that is practically constant over a wide range of load. The output of a power unit not using a glow tube will, of course, vary with the load, although the magnitude of this variation may be held to comparatively low values by good design. A power unit supplying an output voltage that does not depend upon the load may be used with practically any receiver with a knowledge that the voltage actually delivered to the receiver will be correct. Constant voltage output is, however, only one of the advantages accruing from the use of a regulator tube.

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 this action 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.

The fact that the regulator tube keeps the output voltage constant also permits the safe use of condensers of a lower voltage rating than would be permissible if the tube were not used. The rating of the condensers used in an ordinary power circuit is fixed by the maximum values of voltage that they must handle. The voltage output of some units, at no load, rises to comparatively high values and the condensers must therefore have a rating sufficient to withstand these voltages. The output voltage of a power unit with a regulator tube is limited, even at no load, to values only slightly above rated voltage and, therefore, the condensers are not called upon to withstand voltages greater than the rated output of the unit.

No. 174 Radio Broadcast Laboratory Information Sheet March, 1928

Grid Bias

WHY IT IS USED

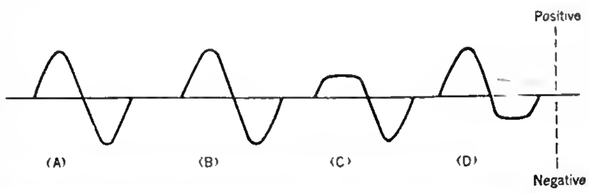
THERE are apparently many, as indicated by letters to the Laboratory, who still feel that the major reason for using C bias on a tube is to reduce the plate current. Although negative bias on the grid of a tube does decrease the plate current, this is not really the most important reason for its use.

C bias is used primarily to reduce distortion and make the tube operate more efficiently. In an ordinary receiver, C bias is most important in the audio-frequency amplifier and we will, therefore, discuss on this Laboratory Sheet the effect of using various values of C bias on the grid of a tube.

The curves A, B, C, and D indicate the distortion of signals which results when too little or too much bias is used. Curve A represents the voltage on the grid of the tube. Curve B shows how the plate current of the tube varies if the bias on the tube is correct. It should be noted that the form of this curve is the same as curve A, indicating that there is no distortion being created by the tube. If too little bias is used, the positive halves of the input voltage wave will cause the grid to become positive when the grid draws current, and the positive peaks are then cut off as indicated at C. If the bias is too great the tube operates on the lower bend of its characteristic and this causes the negative half of the signal to be flattened out, as shown in curve D. To prevent distortion, therefore, the proper C bias must be used.

It is especially important that the bias on the last tube be correct, for this tube must handle the greatest amount of signal current and will, therefore, overload and distort most easily. As a matter of information the correct bias for a 112 or 171 type tube is given below:

TUBE	PLATE VOLTS	C BIAS
112	90	6.0
	135	9.0
	157	10.5
171	90	16.5
	135	27.0
	180	40.5



No. 175 Radio Broadcast Laboratory Information Sheet March, 1928

Filter Choke Coils

EFFECT OF AIR GAP

IF THE filter circuit of a B power unit is to eliminate satisfactorily all hum, it is essential that the filter choke coils have sufficient inductance under actual operating conditions. The value of the inductance of a choke coil as measured without any direct current flowing through it will differ from the value obtained with direct current, so all measurements on choke coils should, therefore, be made with d. c. flowing in the winding.

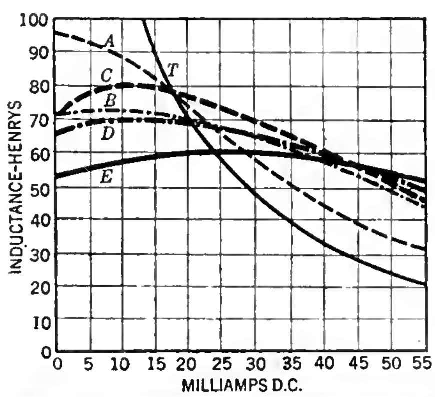
When direct current flows through a filter coil it produces a certain amount of magnetic flux, or "lines of force," in the core. This flux tends to saturate the core of the choke and, when this occurs, the unit will no longer function satisfactorily in eliminating the hum.

Manufacturers are always willing to supply data on the maximum amount of d. c. current their filter choke coil can handle and this value should not be exceeded in practice.

When the filter coil is constructed, the core may be clamped tightly together or a small air-gap may be left. As the current capacity rating of the coil is increased, the air-gap should be increased also, and this tends to prevent magnetic saturation. The group of curves on this Sheet show this effect. The conditions under which they were obtained are given below:

T—No air gap
A—Average air gap
B—Air gap at one end, 0.01 inches
C—Air gap at both ends, 0.005 inches each
D—Air gap at both ends, 0.0075 inches each
E—Air gap at both ends, 0.01 inches each

If the d. c. current is to be 10 milliamperes, construction type T is best, while type C is best at a current of 30 milliamperes, or if the current through the choke is to be 55 milliamperes, type E should be used.



No. 176 Radio Broadcast Laboratory Information Sheet March, 1928

How the Plate Circuit Affects the Grid Circuit

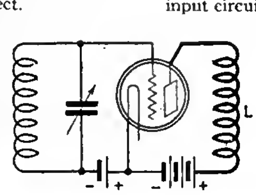
REVERSE ACTION

IN WORKING with tubes, we normally consider that the plate circuit is controlled by the grid and that there is no reverse action. This, however, is not strictly true, for the plate circuit does affect the grid circuit in two ways.

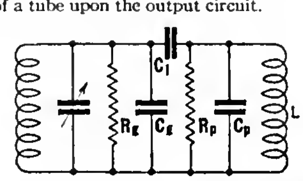
In the first place the plate acts as a grid with respect to the regular grid in the tube and large variations in plate voltage have the same effect with respect to the grid as has slightly varying the grid voltage. The reverse effect is generally not appreciable so long as the grid is held negative, as is the case in an amplifier. The reverse effect is important in oscillator circuits, however, where the grid is not always negative. In making an accurate analysis of the action of an oscillator, it would be necessary to consider this effect.

The second manner in which the grid is controlled by the plate is through the grid-plate capacity of the tube. At (A) in the diagram on this Sheet, we have indicated the circuit of an ordinary r. f. amplifier and at (B) is shown the equivalent circuit with the inter-electrode resistances and capacities indicated. R_g is the grid-filament resistance of the tube, C_g the grid-to-filament capacity, C_i the inter-electrode capacity between the grid and the plate, R_p the plate filament resistance, C_p the plate-filament capacity, and L the load impedance. Probably the most important of the capacities shown is the grid-plate capacity, C_i, for it is this capacity which permits the grid circuit to be affected by what goes on in the plate circuit. In radio-frequency amplifiers it is this capacity which causes the tube to oscillate.

The diagram at (B) should give some idea of the complexity of the network represented by a tube, and the action of this network of resistances, condensers, and inductances must be understood if the action of a tube in any particular circuit is to be accurately foretold. J. M. Millen, in *Scientific Paper of the Bureau of Standards No. 351*, carefully and completely determined the dependence of the input circuit of a tube upon the output circuit.



(A)



(B)

"RADIO BROADCAST'S" DIRECTORY OF MANUFACTURED RECEIVERS

¶ A coupon will be found on page 395. 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 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. 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. Milliammeter 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, 23½ 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. 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. 522. CASE, 62B AND 62C

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 62B, 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.

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: 17¾ x 5¾ 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 NRII

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. 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 7⅛ 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. 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. 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 8½. Price: $130 without accessories.

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. 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.

BATTERY OPERATED RECEIVERS

NO. 542. PFANSTIEHL JUNIOR SIX

Six tubes; 3 t. r. f. (01-A), detector (01-A), 2 audio. Pfanstiehl circuit. Volume control: variable resistance in r. f. plate circuit. One dial. Shielded. Battery cable. C-battery connections. Etched bronze panel. Antenna: outdoor. Cabinet size: 9 x 20 x 8 inches. Price: $80, without accessories.

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. 410. LARCOFLEX 73

Seven tubes; 4 t.r.f. (01-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. 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 24 mA. Volume control: rheostat on r. f. Coils shielded. Battery cable. C.-battery connections. Headphone connection. Antenna: outdoor. Cabinet size: 20 x 13¼ x 10½ 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: 43,A. Volume control: rheostat on r. f. Completely shielded. Battery cable. C-battery connections. Headphone connections. Output device. Antenna: outdoor or loop. Cabinet sizes: table, 25½ 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 to35mA. 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 25mA. 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: 35mA. 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 65 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: 22½ x 9½ 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 25mA. "Technidyne" circuit. Completely enclosed in aluminum box. Battery cable. C-battery connections. Cabinet size, 8¾ x 19½ x 9½ 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: 42mA. 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: 25mA. 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: 19mA. 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: 40mA. 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. 547. ATWATER KENT, MODEL 33

Six tubes; 3 t. r. f. (01-A), detector (01-A), 2 audio (01-A and 71 or 12). One dial. Volume control: r. f. filament rheostat. C-battery connections. Battery cable. Antenna: 100 feet. Steel panel. Cabinet size: 21¼ x 6⅞ 6¼ inches. Price: $75, without accessories.

NO. 544. ATWATER KENT, MODEL 50

Seven tubes; 4 t. r. f. (01-A), detector (01-A), 2 audio (01-A and 12 or 71). Volume control: r. f. filament rheostat. C-battery connections. Battery cable. Special bandpass filter circuit with an untuned amplifier. Cabinet size: 20¾ x 13 x 7¼ inches. Price: $120.

NO. 452. ORIOLE 90

Five tubes; 2 t. r. f., detector, 2 transformer audio. All 01-A tubes. "Trinum" circuit. Two dials. Plate current: 18mA. 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 45 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: 35mA. Antenna: 100 feet. Prices: Model 61A, $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.

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 393. 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.

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.

7. TRANSFORMER AND CHOKE-COUPLED AMPLIFICATION—Circuit diagrams and discussion. ALL-AMERICAN RADIO CORPORATION.

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.

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.

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.

30. TUBE CHARACTERISTICS—A data sheet giving constants of tubes. C. E. MANUFACTURING COMPANY.

32. METERS FOR RADIO—A catalogue of meters used in radio, with diagrams. BURTON-ROGERS COMPANY.

33. SWITCHBOARD AND PORTABLE METERS—A booklet giving dimensions, specifications, and shunts used with various meters. BURTON-ROGERS 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. WHY RADIO IS BETTER WITH BATTERY POWER—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.

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-milliampere 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.

103. A. C. TUBES—The design and operating characteristics of a new a. c. tube. Five circuit diagrams show how to convert well-known circuits. SOVEREIGN ELECTRIC & MANUFACTURING COMPANY.

(*Continued on page 393*)

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.
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.
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.
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.
105. Coils—Excellent data on a radio-frequency coil with constructional information on six broadcast receivers, two short-wave receivers, and several transmitting circuits. Aero Products Company.
106. Audio Transformer—Data on a high-quality audio transformer with circuits for use. Also useful data on detector and amplifier tubes. Sangamo Electric Company.
107. Vacuum Tubes—Data on vacuum tubes with facts about each. Ken-Radio Company.
108. Vacuum Tubes—Operating characteristics of an a.c. tube with curves and circuit diagram for connection in converting various receivers to a.c. operation with a four-prong a.c. tube. Arcturus Radio Company.
109. Receiver Construction—Constructional data on a six-tube receiver using restricted field coils. Bodine Electric Company.
110. Receiver Construction—Circuit diagram and constructional information for building a five-tube set using restricted field coils. Bodine Electric Company.
111. Storage Battery Care—Booklet describing the care and operation of the storage battery in the home. Marko Storage Battery Company.
112. Heavy-Duty Resistors—Circuit calculations and data on receiving and transmitting resistances for a variety of uses, diagrams for popular power supply circuits, d.c. resistors for battery charging use. Ward Leonard Electric Company.
113. Cone Loud Speakers—Technical and practical information on electro-dynamic and permanent magnet type cone loud speakers. The Magnavox Company.
114. Tube Adapters—Concise information concerning simplified methods of including various power tubes in existing receivers. Alden Manufacturing Company.
115. What Set Shall I Build?—Descriptive matter, with illustrations, of fourteen popular receivers for the home constructor. Herbert H. Frost, Incorporated.
104. Oscillation Control with the "Phasatrol"—Circuit diagrams, details for connection in circuit, and specific operating suggestions for using the "Phasatrol" as a balancing device to control oscillation. Electrad, Incorporated.
116. Using a B Power Unit—A comprehensive booklet detailing the use of a B power unit. Tables of voltages—both B and C—are shown. There is a chapter on trouble shooting. Modern Electric Mfg. Co.
117. Best Results From Radio Tubes—The chapters are entitled: "Radio Tubes," "Power Tubes," "Super Detector Tubes," "A. C. Tubes," "Rectifier Tubes," and Installation." Gold Seal Electrical Co.
118. Radio Instruments, Circular "J"—A descriptive manual on the use of measuring instruments for every radio circuit requirement. A complete listing of models for transmitters, receivers, set servicing, and power unit control. Weston Electrical Instrument Corporation.
119. The New Loftin White Circuit—A twenty-four page booklet explaining the principles and application of this popular circuit. Consolidated Radio Corporation.
120. The Research Worker—A monthly bulletin of interest to the home constructor. A typical feature article describes the construction of a special audio amplifier—Aerovox Wireless Corporation.

USE THIS BOOKLET COUPON

Radio Broadcast Service Department
Radio Broadcast, *Garden City, N. Y.*
Please send me (at no expense) the following booklets indicated by numbers in the published list above:

....

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Name...

Address...
(Number) *(Street)*

....
(City) *(State)*

ORDER BY NUMBER ONLY
This coupon must accompany every request. RB 3-28

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 395 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 $30.00.
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.
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 Improved Super 10—Ten tubes; five stages of tuned radio frequency, detector, and four stages of choke- and transformer-coupled audio frequency. Two controls. Price $260.00.
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

Book Review

Principles of Radio Communication. By J. H. Morecroft. Second Edition. Published by John Wiley & Sons, Incorporated, New York. Pages, 1001. Illustrations, 831. Price, $7.50.

MORECROFT has gone into a second edition. The revised volume calls for a supplementary review, for after the lapse of six years (the first edition was issued in 1921) much that was important is slipping into desuetude, and technological fancies have become engineering realities. The ordinary engineer, called on to review Morecroft's monumental work, is placed somewhat in the position of a parish priest ordered to review the Bible. It is safe, however, to quote Professor Morecroft himself in his outline of the changes made in the new edition:

The new material incorporated in this edition so increased the size that it was thought advisable to delete much of the first edition. A considerable part of the chapter on Spark Telegraphy has been taken out, therefore, and two chapters of the earlier edition have been deleted. The chapter on radio measurements, and that on experiments, have been omitted.

Notable additions to the older edition occur in Chapters II, IV, VIII, and X. In Chapter II many new data on coils and condensers at radio frequencies are given. In Chapter IV, dealing with the general features of radio transmission, new material on field strength measurements, reflection and absorption, fading, short-wave propagation, etc., has been introduced. In Chapter VIII (radio telephony) a great deal of material on voice analysis has been added; the performance of loud-speaking telephones, frequency control by crystals, etc., has been discussed. In Chapter X, dealing with amplifiers, the question of distortionless amplification has been thoroughly dealt with, some of the material being given for the first time. The questions of radio-frequency amplification, balanced circuits, push-pull arrangements, etc., have been explained.

Principles of Radio Communication is a comprehensive textbook of radio engineering. The author, a Professor of Electrical Engineering at Columbia University, and a Past President of the Institute of Radio Engineers, is one of the outstanding opponents of guesswork in radio technology. When the publishers in their circular describing the book refer to it as the "most complete, accurate, and authoritative book on radio available" they are simply telling the truth. But in justice to the author, who has put a considerable number of years into this job, it should be stated that when the publishers continue: "—for Designers, Engineers, Service Men, Distributors, Dealers, Salesmen, Teachers, Students, Operators, Set Owners," they talk like hasheesh addicts. I hope that Wiley sells as many copies of Morecroft as the publisher of Durant's *Story of Philosophy* has managed to dispose of, to his own and his client's enrichment, but I feel bound to warn Distributors, Dealers, Salesmen, and Set Owners that, with negligible exceptions in their ranks, the only portions of *Principles of Radio Communication* which they can hope to understand are the articles and prepositions. Not that it is an excessively abstruse work; any student of mathematics through the calculus can follow the demonstrations, and any student of radio engineering can read the whole thousand pages with vast profit. But it is a work in radio *engineering*. Its precise virtue is that dealers, salesmen, and the generality of set owners will not understand it.

How radio has grown! Here is a book of a thousand six-by-nine pages, and yet it is largely an outline of principles. If you consulted it for the actual design of a line equalizer or a 10-TU pad, you would not find either device even mentioned. The author makes no bones about this. "As in the previous edition," he writes in the new preface, "no pretense is made that the book is a treatise on radio practice; in general, only the principles involved in the operation of radio apparatus have received attention. Whatever radio apparatus is discussed is dealt with only to illustrate those principles the text is intended to elucidate." But those principles, by diagram, mathematical and physical analysis, oscillogram, and every other resource of technical instruction, it does clarify. The chapter on vacuum tubes alone runs to 240 pages, a book in itself, and after you have mastered it you know something about tubes. You may burn out the next one you put into a socket anyway, but at least you will not concoct any idiotic theories about it. If you believe that there is a dividing line between principles and practice, and that life is too short to include both, you will, of course, find no use for such a course as Morecroft offers. You had best go out and sell bonds, in that case. But if you are a radio engineer, or want to become one in the only genuine sense of the word, then Morecroft's textbook will be worth more than $7.50 to you.

In a work of this size there are inevitably sections over which other engineers may disagree with the author. The treatment of "Elimination of Strays," pages 340–343, may be cited. In Fig. 16, "one of the early attempts to eliminate 'strays,'" ascribed to De Groot, is shown. This scheme is a neutralization system—one antenna tuned to the desired signal, the other aperiodic, etc. It will not work, which Professor Morecroft knows as well as anyone, but he does not tell the reader that the scheme is worthless, and why. The ingenious and useful wave antenna of Beverage, Rice, and Kellogg, which deserves mention in this section if anything does, is omitted without a word. Roy A. Weagant's name is twice misspelled. But such defects, which might be serious in a lesser work, are overshadowed by the high virtues of Morecroft's imposing contribution to radio science.

CARL DREHER.

USE THIS COUPON FOR KITS

RADIO BROADCAST SERVICE DEPARTMENT
Garden City, New York.
Please send me information about the following kits indicated by number:

....
....
....

Name..

Address ....
(Number) (Street)

....
(City) (State)

ORDER BY NUMBER ONLY. This coupon must accompany each order.

RB 3-28

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)*

....
(City) *(State)*

ORDER BY NUMBER ONLY

This coupon must accompany each order. RB 3-28

The radio leadership of 1928

NOW $90

180 volts on the output tube plate! Gigantic *UNDISTORTED* volume from the Bandbox!

Power! Power! POWER! A feature of the Crosley AC Bandbox that lifts it head and shoulders above competition!

170 to 185 volts on the plate of the power output tube!

Comparative checkings of competitive radios show interesting figures. Under identical testing conditions the Bandbox shows a full 170 to 185 volts on the plate of the 171 power output tube. Other radios show from 100 to 110 and 130 to 140 volts on the plate of output tube. The 171 power tube should have around 180 volts. This better than 40% superiority in one case and 25% in the other is the difference between *today's* radio and yesterday's.

MUSICONE
Type D
$15

Crosley Musicones are famous for their value. This new style is no exception. Its low price of $15 is in keeping with Crosley traditions. It instantly demonstrated its soundness by immediate and enormous sales.

602 Double Unit AC BANDBOX Single Unit 704

The Bandboxes are genuine Neutrodyne receivers. Totally and completely shielded, their acute sensitivity and sharp selectivity is amazing.

They have a single illuminated dial.

Contributing much to the success of this 1928 wonder radio is the Mershon Condenser in the power element of the set. Not being paper, the danger of its blowing out is entirely removed so that the desired *heavy voltage* can be used to produce the acoustic and volume results so greatly desired. IT IS SELF HEALING. It does not have to be replaced as is the case with paper condensers.

The capacity of smoothing condensers in Crosley power units is 30 mf. Other sets use only a fraction of that condenser capacity. Undersize condensers, transformers, etc., are used in order to build down to a price. Crosley builds up to a standard.

The AC Bandbox is purposely made in two models—the 602 in a double unit—the 704 self contained. This is to provide maximum adaptability in all sorts of surroundings and uses.

The 602 double unit provides console cabinet installation in ALL kinds of consoles.

The 704 is for those who want the entire set in one cabinet. The two sets are identical in element, design and performance. The physical difference is solely to meet the human differences of taste, necessity and price! The size of the 704 is 17$\frac{5}{8}$ inches long by 12$\frac{3}{4}$ inches wide and 6$\frac{1}{8}$ inches high.

Battery Type Bandbox $55

This celebrated model needs no picture, for in appearance it is identical to the 602 receiver pictured above. Its amazing performance has won the radio world this season and its value is as outstanding NOW as the day it was first presented.

SELF CONTAINED $95

New

401 Dry Cell Type

BANDBOX JUNIOR

$35

A new dry cell receiver with all the features of the Bandbox—selectivity, sensitivity, volume and appearance. For places where AC current or storage battery service is not available or desired.

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CROSLEY RADIO

RADIO BROADCAST

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An Experimental Screen-Grid Tuner

Converting Receivers for A·C·Operation

How to Build a Short-Wave Telephone Transmitter

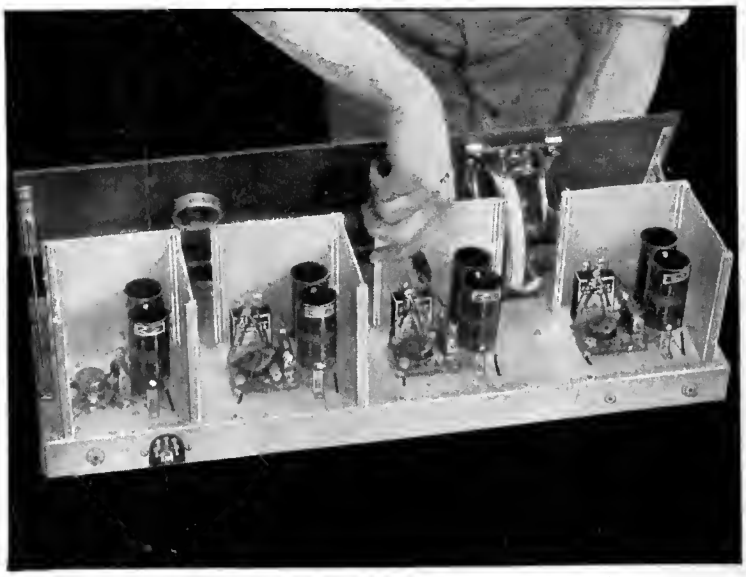
A Non-Motorboating Resistance-Coupled Amplifier

A New Rectifier Tube for B-Supply Units

How Phonograph Records Are Made

35 Cents Doubleday, Doran & Company, Inc. Garden City, New York APRIL 1928

"*I have used* ACME PARVOLT *Condensers for many years and have never had one break down.*"



Showing the well-known L. C. 28 wired for A. C. power supply. Only the finest parts are specified in this high class set, including PARVOLT *By-Pass Condensers.* ACME PARVOLT *Filter Condensers are also recommended for use in the power end.*

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a Power Supply Unit for Your Radio

PLAY SAFE WITH PARVOLTS!

WHEN you buy an electrified radio or power supply unit for your receiver, look for ACME PARVOLT Condensers; they are your guide to quality in all other parts. They cost the manufacturer a trifle more, but they are both his and your guarantee against costly condenser break-down.

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In all required mfd. capacities for 200, 400, 600, 800, 1000, and 1500 Volt D C requirements. Supplied singly or in complete wired blocks for the important power supply units.

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A superior cambric tubing for all practical radio and other electrical requirements. Supplied in 10 colors.

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IF you are earning a penny less than $50 a week, send for my book of information on the opportunities in Radio. It's FREE. Clip the coupon NOW. A flood of gold is pouring into this new business, creating hundreds of big pay jobs. Why go along at $25, $30 or $45 a week when the good jobs in Radio pay $50, $75, and up to $250 a week. My book "Rich Rewards in Radio," gives full information on these big jobs and explains how you can quickly become a Radio Expert through my easy, practical, home-study training.

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Get into this live-wire profession of quick success. Radio needs trained men. The amazing growth of the Radio business has astounded the world. In a few short years three hundred thousand jobs have been created. And the biggest growth of Radio is still to come. That's why salaries of $50 to $250 a week are not unusual. Radio simply hasn't got nearly the number of thoroughly trained men it needs. Study Radio and after only a short time land yourself a REAL job with a REAL future.

YOU CAN LEARN QUICKLY AND EASILY IN SPARE TIME

Hundreds of N. R. I. trained men are today making big money—holding down big jobs—in the Radio field. Men just like you—their only advantage is training. You, too, can become a Radio Expert just as they did by our new practical methods. Our tested, clear training, makes it easy for you to learn. You can stay home, hold your job, and learn quickly in your spare time. Lack of education or experience are no drawbacks. You can read and write. That's enough.

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My Radio course is the famous course "that pays for itself." I teach you to begin making money almost the day you enroll.

My new practical method makes this possible. I give you SIX BIG OUTFITS of Radio parts with my course. You are taught to build practically every type of receiving set known. M. E. Sullivan, 412 73rd Street, Brooklyn, N. Y., writes, "I made $720 while studying." Earle Cummings, 18 Webster Street, Haverhill, Mass.: "I made $375 in one month." G. W. Page, 1807 21st Ave., Nashville, Tenn.: "I picked up $935 in my spare time while studying."

YOUR MONEY BACK IF NOT SATISFIED

I'll give you just the training you need to get into the Radio business. My course fits you for all lines—manufacturing, selling, servicing sets, in business for yourself, operating on board ship or in a broadcasting station—and many others. I back up my training with a signed agreement to refund every penny of your money if, after completion, you are not satisfied with the course I give you.

ACT NOW— 64-Page Book is FREE

Send for this big book of Radio information. It won't cost you a penny. It has put hundreds of fellows on the road to bigger pay and success. Get it. Investigate. See what Radio has to offer you, and how my Employment Department helps you get into Radio after you graduate. Clip or tear out the coupon and mail it RIGHT NOW.

J. R. SMITH, President
Dept. 4-O
National Radio Institute
Washington, D. C.

RADIO NEEDS TRAINED MEN!

Here's the PROOF

Made $185 in Three Weeks' Spare Time

I have met with continued success. For instance, recently I realized a profit of $185 in three weeks for spare time work. I charge $1.50 an hour. Right now I am making more money in my spare time than I am making in my regular job. I have been making good money almost from the time I enrolled. I am going to give up my present position and open a Radio shop. The N. R. I. has put me on the solid road to success.—Peter J. Dunn, 901 W. Monroe St., Baltimore, Md.

Made $588 in One Month

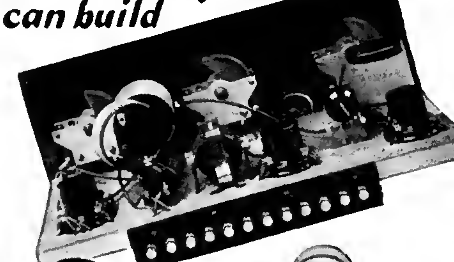
The training I received from you has done me a world of good. Some time ago, during one of our busy months, I made $588. I am servicing all makes of Radio receiving sets. I haven't found anything so far that I could not handle alone. My boss is highly pleased with my work since I have been able to handle our entire output of sets here alone,—Herbert Reese, 2215 South E Street, Elwood, Indiana.

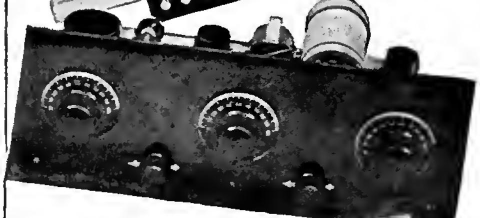
Earns Price of Course in One Week's Spare Time

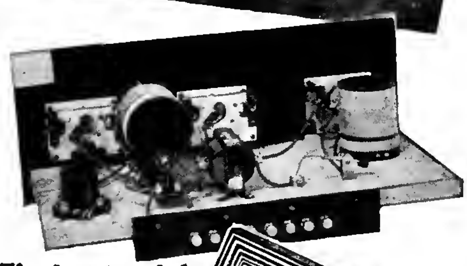
I have been so busy with Radio work that I have not had time to study. The other week, in spare time, I earned enough to pay for my course. I have more work than I can do. Recently I made enough money in one month's spare time to pay for a $375 beautiful console all-electric Radio. When I enrolled I did not know the difference between a rheostat and a coil. Now I am making all kinds of money.—Earle Cummings, 18 Webster Street, Haverhill, Mass.

You can build 100 circuits with the six big outfits of Radio parts I give you

3 of the 100 you can build







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RADIO BROADCAST

APRIL, 1928

WILLIS KINGSLEY WING, Editor

KEITH HENNEY, Director of the Laboratory

EDGAR H. FELIX, Contributing Editor

Vol. XII, No. 6

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The contents of this magazine is indexed in *The Readers' Guide to Periodical Literature*, which is on file at all public libraries.

AMONG OTHER THINGS. . .

THE issue before you contains a variety of articles appealing to all tastes. For the short-wave enthusiast there is the constructional article on the code and telephone transmitter on page 410. For experimentes, we offer many articles, such as those on a two-tube, screen-grid receiver, measurements on the "Lab" circuit receiver, the circuit and description of a non-motor-boating resistance amplifier, the technical editorials, "Strays from the Laboratory," descriptions of tests on B-power units for hum characteristics, how to operate the Hammarlund-Roberts "Hi-Q" set on a.c., and the story on how to convert many standard receivers for a.c. operation. Of more general interest, there are the reviews of new phonograph records. "The Listeners' Point of View," the editorial section, "The March of Radio," the invaluable "As the Broadcaster Sees It," the article by Sylvan Harris describing modern methods of phonograph record making, and many others.

OWING to causes which were beyond our control, we are unable at the last moment to present the article on a new tube for B-supply units, promised in the announcement on our cover. This article will appear as soon as it is finally released by the manufacturer.

THE May RADIO BROADCAST will be full of features which will make it one of the most important issues we have had in many months. Lloyd T. Goldsmith of M. I. T. has written a description of a short-wave receiver, and an intermediate-frequency amplifier using the screen-grid tube. This receiver, especially when used for code reception, provides efficiency heretofore impossible before the advent of the screen-grid tube. There will also appear in the May issue a most accurate list of international short-wave stations. Many readers have asked for a description of a power supply circuit for use in direct-current districts and an article describing a practical circuit for this purpose will appear in May.

THE problems of synchronizing broadcasting stations and, in general, of accurate frequency control for radio stations, has assumed great importance in the past year. Edgar H. Felix has prepared an accurate report of what has been accomplished to date and an analysis of the immediate possibilities in an interesting article scheduled for the May number. For radio constructors, Hugh S. Knowles is writing a description of an a.c. operated "Lab" circuit receiver which has many interesting features, besides its efficiency and flexibility of use, to commend it. This story is also scheduled for May.

SEVERAL additional regular features are being planned for the coming numbers of RADIO BROADCAST and it is hoped to start the first of them with the May issue. Each of these features will appeal in a very practical way to a large number of the radio fraternity. . . . Those interested in information about the Cooley Rayfoto system of picture reception who desire to be placed in touch with the manufacturers may address their letters to the undersigned who will forward them.

—WILLIS KINGSLEY WING.

DOUBLEDAY, DORAN & COMPANY, INC., Garden City, New York

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Frontier Stories
West
The American Sketch

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TERMS: $4.00 a year; single copies 35 cents.

© Julius Kirschner

Francis Gow Smith

THE INTREPID explorer whose recent expedition to the jungles of the Brazilian hinterland was facilitated by the use of short-wave radio equipment carried by the party. Twice weekly time signals were sent out on one of WGY's short-wave channels to aid Mr. Gow Smith in his map making. The special microphone used for the purpose is still known up at Schenectady as the Gow Smith "mike." The story beginning on the next page relates the amusing adventures of the explorer in the smaller towns on his route leading to the heart of the dark continent. Listening-in was a pastime never before indulged in by the inhabitants of many of these towns, and the explorer, who otherwise might have been received coldly, was acclaimed wherever he went, and was embarrassed by the great number of invitations to social functions which he received

MOUNTED BRAVADOS IN A MATTO GROSSO TOWN

The author frequently encountered mounted groups of nomadic ex-convicts whose thirst for amusement seemed to be satisfied only by plundering. Sometimes they will lay waste a whole settlement, murdering and robbing the inhabitants

Thanks to WGY—!

By Francis Gow Smith

THIS is WGY calling Francis Gow Smith, on the Upper Paraguay River, Matto Grosso: The discovery made in the use of your set without antenna or ground while you were on the steamship *Pan America* this last March is expected to have important results in the further development of radio."

This message, broadcast for me by the General Electric Company from Schenectady, and reaching me one spring night in the tiny frontier town of São Luiz de Caceres, forty-five hundred miles south of New York, finally convinced my Brazilian friends that I was not a magician or a faker or a spy but a *bona fide* explorer.

And whatever value there may have been to radio in the experimental short-wave broadcasting that I received during my latest and most adventurous trip into the wilderness of Brazil, there is no doubt in my own mind that these experiments helped greatly to build goodwill for the United States in a backwoods region where North Americans have hitherto been looked upon with suspicion.

Incidentally, I owe my safe return from that expedition very largely to the radio set I carried. It was a neat, portable two-tube affair, specially built for me by RADIO BROADCAST. When I sailed with it for Rio, aboard the *Pan America*, I appreciated it rather as a possible source of recreation during the long months I would be isolated from civilization. I had no inkling of its future utility in making my expedition a success.

Indeed, I was very much disappointed, the first few nights out, when I strung the antenna around my cabin expecting to get news reports and actually getting nothing in the phones but dead silence. Finally one night I turned it over to the radio operators to experiment with.

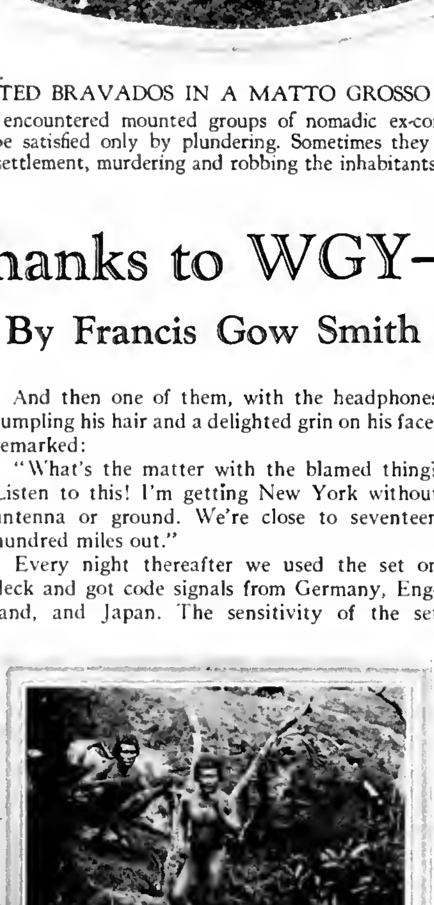
"What's the matter with the darn thing?" I asked.

"Give it a chance," said they. "Bring it up on deck."

And then one of them, with the headphones rumpling his hair and a delighted grin on his face, remarked:

"What's the matter with the blamed thing? Listen to this! I'm getting New York without antenna or ground. We're close to seventeen hundred miles out."

Every night thereafter we used the set on deck and got code signals from Germany, England, and Japan. The sensitivity of the set amazed the radio boys, and was the occasion for that later message from Schenectady, which I received at São Luiz de Caceres.



SATURDAY NIGHT!

A community bathing "crevice" makes unnecessary the "hot and cold water" clause in the South American Indians' lease

In Brazil to-day, radio is barely emerging from its infancy. There are two broadcasting stations in Rio and one in São Paulo, while the General Electric Company is erecting another. Entertainment programs and lessons in English are on the air constantly; but outside of the cities and a few prosperous ranches, there is nobody in Brazil equipped to hear the programs.

Here's a nation bigger than the continental United States, with a population of more than thirty million, and increasingly prosperous economic conditions. Some day soon it is bound to be a profitable market for American radio products. And when American radio programs are being received by American radio sets throughout Brazil, a greater influence will have come into being for Pan American goodwill and commercial development than all the spectacular goodwill flights and conferences that we can organize.

For radio will break down among the common people that suspicion which at present is fed by local propagandists to the detriment both of political amity and friendly trade.

I'm positive of this, because I've seen how it works out. When I reached Corumba, on the upper Paraguay River, I was just another of those Yankees, regarded with vague suspicion. I had a few acquaintances there, from previous trips, but no friends to speak of and no entrée into the intimate social life of the town. I put up at the hotel, and asked the proprietor's permission to install my radio.

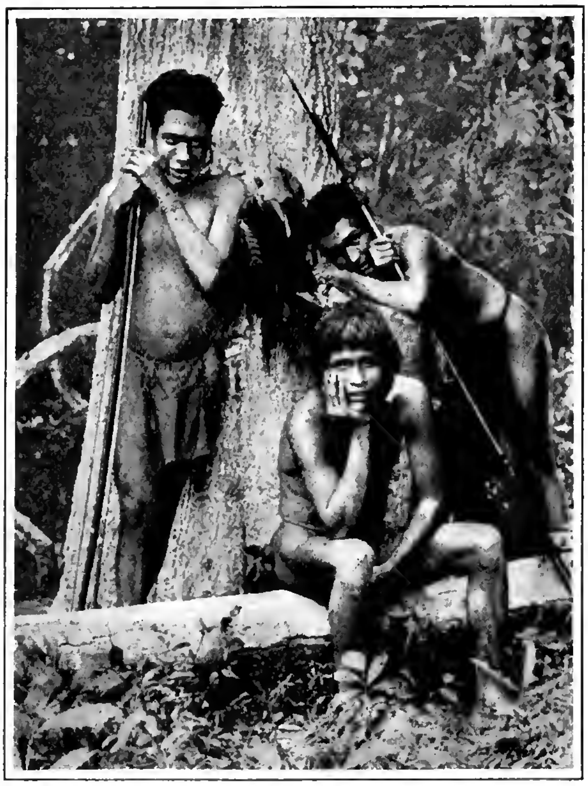
He looked at me blankly. Corumba has water supply, electric lights, and telephones. But radio? Huh! There was no use trying to persuade the hotel man that the little wooden box I carried could perform any of the radio miracles he had indefinitely heard about. Still, he skeptically authorized me to put up an antenna on his roof.

My opening act was unfortunate. One of the poles slipped while I was erecting it, fell through the red tile roof of the house next door and just missed hitting on the head one of the society leaders of the town. She came storming outdoors and gave me frankly a piece of her mind. Soon it was all over town that this crazy Yankee was destroying property with something he called a radio.

But that night I invited the hotel proprietor to bring a few friends into my room. They stood around rather abashed. What was the sense of all this fuss over a box with some wires and two oddly shaped electric light bulbs in it?

And then, singing sweetly in the phones, came from Schenectady a musical program given experimentally on short waves for a man in Johannesburg!

My guests were thrilled as they had never been in their lives. They were almost incoherent in their enthusiasm. The news spread like wildfire through the town. The leading citizens flocked into my room, uninvited; the crowd jammed the corridor outside. Men waited hours for their few minutes' turn with the phones; many went away disappointed and came back night after night until they had heard for themselves this miracle. The lady next door was placated—she wouldn't even let me pay for the damage to her roof. While the hotel proprietor was in the Seventh Heaven of bliss. His bar had never done such a flourishing business.



SOME FRIENDLY INDIANS OF MATTO GROSSO

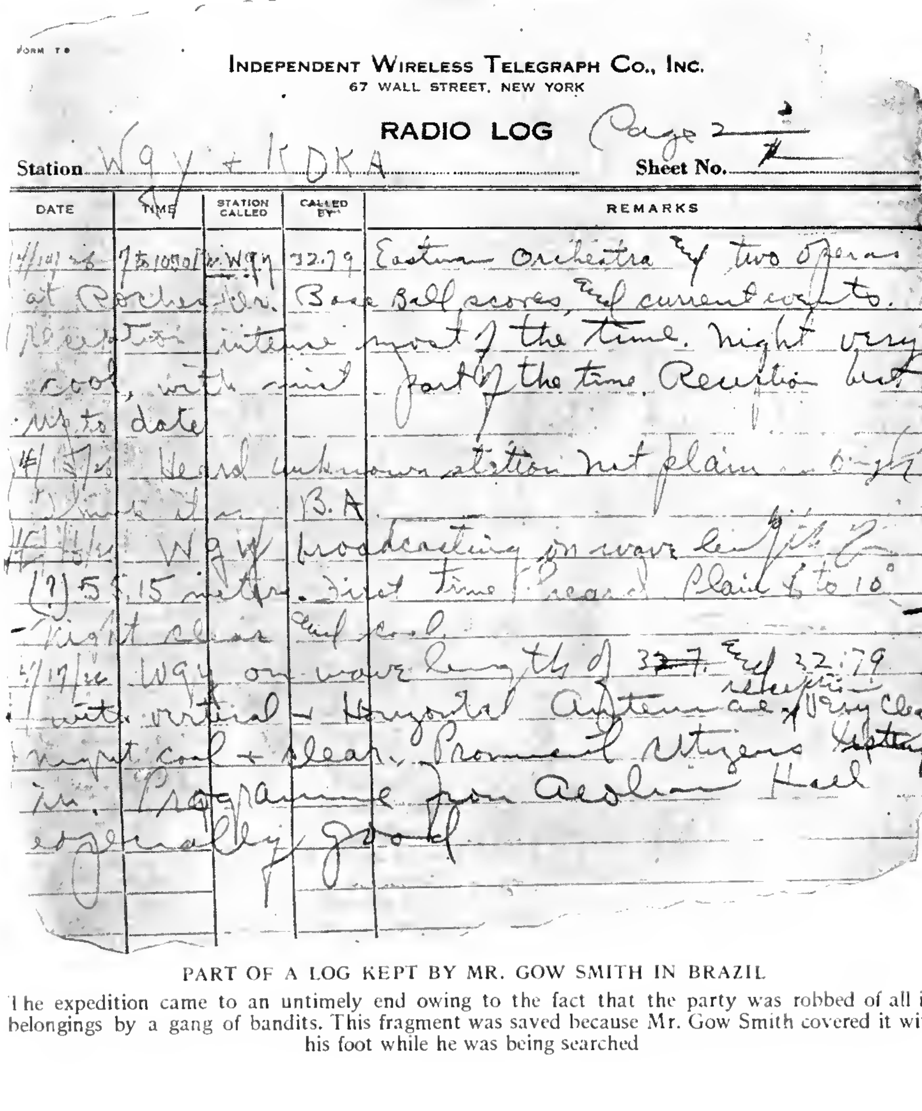
While these were only too willing to pose for their photographs, there are others who could not be approached with safety

For eighteen days, while waiting for the little stern wheeler that would take me up to São Luiz de Caceres, I had the set working. There was considerable fading at times, but it worked, better after nine at night. Soon I had become the personal friend of the most important business men and politicians in Corumba. They heard dance music from the Waldorf and music from Aeolian Hall; they heard Chauncey Depew speak; they listened to plays and to operas from the Eastman Theatre in Rochester; they got the news of Amundsen's flight over the North Pole, and of one of the attacks on Mussolini.

I translated the news every night for the local newspaper. Corumba had never before been so intimately in touch with the outside world. The community became pro-American. Nobody could do enough for me; they wanted me to settle down and stay with them; they all said they were going to learn English; and I could have sold the set a hundred times over at any price I asked.

When I left, the leading citizen of the town pressed on me a letter of introduction to an influential friend of his in Cuyaba, the frontier capital of the state of Matto Grosso. I wasn't going anywhere near Cuyaba, but he wanted me to make a special trip there anyhow. His letter read:

"This is to introduce to you my good friend Mr. Francis Gow Smith, who is coming to you with a most marvelous machine called the *radio telephonia*, which has proved in experiments here to be a very amazing thing indeed and I want you to have the privilege of listening to this truly magical instrument."



FORM T8

INDEPENDENT WIRELESS TELEGRAPH CO., INC.
67 WALL STREET, NEW YORK

RADIO LOG (Page 2)

Station WGY & KDKA Sheet No. 2

DATE	TIME	STATION CALLED	CALLED BY	REMARKS
4/14/26	7 to 10.30 pm	WGY	32.79	Eastman Orchestra & two Operas at Rochester. Base Ball scores & current events. Reception intense most of the time. Night very cool, with wind part of the time. Reception best up to date
4/15/26				Heard unknown station not plain ... B.A
4/16/26		WGY		broadcasting on wave length ... 15 meters. First time heard. Plain 8 to 10. Night clear & cool.
4/17/26		WGY		on wave length of 32.7 & 32.79 with vertical & Horizontal Antennae. Very clear reception. Night cool & clear. Prominent citizens listening in. Programme from Aeolian Hall especially good

PART OF A LOG KEPT BY MR. GOW SMITH IN BRAZIL

The expedition came to an untimely end owing to the fact that the party was robbed of all its belongings by a gang of bandits. This fragment was saved because Mr. Gow Smith covered it with his foot while he was being searched

SÃO LUIZ

WARNED by my experience in Corumba, I rented a big twelve-room house when I reached São Luiz de Caceres. I knew that no hotel room would hold the crowds that would come. And besides, São Luiz boasts no hotel worthy of the name. It's the jumping-off place on the Brazilian frontier—a town of five thousand population, at the edge of the jungle. To the northward beyond it are scattered ranches, a few hamlets of rubber and ipecac gatherers, and then unexplored wilderness, several hundred thousand square miles in extent, peopled sparsely with naked savages.

In São Luiz I was received with greater suspicion than in Corumba. Many of the common people thought I was some sort of gringo spy. Why did I have a camera, if it wasn't to take photographs of sites for future forts, when the dreaded "Colossus of the North" should begin the process of gobbling up Brazil? The people misunderstand the United States completely. They have been filled up with such fantastic bugaboo stories about us that they extend toward us a hazy mixture of dread and dislike such as a child feels toward imaginary giants and dragons.

The inhabitants are practically cut off from the world. They have a weekly four-page newspaper, but it publishes only items concerning local society events—marriages and birthday festivals, and perhaps a sprinkling of political news. Besides, most of the people can't read.

The streets are unpaved; there is no electric light, telephone, or water supply. Water from the river is peddled in barrels about the streets. On the edge of the barren plaza, fronting the river, there stands an unfinished stone church, and the piles of building stones beside it are alive with snakes, lizards, and rats.

Naturally, in this isolated community, I was looked upon with disfavor by the uneducated. My radio set in its mysterious box with the iron handles was set down in their minds with my camera as evidence that I had some mysteriously unfriendly intentions. They couldn't believe I was using the town merely as a jumping-off place for exploration. Why should anybody in his senses penetrate the jungles beyond and get himself shot at with poisoned arrows? No; obviously I had come for no good purpose, doubtless as a secret agent of the United States, either to survey gun emplacements or to detect hidden mineral wealth.

What a change in their attitude my radio worked!

There wasn't a stick of furniture in the house I had rented, except an old table. I set up the radio on that table, and slung my hammock in one of the bare rooms. I hired a boy to help me, went into the jungle and cut down two fifty-foot bamboos, which we erected as antenna masts in the *quintal*, or back garden, of my house.

The villagers watched these proceedings with growing suspicion. Many of them had never even heard of radio. Then I invited the mayor and a few prominent citizens to come and hear the set work. To give a touch of festivity to the occasion, I had hung Eveready electric flashlights around the walls, and softened them with bits of colored paper. The evening was a phenomenal success. Three sets of phones were working all the time. Sometimes a listener, after hearing ecstatically a few bars of music, would drop the phones and scurry out of the house, to round up his wife and children and friends.

Soon I was mobbed, as I had been in Corumba. Every citizen prosperous enough to wear shoes felt himself privileged to come in; the barefoot families humbly congregated about the doors and windows and stared in, imagining some queer sort of magic was going on.

So, within a few nights I was welcomed into the center of the town's social life, invited to all the most elite weddings, birthdays, and funerals, and offered banquets in every home. The bare rooms of my rented house began to fill up with furniture—chairs, tables, wine glasses, and even that rare and valued treasure, a bed! All contributed by the citizens to their distinguished guest —who had done nothing to distinguish himself but bring a radio set into their midst.

But suspicion still smouldered among the poor and illiterate, and I was advised to allay it by having a barefoot soirée, when the unshod portion of the populace could hear the radio work for themselves. Many of them heard it, but were still unconvinced. They'd go out into the back yard and stare up at the aerial; they poked about in the rose bushes, and surreptitiously investigated the empty rooms of the house. Somewhere, they were sure, I had a confederate hidden, to play on a musical instrument.

Then came the three special programs, broadcast by the General Electric Company for my benefit from Schenectady. The dentist in São Luiz understood English, and when the rest of the guests heard him translate the messages addressed to me, the last bit of skepticism vanished. But my reputation was enormously enhanced. Everybody called me affectionately "Mister," or "Mister Yank," and it was said that I was a great and influential millionaire.

Certainly nobody but a millionaire could have a wonderful radio set and receive special news and musical programs sent through the air, forty-five hundred miles over sea and jungle, just so that his evenings on the frontier might not be lonely!

AT CORUMBA
Listening-in with the short-wave receiver built for the expedition by Radio Broadcast

The girls of the town could never quite get over the notion, however, that I was some sort of magician as well. Some of them asked me to tell their fortunes with cards, and when I did so, invariably predicting a forthcoming marriage, the town's regular and previously prosperous fortune teller was deserted. She couldn't compete with the authentic forecasts that I had to offer—for didn't I get them straight out of the air, wearing my headset and listening wisely while I read the cards?

The guests came to these radio soirées clad in the strangest mixture of costumes. Some of the men wore evening dress; others came in homespun. There were cowboys wearing sombreros, gaudy neckerchiefs, and sidearms; there were ranchers in khaki shirts and big boots. But many of the women, with their bobbed hair, low cut evening gowns and sparkling diamonds, might have just stepped out of a Broadway night club.

I understand that this experimental short-wave broadcasting was of some interest to the General Electric Company. However that may be, it certainly put a backwoods community of Brazil into a turmoil of excitement. The old suspicions of the United States vanished, and the town became a focal point of boosting for Uncle Sam. Every inhabitant wanted a radio, and they all insisted that nowhere else in the world could it be so great a blessing as it will soon be in these backwoods regions where there are only the most meager entertainments and no contact at all with outside events.

When finally my batteries gave out, it was considered a disaster. I left the set in São Luiz, and carried out my expedition into the wilderness, the entire services of the town being put at my disposal while I was making ready. Months later, having been waylaid by bandits, robbed of all my equipment and left fever-stricken and starving in the jungle, I was rescued by a boat coming up the Sipotuba River from São Luiz. They brought me down to the village too weak to walk, put me up in a private home, nursed me back to health, and lavished attentions upon me.

All this in the town that I had entered first amid such an atmosphere of suspicion. And when I was strong enough to leave I was escorted down to the little river steamer by practically the entire populace. Knowing that I had been robbed and left penniless, they thrust handfuls of currency at me; and I even discovered that some of them had secretly stuffed money into my pockets.

Believe me, a radio receiving set will be an essential part of my equipment on my next exploration trip. I don't mind the isolation in the jungles myself, and I dislike to increase the weight of my equipment; but a radio works wonders in building goodwill for the stranger along the frontier. I might not have survived the illness of my last trip but for the friendly attentions which Radio Broadcast's portable set had won for me. And I think that, when it comes to the touchy job of dealing with hostile Indians in the wilderness, a radio would be even more valuable in winning friendship and esteem.

THE CROSS MARKS THE HOTEL "GALILEO," CORUMBA
It was here that Mr. Gow Smith unfortunately permitted one of his antenna masts to crash through the roof of a local society leader's house

The March of Radio

News and Interpretation of Current Radio Events

Picture Broadcasting Becomes a Practical Reality

HARDLY a day passes without some news of progress in radio picture transmission. On November 6, WOR broadcast its first complete radio picture, using the Cooley system. On January 13, Dr. E. F. W. Alexanderson publicly demonstrated his television device in Schenectady. On January 26, WEAF broadcast its first picture, utilizing equipment also developed by Doctor Alexanderson. On January 31, WOR began the regular broadcasting of Cooley radio pictures three times a week. Each event is significant and brings nearer the day when the radio reception of pictures becomes an integral part of the broadcasting art.

The transmissions from WOR have been continued since the initial experiment in November, at first occasionally and then on a regular basis. A group of twenty or thirty enthusiasts have installed Cooley Rayfoto receivers and the number increases as rapidly as the equipment is manufactured. These experimenters are typical set builders rather than specially trained professional engineers. Phonograph recordings of actual pictures have also been made successfully which make possible experiments with Cooley apparatus at any time, regardless of the availability of broadcasting. The sponsors of the Cooley system advise that, within two or three months, their equipment will be available in quantity and a rapid growth of the picture reception audience may be expected.

We witnessed a confidential demonstration of Doctor Alexanderson's apparatus at Schenectady some months ago. Several radio channels are required to transmit television images and consequently the system is now restricted to short-wave transmission. The conventional broadcast receiver cannot be utilized, therefore, in the reception of television by this system. The Alexanderson television outfit, which uses Daniel Moore's improved neon tube, is infinitely simpler than the elephantine apparatus demonstrated by the Bell Laboratories a year ago. The picture, with the Alexanderson system, is scanned eighteen times a second. The received picture is in the form of a pinkish glow, covering an area of three by three inches. It is not rich in detail. Presumably three to five years of development are necessary before this apparatus is capable of reproducing sufficiently good moving pictures at a reasonable cost to the average user.

The picture receiver, demonstrated at WEAF, employs the neon tube and requires about ninety seconds for the reception of a picture. It utilizes high-grade synchronous motors to keep transmitting and receiving drums in step. The transmitted signal was a high-pitched audio note, similar to that used in sending Cooley pictures. No statement has been made as to when the equipment necessary to build these picture receivers will be on the market. Since the synchronizing equipment is somewhat more expensive than the "stop-start" system used with the Cooley apparatus, its cost may be fairly high. It is capable of excellent detail and possesses considerable reliability.

ANOTHER RADIO PICTURE RECEIVER

Readers of this magazine are familiar with the Cooley Rayfoto picture system demonstrated at the New York radio show last September and which was first heard over WOR on November 6, 1927. On January 26, 1928, Dr. E. F. W. Alexanderson of the General Electric Company demonstrated one of his systems of radio picture transmission and reception through WEAF. The illustration shows Doctor Alexanderson and the receiver. The rectifier and amplifier unit is in the box near the wall and the mechanical element with paper on the receiving drum is in the foreground. Pictures are received in 90 seconds and are excellent in quality

The adoption of a regular picture broadcasting schedule by WOR, the fourth significant event, is an indication that that station has already established a picture receiving audience and is preparing to extend it. That this audience will grow rapidly as soon as the apparatus is available in quantity is foreshadowed by the fact that the Cooley equipment is no more expensive than the parts for a good broadcast receiver.

At the same time that these various news events occurred in the field of radio vision, a representative of the Baird system, *en route* to the United States, announced that television between London and New York had been definitely established. One demonstration for the press was held some weeks ago and the first transatlantic television transmission is claimed by Baird's representative in New York.

Possibilities of Still Picture Broadcasting

TELEVISION, or radio vision, naturally has a much greater appeal to the public imagination than the transmission of still pictures. Because of the tremendous number of images which must be broadcast at an extremely high rate of speed, the perfection of radio vision is a problem a thousandfold more complex than radio photography. It is unlikely that television will ever be possible in the present broadcasting band, since it requires a number of channels used simultaneously to transmit all the necessary images. In its present development, the subject of television transmission must stand within a few inches of the scanning device and, as a consequence, only the bust of a single individual can be broadcast. Any rapid motion is blurred. Under the circumstances, present-day television has few, if any, advantages over the transmission and reception of still photographs.

All of the defects in television will, of course, be remedied gradually and the present state of the art is sufficiently advanced to make clear and entertaining radio moving pictures a prospect of the next few years. In the meanwhile, does radio picture reception offer sufficient fascination to promise rapid extension in the homes of broadcast listeners?

The existing systems of radio picture transmission and reception have many practical advantages. The pictures may be radiated from an ordinary broadcasting station and received with the aid of any good broadcast receiver. High-grade reproduction of pictures in the home is quite possible with apparatus now available. Broadcasting of pictures by remote control, with the aid of wire lines, is feasible with all existing systems. A news photographer can take a picture at a broadcasting studio, or at a remote point connected with the studio by wire, and put it on the air within two or three minutes. Radio picture broadcasting serves the same useful purpose that illustrations do in a book, magazine, or newspaper and enhances a radio program to an equal degree. The broadcasting of sporting and news pictures, photographs of prominent artists, and technical diagrams and data accompanying educational lectures is entirely possible and adequately useful or entertaining. Whatever the camera records, so long as the subject is not entirely too fine in detail or lacking in contrast, is suitable material for radio picture transmission.

It is not unreasonable to expect, in radio picture broadcasting, a new field destined to rapid growth. Those who have the foresight to participate in early experiments will reap their reward in the manufacture, marketing, and servicing of picture sets.

Foreseeing these possibilities, RADIO BROADCAST has been diligent in presenting all available information. So far, constructional information has been limited to the Cooley system but, as rapidly as information regarding other systems is available, we will present it in these pages, so that our readers may keep abreast of progress in the art.

The Shrinking Short-Wave Spectrum

FORESEEING the international complications which would result from the indiscriminate assignment of the higher frequencies to the numerous applicants therefor, we have persistently urged conservation of these frequencies. Not until the hearings in Washington, however, did we realize that the Federal Radio Commission's problem in the short-wave spectrum is already more complex than that existing in the broadcasting field. Competent engineering authorities, with a long background of experience in short-wave transmission, pointed out that a short-wave radio telegraph station requires a channel having a width of 0.2 of one per cent. of the assigned frequency. Thus, immediately below the broadcasting band, a radio telegraph channel must be 3 kc. wide, while, at 30,000 kc., or ten meters, frequency variation is so great that the channel must be 60 kc. wide.

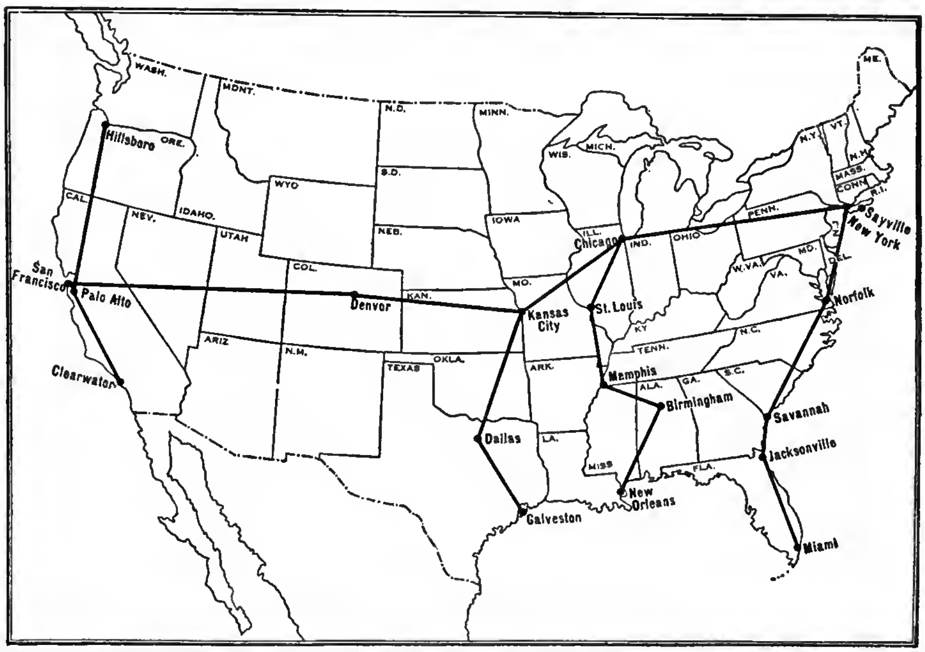
Assuming this separation, or channel width, to be necessary, there are only 1316 channels between 1500 and 30,000 kc. A part of these has been assigned to mobile, amateur, and broadcasting purposes, leaving only 666 channels available to the entire world for point to point short-wave communication. Inasmuch as, even with the most insignificant powers, a radio telegraph transmitter, assigned to these wavelengths, is likely to cause interference in all parts of the world, duplication of station assignments, for operating continuously is quite impossible.

Furthermore, to maintain continuous service over long distances, the varying transmission qualities of these frequencies at different hours of the day and night make it necessary to use two, three, and four channels. Consequently, instead of a host of channels, sufficient to meet the needs of all communication interests, the Army and the Navy, and the considerable number of private concerns which desire channels, there is only a very limited number of channels to be divided among the numerous applicants. Assuming that the United States is entitled to twenty per cent. of the channels available to all the nations of the world, there are only approximately 126 channels to be considered after discounting those assigned for broadcasting, amateur, and experimental purposes.

The Radio Corporation of America has already established a number of short-wave, transoceanic services. It desires to extend these services greatly and, were all its prospective requirements considered exclusively, there would be no room on the air for any but Radio Corporation stations and the stations of the Army and the Navy. The Mackay interests propose to enter the radio telegraph field and have made demands for channels in numbers sufficient to absorb any reasonable allotment to the needs of the United States.

How the demands of brokerage houses, department stores, newspapers, oil companies, railroads, bus transportation services, and the thousand-and-one other interests can be met with this meager allotment of frequencies is not apparent until considerable technical progress is made in maintaining frequency stability. As soon as we learn how to hold stations within a few hundred cycles of their assigned frequencies, the capacity of the short-wave bands will be increased a hundredfold.

The Commission has announced that it will require two months of study before it can make any decisions. It is hoped that it



THE PRESENT AND PROPOSED MACKAY RADIO SYSTEM

Recently the Mackay Company entered the radio field and took over the Pacific Coast stations of the Federal Telegraph Company. These stations are at Hillsboro, Oregon, and Palo Alto and Clearwater, California. The points shown on the outline map are the basis of a short-wave system to furnish communication which will supplement the present Postal Telegraph wire system. The proposed channels will connect points most subject to storms and other interruptions to wire service. In addition to this land radio system, the old Sayville station on Long Island has been purchased and will shortly be opened for marine communication with ships on the Atlantic. The Mackay system now holds 42 wavelengths in the short-wave spectrum, of which 34 are for a chain of stations for transpacific communication will establish a definite policy and stick to it. In the broadcasting spectrum, expediency, rather than an established set of principles, has ruled. In view of the complexity of the short-wave problem, it is most urgent that definite principles be enunciated, lest the Commission be later charged with favoritism or discrimination.

The first obvious principle is that there is no short-wave channel available for any service which can be conducted by wire. The Mackay interests, as one of their plans desire to establish an emergency network so that, should wires break down, they may use short-wave radio transmission. There is every reason why a duplicate emergency radio service should be available in national emergencies but, should such a system be established, permission to utilize the radio network should be restricted to grave emergencies.

The requirement that wire services be used where available is complicated by certain economic factors. A chain of department stores, for example, can erect short-wave transmitters and maintain communication at a much lower cost than entailed in using public service wire telegraph channels. The application of this principle requires, therefore, discrimination against private interests in favor of the wire companies. In view of the needs of transoceanic services and the value of an independent American communication service, this discrimination against private interests appears entirely necessary. Furthermore, it is utterly impossible to serve all private interests with the limited facilities available. Only a selected few could be accommodated, were short-wave radio telegraph channels assigned to private interests.

This suggests a second principle which may be established as a policy of the Commission. No short-wave channels shall be assigned for any service unless such service be opened to the general public upon an equitable basis of charges without discrimination.

It is unfortunate that the wire interests, which are so well entrenched and established in the United States, should seek to enter the radio field and compete with existing radio communication companies and that radio communication interests, on the other hand, should seek to compete with the wire interests. For example, application was made for the right to conduct a New York to Montreal service by a radio communications company. These cities are already well linked by wire telegraphy and telephony. Possibly there might be some simplification of the situation if the radio companies decide not to establish radio communication networks where wire services exist and the wire companies, in turn, stay out of the radio field and stick to their well established and profitable wire business.

The stifling of competition is clearly un-American in principle and carrying out this suggestion would obviously tend to stifle competition. But what alternative exists? We do not grant street railway franchises for routes along the same avenue to two or three rival companies in order to establish competition. If radio channels are limited, they must be regarded as a franchise and be distributed in such a manner as to assure the greatest possible public service.

A further embarrassment in the situation exists in the fact that long-distance radio communication is dominated by a single interest. Whatever the means used to gain this acknowledged ascendancy, the fact remains that it exists. In almost every important line of industry there is a dominant company which has established its acknowledged leadership in the field. This company is always the object of vilification by politicians but, because of sheer strength and competence, merrily goes on occupying its position. Under the circumstances, the Federal Radio Commission is bound to be criticized as the tool of monopoly and its activities will always offer subject matter for spellbinding politicians because the dominating company, if fairly treated, will have a preponderance of assigned channels. For this situation, there is no practical and fair remedy other than the uneconomic proposal of government ownership.

The demands of the press for short-wave channels, although clothed in high-sounding phrases regarding public service and freedom of the press, are really an effort to reduce its wire costs. Signals travel through the ether no faster than they do over wire circuits. The demands of the press for special radio channels are in the same category as all other requests of private interests, excepting in those few instances that wire services are not available. The press already receives preferred consideration from the wire services which carry most of its communications at or below cost.

The Commission Retreats

THE Federal Radio Commission has issued new application blanks, requiring the submission of considerable information on the part of broadcasting stations concerning their technical equipment, their program hours, the proportion of time devoted to commercial broadcasting and facts regarding chain affiliations. The Commission should have gathered this information immediately on its accession, to authority last March.

Congressman Wallace H. White has expressed again and in greater detail his disappointment in the functioning of the Federal Radio Commission. He has urged, as we have in these columns for many months, that the future appointees be possessed of sufficient technical qualifications so that they may perform their duties efficiently.

The members of the Commission have been testifying before the House Merchant Marine Committee and they have hardly had a pleasant time of it. Judge Sykes admitted that a much larger proportion of channels had been assigned to New York and Chicago than those cities deserved, an abuse which we have frequently stressed in these columns for more than a year. The favorable position of chain stations which, the testimony brought out, occupy twenty-one out of the twenty-five cleared channels, does not please members of the Congressional committee.

The saddest news which we have heard from the Commission so far is the announcement by Acting Chairman Sykes that the 300 stations which were to be scheduled for elimination on March 1 will have their licenses extended. This move, he says, is made because three of the four members of the Commission are not confirmed by the Senate. Naturally, each of these three hundred stations is the pet of some congressman or senator and the unconfirmed members of the Commission could not hope for a confirmation if they took the necessary and drastic action of eliminating such stations. Politics now rule radio, confirming our predictions made when a commission control of radio was first proposed before the Radio Act of 1927 was passed.

Representative White has presented a bill extending the powers of the Commission for another year and including, in addition, some provisions aimed at the Radio Corporation of America and the National Broadcasting Company. An amendment to Section 10 of the Radio Act, which he proposes, is to permit the Commission to refuse a license to a station intended for international commercial communication, if the company operating that station has entered, or intends to enter, into exclusive rights with a foreign country. We understand that the Radio Corporation has made several such agreements. The Commission, however, may grant such a license if the company will maintain just and reasonable rates and will secure and maintain equality of right and opportunity for other American citizens to engage in competitive services.

Other proposed changes in the Act are the strengthening of the powers of the Commission to revoke licenses for false statements in applications, or for failure to observe any of the terms, restrictions, and conditions of the Act or regulations issued by the licensing authority. To the powers of the Commission, Representative White proposes to add that it may fix the hours during which chain broadcasting may be carried on, designate the stations and limit the numbers participating therein, and that it may prohibit commercial broadcasting through chain stations and, in fact, may make any rules and regulations in the public interest, applying to chain broadcasting.

The crowning touch of Representative White's bill is a proposed provision to be included in the Radio Act that it shall be unlawful for any firm to import or ship in interstate commerce any vacuum tube, whether patented or unpatented, which shall have any restrictions of the use to which such tube may be put or which shall have the effect of fixing the price at which the tube may be sold. It is doubtful whether this unusual curtailment of patent rights of a single group is constitutional. This proposal is really an amendment to the patent law and is not properly a part of the act regulating radio communication.

If the fundamental theory of our patent law must be changed, why does not Congress undertake its thorough study and pass a new patent law instead of singling out vacuum-tube manufacture as a special case? High-grade vacuum tubes, suited to all purposes, are available to the public and sold without exorbitant profit. If the R. C. A. is indulging in unfair practices, there are adequate measures which can be taken without depriving it of the benefits of normal patent protection. If the patent monopoly, established by patent law, confers too great powers on the patent holder, then the patent law should be modified. A possibility worth considering is the compulsory issuance of licenses upon an equitable basis to all who apply, thereby assuring patent holders of adequate reward, but preventing the use of patents to establish monopolies or embarrass competition. The principle of singling out a particular patent situation for special legislation is contrary to the principle of equal rights to all.

The Blue Laws of Radio

FAIRFIELD, IOWA, has passed an ordinance prohibiting the use of electrical equipment which causes interference with radio reception between noon and midnight. Interpreted literally, not only do vacuum cleaners, washing machines, electric toasters and flatirons fall within the ban, but also electrical incinerators, elevators, refrigerators, cash registers, fire alarm signals, and railroad block signals. Violations are punishable by a fine of one hundred dollars or thirty days imprisonment or both.

There is nothing reasonable about this ordinance. It is doubtful whether this practical confiscation of property is legal. Electrical interference problems should be solved by aiming at the cause rather than the effect. A modern cash register, for example, should be designed so that it cannot cause electrical interference, although even the best of them do so. Any electrical device can be equipped with suitable interference preventors which will eliminate the possibility of interference with radio reception.

In Providence, Rhode Island, they have invoked an old blue law to embarrass a radio dealer. The ordinance prohibits any person to ring a bell or to use any other instrument or means for the purpose of giving notice of any public sale or auction of any article. This has been interpreted by the police to embrace the use of radio loud speakers in stores, although it is doubtful whether the writers of the blue laws had radio in mind. To be really fair in the matter, the police ought to be prohibited from using whistles.

Here and There

AN APPEAL has been filed by the Westinghouse Electric and Manufacturing Company for a review of the decision of the Circuit Court of Appeals which upheld DeForest against Armstrong in the invention of the feedback circuit. ⁑ ⁑ ⁑ THE HAZELTINE Corporation has filed against the Charles Freshman Company and the Stewart-Warner Speedometer Corporation in the Southern District, citing U. S. Patent No. 1,648,808. ⁑ ⁑ ⁑ THE ORIGINAL decision of the examiner, rejecting claims 1 to 6 inclusive, 8, 9, 11, 12, 15, 19, 21, and 22 as unpatentable over prior art, was affirmed in the case of re-issue patent 16834, issued to Lloyd N. Knoll on December 27, 1927. The references cited were Bellini, Kolster, and a scientific paper issued by the Bureau of Standards. ⁑ ⁑ ⁑ A SUCCESSFUL appeal from the decision of the primary examiner, denying the patentability of several claims of patent 1,654,285, issued to Charles Fortescu, describing a modulation system for quickly absorbing residual energy stored in the antenna system after signal impress has been completed, has been announced by the Board of Appeals. ⁑ ⁑ ⁑ CORNELIUS D. EHRET, counsel for the applicant, Frederick A. Kolster, in Patent 1,637,615, called our attention to the fact that our item in the December issue, citing the substance of the opinion of Second Assistant Commissioner of Patents M. J. Moore, implies that the claims referred to were rejected after the patent was issued. While we fail to see how this conclusion was reached from our item, we are pleased to state, in deference to Mr. Ehret's wishes, that no claims were declared invalid after the patent was issued.

THE FIELD FOR GOOD RADIO SETS

ARTHUR SMITH, radio dealer of Tampa, Florida, sends us a most lucid letter explaining the position of the radio dealer in locations where high-grade local broadcasting is not available. He complains that radio manufacturers concentrate their advertising almost exclusively upon the cheaper models and fail to point out the advantages to the user of the high-grade, super-power, radio receivers, really necessary in such areas. As a consequence, the dealer is compelled to demonstrate the cheaper type of receivers which do not give satisfactory results when remote from good broadcasting. He states as his opinion that less than one per cent. of the listeners in his area are utilizing receiving sets with 210 power output tubes and that most of them are still using the cheapest type of set which has been so forcibly heralded in the advertising columns. He urges that set manufacturers devote more advertising space to high-quality radio sets because the public, once appreciating their capabilities, is quite willing to spend the necessary money for better models.

E. T. CUNNINGHAM announces the introduction of the CX-371-A tube which has the characteristic of the 371 and 171 type except that it has an oxide-coated filament. This reduces the filament current required to a quarter of an ampere, effecting an economy of filament current. The oxide coated filament also gives uniform emission throughout its life instead of gradually falling emission which is characteristic of the thoriated filament.

JUDGE HUGH BOYCE in the Federal Court at Wilmington, Delaware, dismissed the suit of the General Electric Company, charging the DeForest Radio Company with infringement of Langmuir's high-vacuum tube patent. If this decision is sustained in higher courts, to which it will undoubtedly be appealed, one of the most important reliances of the R. C. A. in its hold on the tube situation is destroyed.

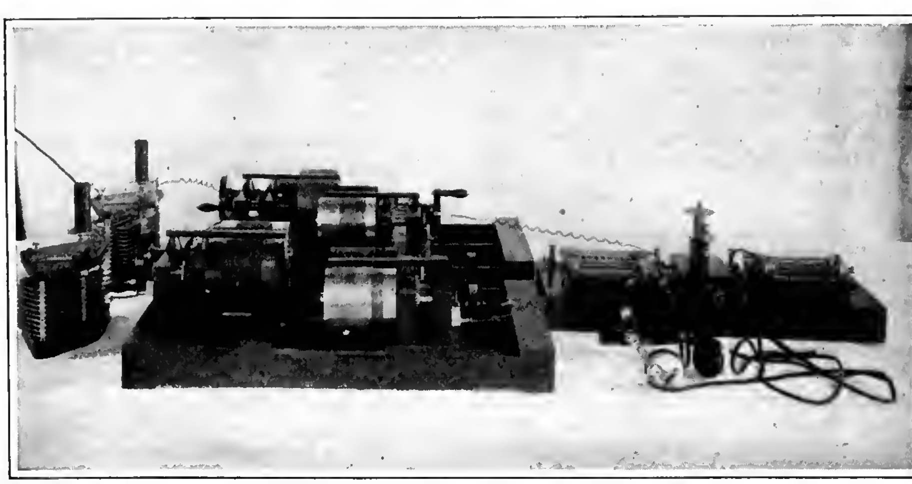
THE Federal Trade Commission proposes to broaden the scope of its investigation of the radio combination, amending its formal complaint against the radio group by adding the following charge:

The defendants have: "8. Substantially lessened competition and tended to create a monopoly in the sale in commerce of unpatented parts of chassis, and of unpatented consoles and cabinets, and of other unpatented parts of radio devices," etc. etc.

THE Mackay interests have acquired the famous transatlantic station at Sayville, Long Island, which they will use in ship-to-shore service. Another station for the same purpose is planned somewhere near Norfolk. The system is already operating stations in San Francisco, Los Angeles, and Portland on the Pacific Coast and expects by next summer to have transpacific service to Honolulu and the far east.

THE National Better Business Bureau collected advertising literature at the Radio Show in New York last September and analyzed the inaccuracies and violations of their standard code of radio ethics and advertising practice. They found 232 inaccuracies, of which 39 per cent. were violations of their Rule 4 which calls for the accurate naming of cabinet woods. Twenty-six per cent. violated Rule 2-B, which provides that price quotations state clearly whether the offer includes accessories or not. Sixteen per cent. disregarded Rule 8 which holds that superlative claims lack selling force. The fact that only 58 complaints were investigated during the year 1927, as against 123 in 1925, is taken as an indication of the coöperation which has been extended by the radio industry in the work of the Bureau.

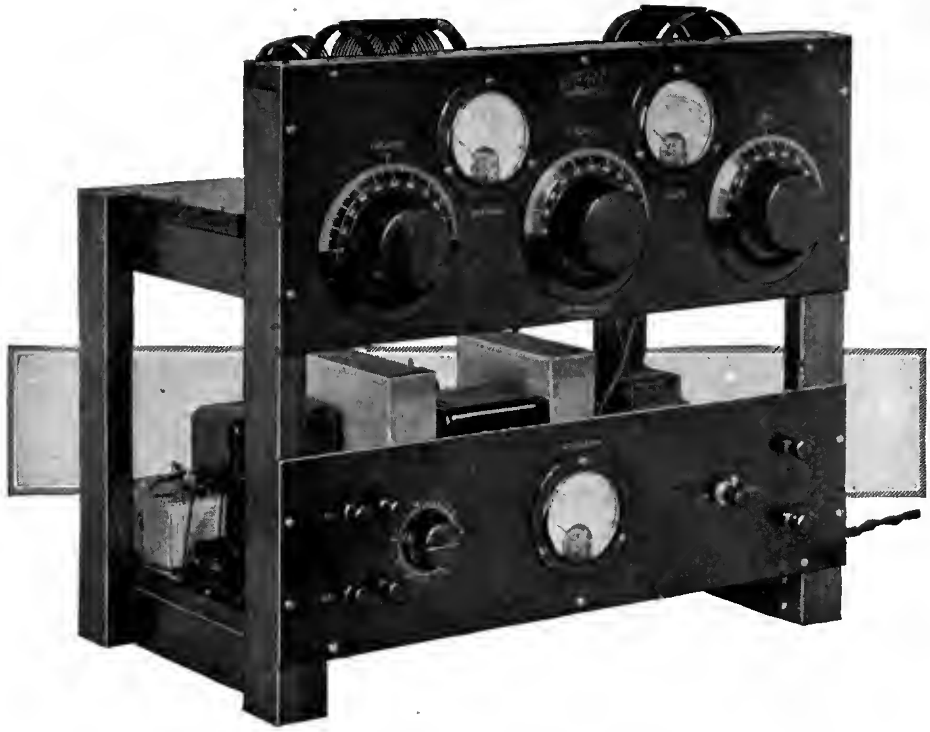
THE International Radio Telegraph Conference has adopted a new schedule of "Q" signals and, in addition, has recognized a number of one-, two- and three-letter combinations, some of which have been widely used but did not heretofore have the stamp of official approval. Prominent among these is the adoption of CQ as the general calling signal, replacing the three-letter combination QST. Some changes were made in the assignments of alphabetical groupings to the various nations from which each assigns call letters to the radio stations under its jurisdiction. The United States, hereafter, will have the entire letter K combinations at its disposal, instead of only a part, as well as the entire range of N and W calls.



—*Courtesy J. V. L. Hogan*

AN EARLY FESSENDEN RADIO RECEIVER

It was "wireless" in those days, however. The antenna and ground circuits enter on the left, through the variable air condensers; the four drums, wound with wire, and each with its handle, illustrate the ingenious method of continuously varying the inductance of the closed circuit; the crystal detector and headset are on the extreme right



THE TRANSMITTER IN ITS FINAL FORM

By the mere throwing of a switch, it may be used for either c.w. or phone signals. It has covered a thousand miles with phone signals during its tests, although this figure is somewhat high to expect for regular work

A Short-Wave Phone and C. W. Transmitter

By Kendall Clough

WITH appetites whetted by the remarkable expanse of their eavesdropping, consummated with the simplest of equipment, the broadcast listener who became interested in short-wave reception, satisfied his curiosity, and listened half way round the globe, is now ready for new fields to conquer. The logical outlet for his enthusiasm lies in the construction of a transmitter, for it is provoking to hear a fellow a thousand miles away pounding out a crystal-clear message, terminating such with a remark to the effect that "I'm using a single 201-A, OM," and not to be able to answer him back, and report a better "watts-per-mile" record.

To supply the demand created by this growing enthusiasm, several well-known parts manufacturers have coöperated in the design of a short-wave radio telephone transmitter which can be built for about the same cost and with the same ease as a good receiver constructed for the reception of broadcasting. While this design is of a low-power type transmitter, it has been repeatedly demonstrated that the power is sufficient to carry on conversations over surprising distances. It will be noted from the photographs that the manner of construction permits the isolation of all the parts carrying radio-frequency currents on the upper "deck," or shelf, while all the circuits associated with the power or voice currents are on the lower "deck." This form of construction insures that the masses of metal contained in power devices, such as transformers, condensers, etc., will not be in the fields of any of the radio-frequency coils, since this would introduce losses therein. Corresponding to the arrangement of the circuits in decks, the front controls are also grouped. Thus, on the upper panel we have the controls for the tuning condensers, the antenna-current meter, and the plate-current meter for the oscillator tube. On the lower panel we have the plate-current meter for the modulator tubes, the modulator C bias control, the switch for changing from telegraphy to telephony, and the necessary binding posts for the key, microphone, and battery. The circuit diagram of the transmitter is shown in Fig. 1. That portion of the circuit shown on the upper "deck" is the justly famous tuned-grid, tuned-plate circuit, which has been in use for several years. This circuit employs a series feed for the plate voltage to the oscillator rather than the shunt feed ordinarily used. In this way an already efficient oscillator circuit has been improved by eliminating those losses in the choke coil that are bound to occur when using shunt feed. Naturally enough any losses eliminated in the choke coil result in additional energy being available for actual transmitting purposes.

Considerable voltage is developed between the plate coil and the ground by this method, so that it is necessary to use two condensers in series (C_8 in Fig. 1) as an r.f. bypass. An r.f. choke, L_4, serves to keep the radio-frequency currents from finding their way down to the lower "deck."

The power supply consists of a Silver-Marshall 328 transformer, T_1, which supplies the plate current as well as lights the filaments of the oscillator and modulator tubes. In order to secure direct current, which is necessary for phone operation, the high voltage of T_1 is rectified by means of a gas tube, and filtered with a Silver-Marshall 331 Unichoke, L_5, and Tobe condensers, C_6, and C_7. It will be noted that two modulator tubes, V_2 and V_3, are used in conjunction with one oscillator, V_1, of the same type. This is in accordance with the best practice and while the set is perfectly operable with only one modulator, it is recommended that two be used where the best quality of transmission is desired. The modulator tubes and the oscillator tube are all of the CX-310 (UX-210) type.

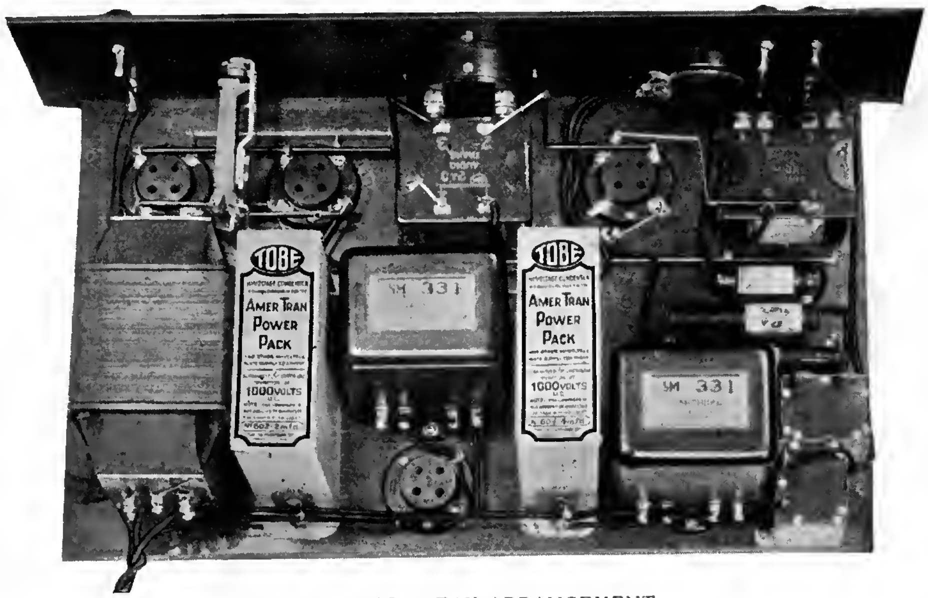
In order to operate the modulator tubes at maximum capacity, it is necessary to amplify the output of the microphone transformer to bring the speech to the proper volume level. This amplification is accomplished by means of a CX-312 (UX-112) tube, V_4, and a Silver-Marshall 240 transformer, T_2. The proper C and B voltages for the CX-312 are secured from the power supply by means of the resistors R_4, R_5, and R_6, the latter supplying the C voltage for this tube. During the preliminary experimental work a CX-326 (UX-226) was used in place of the CX-312 and was lighted from the power transformer. In view of the fact that a 6-volt battery was necessary for the operation of the microphone, however, the same battery was finally used to light a CX-312 instead of the a. c. tube, since a quieter signal from the transmitter resulted.

DETAILS OF ASSEMBLY

THE construction of the transmitter may well commence with the lower "deck" as this unit must be assembled and wired before the work is started on the upper structure, otherwise the latter will hinder the wiring. The lower deck is shown separately in an accompanying illustration. The board for this assembly is screwed to the cleats below, and the screw holes for the equipment are located with the aid of the full-size template supplied with the foundation unit specified in the list of parts.

After screwing down the parts for the lower "deck" and wiring them in accordance with the circuit diagram, the lower front panel and the equipment on it should be screwed in place as shown, after which the wiring of the lower "deck" may be completed. This unit may be tested separately before proceeding with the work. In order to do this the unit is connected, as it would be in operation, with the microphone, storage battery, etc., and the switch on the panel is thrown to the "Phone" position. Most of the resistance, R_3, should be in circuit. The tubes should all light properly and the needle of the modulation meter, M_3, should jump up when the microphone is spoken into. Now, to check the quality, a loud speaker should be connected across the modulation choke, L_6, by means of a long cord leading into another room. It may be necessary to shut the door between the rooms in order to keep the loud speaker from transmitting acoustical energy to the microphone and setting up a continuous howling noise. When the equipment on the lower deck is operating properly, the microphone speech input as heard by another observer at the loud speaker, should be very clear and distinct. The resistance, R_3, should be adjusted during the test until speech is at its clearest point, at which time the modulation meter will indicate from 20 to 30 milliamperes.

The equipment on the upper "deck" should now be assembled from the template and diagram in the same manner as the lower "deck" was, after which the whole frame (supplied with the foundation kit) may be put together with wood screws. The upper panel, with its equipment, should be attached last. The wiring is next completed in accordance with Fig. 1.



THE LOWER DECK ARRANGEMENT

The circuits associated with the power or voice currents are located on this deck. The two-deck arrangement prevents losses which would otherwise occur

LIST OF PARTS

M_1 Weston Model 425 Thermoammeter, 0-1 Amp.	$13.50
M_2 Weston Model 301 Milliammeter, 0-100 Mils.	8.00
M_3 Weston Model 301 Milliammeter, 0-50 Mils.	8.00
L_1, L_2, L_3 Aero Short-Wave Transmitting Coil Kit (2040K, 4080K, or 9018K)	12.00
L_4 Aero 248 Radio-Frequency Choke (Included with Above)	—
L_5, L_6 S-M 331 Unichokes	16.00
C_1 Cardwell 0.0005-Mfd. Condensers	15.00
C_2 Polymet 0.002-Mfd. Moulded Condensers	.80
C_3 Polymet 0.0005-Mfd. Moulded Condensers	.70
C_4 Polymet 0.00025-Mfd. Moulded Condenser	.35
C_5 Tobe 2-Mfd. 300-Volt Condensers	2.50
C_6 Tobe 2-Mfd. 1000-Volt Condenser	3.50
C_7 Tobe 4-Mfd. 1000-Volt Condenser	6.00
C_8 Tobe 1-Mfd. Condenser	.80
R_1 Yaxley 810-Type 10-Ohm Resistors	.60
R_2 Polymet 10,000-Ohm 10-Watt Resistor	.75
R_3 Yaxley 2000-Ohm Potentiometer, No. 2000	1.75
R_4 Polymet 25,000-Ohm 10-Watt Resistor	1.25
R_5 Polymet 15,000-Ohm 10-Watt Resistor	1.00
R_6 Polymet 750-Ohm 10-Watt Resistor	.75
R_7 Yaxley 1.5-Ohm Resistor, No. 2L	.15
R_8 Yaxley 100-Ohm Resistance, No. 8100	.25
T_1 S-M No. 328 Transformer	18.00
T_2 S-M No. 240 Transformer	6.00
T_3 S-M No. 242 Transformer	7.00
S_1, S_2, S_3 Yaxley 2-Pole Switch, No. 63	1.60
Five S-M No. 511 Tube Sockets	2.50
Aero Transmitter Foundation Unit (Consists of drilled and engraved Westinghouse Micarta upper front panel, 7 x 18 x 1/4 inches, drilled and engraved lower front panel, 5 x 18 x 1/4 inches, seasoned walnut lacquered frame kit cut to size for making a stand 16 x 18 x 10 1/4 inches, with all screw holes drilled that are necessary to put framework together, wiring diagram, and layout sheet.)	27.00
No. 159 Frost Desk Microphone	8.75
TOTAL	$164.50

ACCESSORIES

V_1, V_2, V_3	CX-310 (UX-210) Tubes	$ 27.00
V_4	CX-312 (UX-112) Tube	3.50
V_5	Manhattan No. 2721 Gas Rectifier	7.00
	Transmitting Key	1.50
Three Four-Inch Bakelite Dials		1.50
Six Binding Posts		.90
	TOTAL	$41.40

Since the accompanying photographs were taken, a "key click" filter, consisting of a 1-mfd. Tobe condenser, C_8, in series with a 100-ohm Yaxley resistor, R_8, has been connected across the key terminals as shown in the circuit diagram. Space is available for these items on the baseboard just behind the key binding posts. Its use will be appreciated by near-by broadcast listeners, who otherwise would hear the key clicks in their receivers.

The set should be tested to insure that it oscillates properly. The plug is inserted in the 110-volt 60-cycle light socket and the switch is thrown to the c.w. side. This should leave only the oscillator tube lighted and, on shorting the "key" binding posts, current will be indicated in the plate meter. Probably this current will cause almost a full-scale deflection but by varying the plate or grid condensers it will snap back to 20

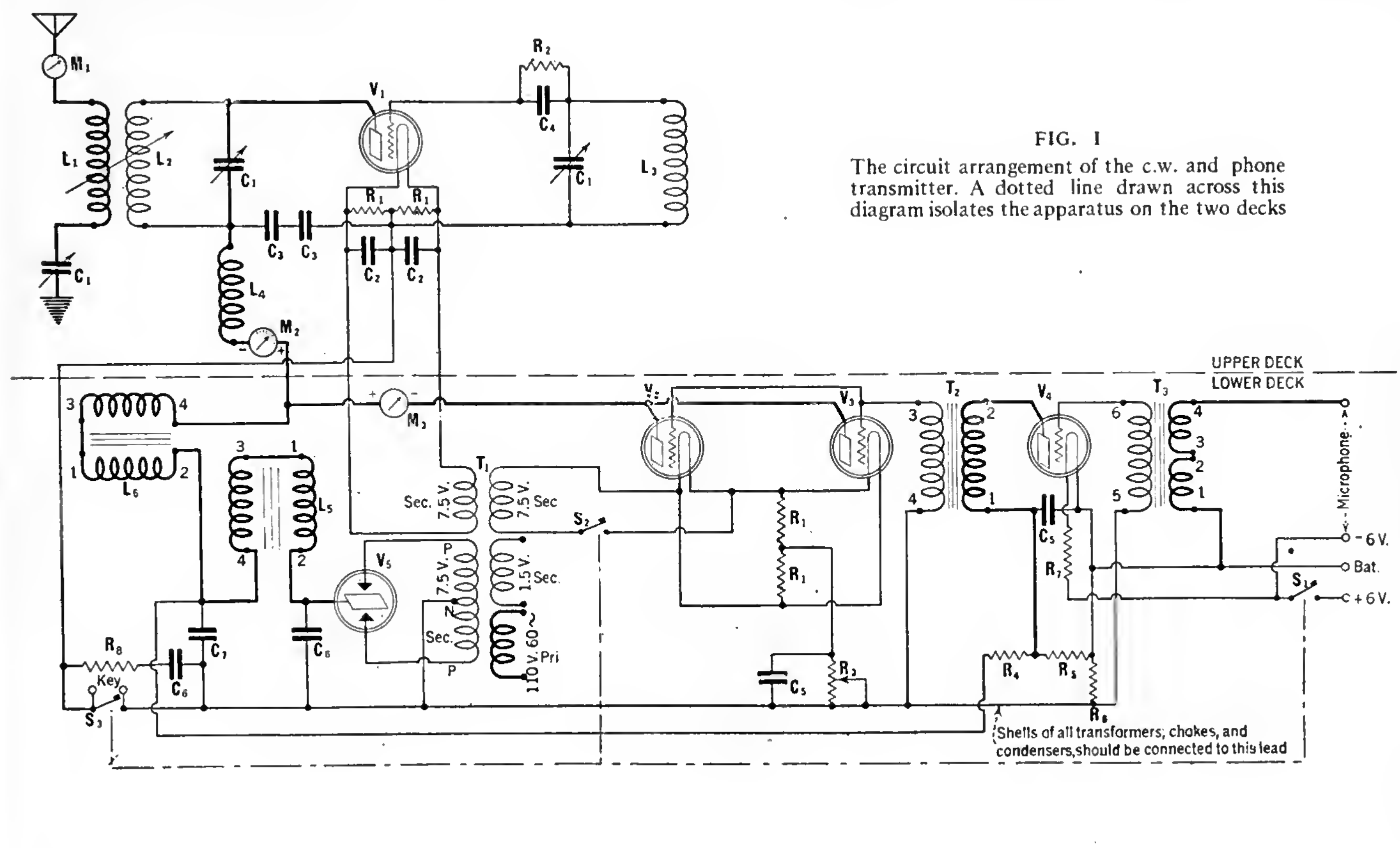
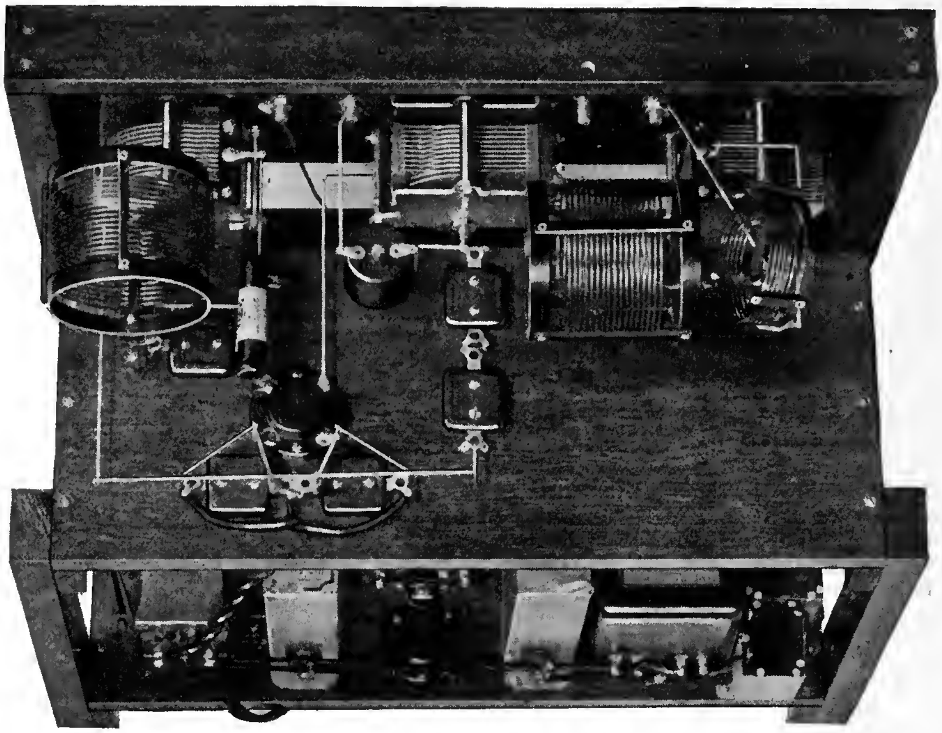


FIG. 1

The circuit arrangement of the c.w. and phone transmitter. A dotted line drawn across this diagram isolates the apparatus on the two decks or 30 milliamperes at a certain point, indicating that the tube is oscillating. On connecting an antenna and ground, and tuning the antenna condenser, this reading will be increased when resonance is obtained, and at the same time some antenna current will be noted. If the coupling is too close the tuning of the antenna will tend to throw the tube out of oscillation and it will be necessary to loosen somewhat the coupling between the hinged primary coil and the plate coil (L_1 and L_2).

Final tuning should always be done with a wavemeter in order that transmission may be within one of the bands licensed by the Government. One of the features of the transmitter is, however, that due to the interchangeable coil feature, the set may be tuned to any wave between 18 and 180 meters so that it is not rendered unserviceable by any slight changes in wavelengths granted by the Government. The transmitter may not be used, of course, unless the operator has a license which permits him to do so.

Space does not permit us to go into the antenna construction, operating methods, etc., at this time, and the reader is referred to *The Radio Amateurs' Handbook*, published by the American Radio Relay League, Hartford, Connecticut, for excellent information along this line. This transmitter is now in operation at 2 GY, the RADIO BROADCAST station at Garden City, New York, and there is also a similar one now working at the Aero Products station located at Chicago and the results that have been obtained in a limited time are very gratifying. With c.w., on the 40-meter band, all U. S. districts have been worked from Chicago as well as NC 5ZZ in Vancouver, British Columbia. Twenty-meter phone work has been unusually successful. The following stations have been worked on 20-meter phone with reports varying from R-5 to R-7: 1 BBM, Harwich, Massachusetts; 1 ASF, Medford, Massachusetts.; 1 SW, Andover, Massachusetts; 2 BSC, Glen Head, New York; 3 AKS, Philadelphia; 4 MI, Asheville, North Carolina; and 8 CVJ, Auburn, New York. In all cases where the transmission has been on phone, the quality of the speech has been reported to be very fine. Even greater distances have been worked on code with the transmitter located at Garden City.



A PHOTOGRAPH OF THE UPPER DECK

All the equipment carrying radio-frequency currents is mounted on this deck. Fig. 1 will clearly show just what equipment is placed on this deck

FOR CODE WORK ONLY

MANY amateurs are interested in c.w. transmission to the exclusion of phone. In such cases the transmitter may be constructed for that purpose only at a substantial saving in parts. The conversion requires simply the omission of the parts that are necessary for phone operation since the transmitter described here is an ideal c.w. transmitter in itself.

The circuit diagram of the outfit wired for c.w. only is shown in Fig. 2.

The values of the parts shown in Fig. 2 are exactly the same as those of the parts in Fig. 1. The only addition is the inclusion of R_9 in the second diagram. This is a 50,000-ohm Polymet resistor of 10 watts carrying capacity. It lists at $1.50, and is used to prevent the voltage on the final filter condenser from rising to an unsafe value when the key is up.

As it will be noted in the above list of parts, there are three distinct sets of Aero coils available for transmitting purposes. The most popular kit is the 4080K, which covers a wavelength range of 36 to 90 meters (8330 to 3330 kc.). The 2040K kit covers the band between 18 and 52 meters (18750 and 5770 kc.). The No. 9018K kit is suitable for the band between 90 and 180 meters (3330 and 1670 kc.).

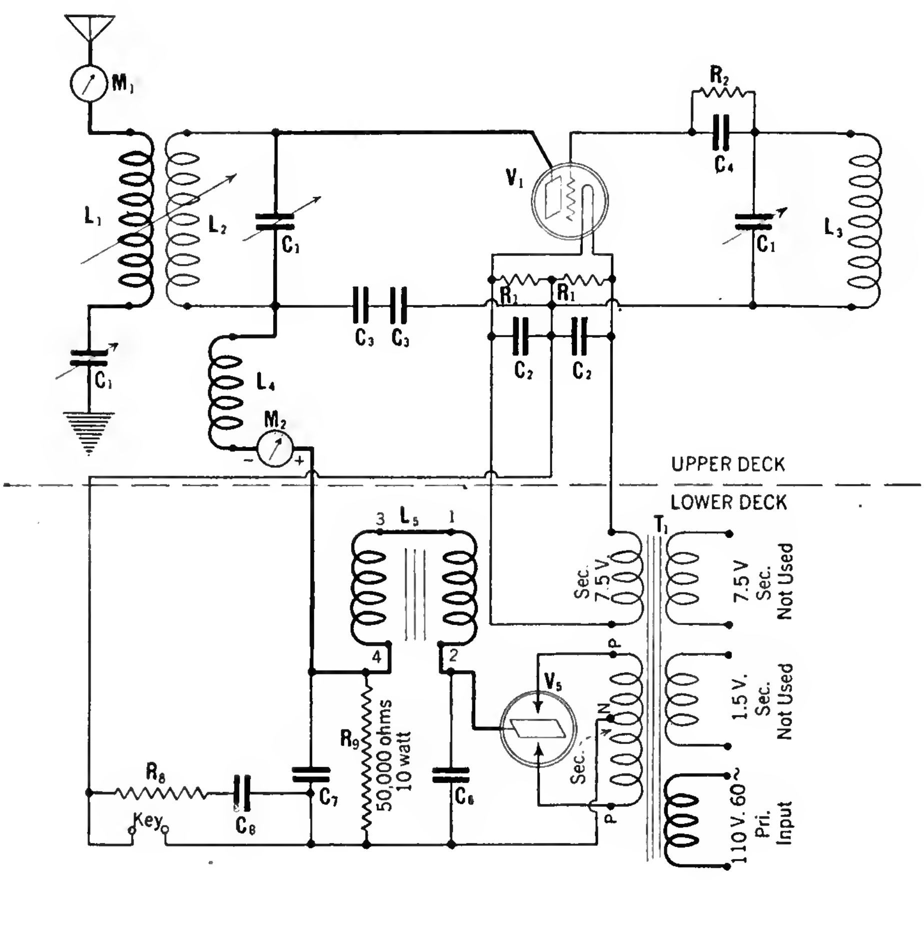


FIG. 2

Here is the transmitter circuit diagram for the experimenter who wishes only to transmit c.w. signals. The upper and lower deck feature, it will be seen, is still maintained

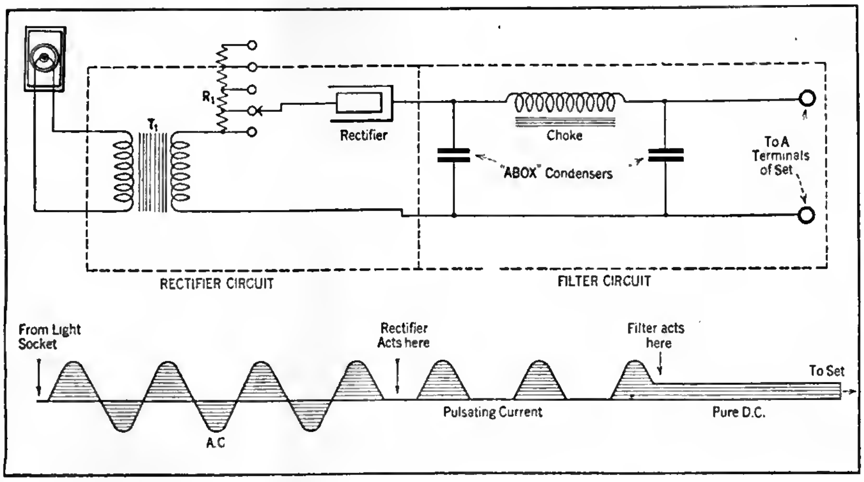
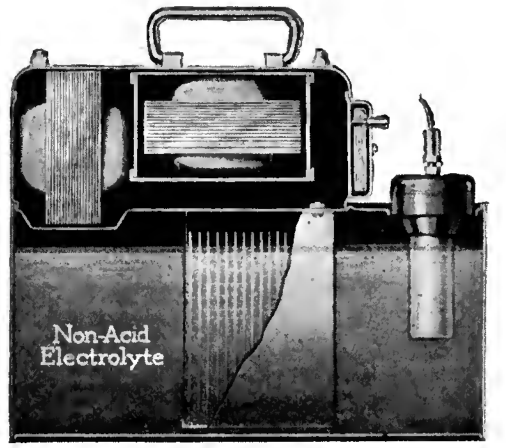


FIG. 1: THE CIRCUIT OF THE "ABOX" UNIT



A SECTIONAL VIEW OF THE "ABOX"
Its circuit arrangement is given in Fig. 1

Electrification Without A. C. Tubes

By Lewis B. Hagerman

"JUST push the plug into the light socket," is the answer most radio set users would like to give to the query: "How do you turn on your radio receiver?" In this classification, so many believe, are included only those receivers using a.c. tubes, and so when they go out to buy an "electric" receiver, they examine it to be sure that it uses a.c. tubes. Also, when they consider converting their battery-operated sets for a.c. operation the problem to most of them becomes one of adapting the set to use a c. tubes. It is possible, however, to electrify a receiver in another way which is frequently much easier to accomplish and generally just as satisfactory. We refer to the use of accessories in conjunction with a receiver originally intended for battery operation so that the equivalent of light socket operation is obtained without the substitution of new tubes.

Electrically there is practically no difference in the operation of a receiver from a.c. tubes or from storage battery type tubes in conjunction with an external A power unit connected to an a.c. source. With a.c. tubes we supply a.c. power either directly or indirectly to the electron emitting surface which then emits electrons. With d.c. tubes we supply a.c. power first of all to a rectifier which in turn supplies power to the filaments, and these become hot and their surfaces then emit electrons. In neither case does the current in the filament enter directly into the operation of the tube; it is merely the agent which causes the electron emitting surface to become hot. Socket power operation is a means of eliminating the problems associated with the *storing* of electric power for the operation of the receiver, such as by means of a storage battery, and any method which enables us to do this implies direct operation of the receiver from the power mains. If you want to electrify your receiver, you can do it by using a good B power unit and a reliable A power unit, such as the "Abox."

Many of RADIO BROADCAST's readers are at present obtaining plate voltage for the operation of their receivers from a B power unit and, therefore, a socket power A unit will complete the electrification of the receiver. When the plus and minus terminals on the "Abox" unit are connected to the corresponding A terminals on the receiver and the power lead is plugged into the light socket, there will be available, from the "Abox" unit, a source of filament current, and from the B power unit, a source of plate voltage, both obtained directly from the light socket.

Electrically, the problems associated with the design of a satisfactory A power unit are similar to those connected with the design of a B power unit. In both cases the problem is to take alternating current power from the light socket and rectify and filter it so that it will be satisfactory for the operation of the receiver. The problem in the design of an A power unit is that it must deliver large amounts of current, which necessitates a great difference in the values of the constants incorporated in a proper rectifier and filter unit, as opposed to those of a B power device.

An A supply unit must deliver at least two amperes to be universally adaptable to most receivers and this value of current is approximately one hundred times the output in amperes of a low power B device. As the current to be handled increases, the capacity of the filter condensers must also be increased in direct proportion, which will be about 100 times, and it is only recently that large capacity condensers of reasonably small physical dimensions have been commercially available at a low price.

Then we have the voltage factor. A given condenser stores more power the greater the voltage; at one hundred and fifty volts, therefore, it will store much more energy than at six volts. To compensate this, the capacity of the filter condenser must be increased in proportion to the difference in voltage, or another twenty-five times. Since the A device delivers current to the filament circuit, any hum will tend to effect the grid bias and be amplified by the tube. The capacity of the filter condensers must be increased about seven times to offset this effect.

Thus it will readily be understood that the filter condenser of an A power-supply device must be one hundred times twenty-five times seven times, or 17,500 times, as great as that used in a B device. The capacity of a B filter condenser is about 4 microfarads; the capacity required for an A power unit is, therefore, in the neighborhood of 70,000 microfarads.

To obtain this the "Abox" Company developed a condenser consisting of a number of nickel and iron plates immersed in a caustic potassium solution, which is not an acid. This solution causes thin films of oxygen and hydrogen to form on the surface of the plates, and these films constitute the dielectric of the condenser. The caustic solution is one side of the condenser while the plates form the other.

Since the capacity of a condenser increases as the thickness and amount of dielectric decreases, this infinitesimally thin gas film is responsible in part for the tremendous capacity obtained.

This film has several advantageous features. Should an excess voltage be impressed on the condenser, the film immediately breaks down and bypasses the excess energy. When the output returns to normal, the film forms again, and the condenser is as good as new. The bugaboo of burnt-out condensers is thereby done away with.

The capacity of the condenser is far in excess of that required; it has been estimated that its capacity is in excess of 200,000 microfarads. When used with the "Abox" rectifier, it reduces the alternating component of the input pulsating d.c. to less than $\frac{1}{3000}$th of its original value.

Both the rectifier and condenser work in the same solution. The addition of distilled water every six months or so is the only maintenance needed. The condenser plates are never affected by use or disuse, and the rectifier electrode has a life of several years and can be replaced in a few seconds at a very low cost. The tapped resistance, R_1, which compensates for the number of tubes used is adjustable from the front of the unit.

Fig. 1 shows the circuit of the complete eliminator. The alternating current from the house lighting circuit is stepped-down from 110 volts to the proper low voltage by the transformer, T_1. The current then flows through the rectifying valve which will pass current in one direction only, thereby eliminating one phase of the alternating current and creating a pulsating direct current. It is next passed through the filter circuit, where it is smoothed, and all variations and pulsations in current are removed. The drawings at the lower part of this diagram show the effect of the rectifier and filter on the alternating current. The rectifier changes the alternating current to pulsating direct current by eliminating one phase of the a.c. wave, and the filter then smooths out the pulsating current, producing practically pure direct current. When this A power unit is used in connection with the average receiver, it will not cause any hum.

A "HUDDLE" IN ONE OF THE VICTOR TALKING MACHINE COMPANYS STUDIOS FOR RECORDING, OLD STYLE

How Radio Developments Have Improved

THE electromagnetic phonograph reproducer, also often simply called the "unit" or "pick-up," is acquiring great popularity nowadays on account of the tie-up it creates between the radio receiver and the phonograph. When static is bad, or when radio programs are not to one's taste, it becomes a simple matter to change over to the phonograph and enjoy the best or the worst in musical art, according to the choice of the person who purchases the records.

On the other hand, since most of us are able to afford only a limited number of phonograph records, and must play them many more times than once in order to realize on our investment, such repetition occasionally palls, as it were, and we turn to the "air" to supply us with programs new to our ears.

Although there are a great many "pick-ups" already on the market, and more are coming on every day, their commercial exploitation is relatively new. The development of a new device requires the simultaneous development of a technic particularly suitable to it. At this early stage of the development, it is not to be expected that all those who design reproducers know everything about them, and it must also be remembered that many of those who are working on the problem are radio engineers, and are not versed in the phonographic art.

On the other hand, although the electric reproducer is new to the radio public, it is not by any means new to engineers. The writer remembers a demonstration of a piezo-electric reproducer which he witnessed in New York as far back as 1921, and the engineer who developed this reproducer had been working on it for a period of several years before. Electromagnetic pick-ups are likewise fairly old in the art, as also is the capacity type of pick-up, but the advent of these devices for practical and commercial application had to await the development of suitable amplifiers and loud speakers.

There are quite a few phases of the art to consider. These may be listed as follows:

Recording
- Method of sound pick-up (horn, microphones of various types).
- Method of actuating cutting head.
- Amplification

Reproducing
- Type of pick-up (capacity, piezo-electric, carbon, electromagnetic).
- Amplification.
- Conversion into sound (type of loudspeaker)

This list outlines the complete process from beginning to end, which we will describe briefly in the next few paragraphs.

At the recording studio we have a band, orchestra, singers, or other artists furnishing the original music. The sound waves of this music are collected by a horn, in the old "air-line" method of recording, or by a microphone in the newer system of "electrical" recording.

In the "air-line" method, the sound waves, entering the collector horn, were concentrated in it, so that sufficient energy could be obtained for actuating a diaphragm, to which was rigidly fastened a "cutting-head." Under this cutting-head traveled the wax disk known as the "matrix," on which the cutter engraved waves corresponding to the sounds entering the horn. Naturally, the power available for driving or actuating the diaphragm which carried the cutter was limited to that which could be collected from the original sounds in the studio.

In order to obtain sufficient power for cutting the record, it was necessary to use a resonant diaphragm, so that at the outset we have two inherent difficulties in the air-line system of recording; in the first place the horn which collected or concentrated the sound waves was a cause of distortion, due to its "resonance" at various frequencies, and, secondly, the same was true of the diaphragm, which was made resonant in order to operate the cutter satisfactorily.

These difficulties are avoided in the electrical system of recording, in which the sound waves operate directly on the diaphragm of a microphone. The energy pick-up of this microphone is, of course, exceedingly small—much smaller than that picked up by the collector horn in the old system—but the advantage lies in the fact that since the microphone converts the energy of the sound waves into corresponding waves of electric current, it is possible to amplify them to any degree we might desire. On this acount distortion need not be permitted at the outset, *i. e.*, as in a horn or resonant diaphragm. On the other hand, we run into the difficulty of distortion in the amplifier or in the microphone.

This is what we referred to previously when we stated that the development of electrical recording and reproducing had to await the development of the amplifier. To-day we can build amplifiers having negligible distortion, and the microphone, collecting such a small amount of power and having no extended surfaces, is inherently far superior to the collector horn of the old system. The main advantage of the "air-line" system of recording and the old method of reproducing, is simplicity. The new electrical systems show to greatest advantage in the recording, for it must be understood that very good quality is obtainable in reproducing by the old system when slowly expanding exponential horns are used in which the resonances have been reduced and the range of response has been extended to include the lower tones. But good reproduction by the old method requires that the recording be done properly, so it is here that the electrical system is especially valuable.

VOLUME CONTROL

ANOTHER feature of the electrical system which is of great importance is the ability to control the volume of reproduction. The phonograph record is a form of mechanical power amplifier, deriving its power to amplify from the motion of the turntable which carries the record. We can understand how this is by considering the old "air-line" system. The acoustic power con-

HOW A VICTOR RECORD IS MADE NOWADAYS. FOOTBALL TACTICS HAVE BEEN FORGOTTEN, AND BETTER RECORDS RESULT

Recording and Reproducing—By Sylvan Harris

centrated in the collecting horn and which actuates the diaphragm to which the cutter is attached is very small. After the record is made and is being run on the turntable under the needle of the pick-up, it is the motion of this needle, caused by the rotation of the disk, which furnishes the sounds which come out of the horn. In other words, the power which drives the disk causes the needle to vibrate in the grooves of the record. The waves themselves, in the grooves of the record, furnish no power. It is only the motion of the record which furnishes the power.

We have a very analogous situation in an amplifier; a voltage is impressed on the grid of the amplifier tube, but this voltage is not power. It is only due to the influence of this voltage on the power furnished by the B supply that an amplified reproduction of it occurs in the plate circuit. The alternating grid voltage is similar to the waves on the record; the power of the B supply is analogous to the power in the mechanism which drives the record.

In spite of the inherent amplification in the phonograph record, this amplification is not always sufficient when there are wide ranges of volume in the original music. It is also difficult to obtain all the volume that one might desire for ordinary purposes without introducing considerable distortion, unless electrical amplification supplements the mechanical amplification of the record. First we must amplify the weak output of the microphone, because the microphone pick-up is so small. Yet we must not amplify too much, for we run into other difficulties of recording, as, for instance, where the cutter cuts through from one groove to the next, or where distortion arises in the cutting apparatus.

This brings us to the next phase of the subject—the cutter. This is a specially ground amethyst set into the end of a rigid rod or bar, which, in the old system, was attached to the middle of the diaphragm at the throat of the collector horn. When the diaphragm was set into vibration by the sound waves in the studio, this bar and the jewel at its end were likewise set into vibration. The jewel, cutting a groove into a heavy wax disk (the matrix), at the same time cuts waves in either the walls of this groove or at its bottom, depending upon the particular construction of the cutting-head, as it is called.

There are two methods of cutting—the "hill-and-dale" cut and the "lateral" cut. In the hill-and-dale method, the cutter vibrates up and down in the groove, so that there are "hills" and "dales" at the bottom of the groove. This was the original method used in the phonographic art, and is hardly ever used nowadays. It has been superseded by "lateral" cutting, in which the cutter is made to vibrate "laterally," or from side to side. The result is that the groove cut in the wax, while circular around the center of the disk, is at the same time wavy. We will not discuss the advantages and disadvantages of the two methods here; they are mentioned merely to acquaint the reader with the general ideas involved.

In either case the vibrating bar of the cutting-head is connected (generally through a system of levers) to an armature (in the electrical system) which is actuated by an electromagnet. This electromagnet obtains its power from the amplifier, the input of which is connected to the microphone. The principle of the cutter is the same as that of a loud speaker, excepting that instead of having a cone for the load on the armature, we have the jewel cutting into the wax.

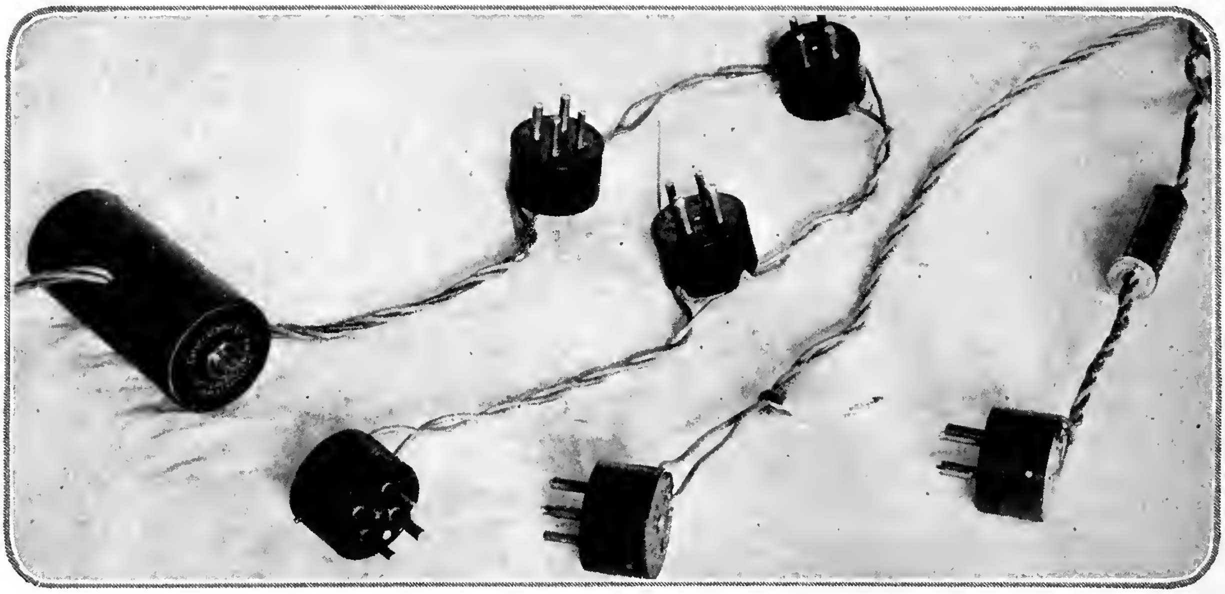
So, in the electrical system of recording we have first the microphone, which may be any one of several types, next, the amplifier, which may also be any one of several types, and finally, the cutting-head, which includes an electromagnet for actuating the armature to which is attached the cutter. There is no standard design of cutting-head, the type used often being the arbitrary choice of the man who does the recording, and the design often being his own. The design of the cutting-head is, however, extremely important, the success of the whole system depending to a very great extent upon it, not so much perhaps, upon the electrical part of it as upon the mechanical arrangement of the levers, the damping of the movable parts, the shape of the cutting point, the depth of the cut, etc.

We will now skip over the actual making of the records for this is a mechanical process; in this article we are considering only the electrical features. Suffice it to say that from the large, thick wax disk (the matrix) upon which the cutting is done, a "master" is made, and from this master any number of impressions can be made, resulting in the records as they reach the music store.

In the old system of reproduction the vibration of the needle in the grooves of the record actuated a diaphragm of mica or other material, which directly communicated the energy of vibration to the air column of a horn of one type or another. In the newer electrical method power is communicated to the needle by the rotation of the turntable in the usual manner, but now, instead of driving a diaphragm, the needle drives an armature located in the magnetic circuit of a permanent magnet. A coil is also connected in the circuit so that the variations of the magnetic flux caused by the vibration of the armature induce fluctuating voltages in this coil, and these can be impressed on the input of an audio amplifier, the output of which is connected to a high-grade loud speaker.

So we have a means of amplifying the "pick-up" from the record, and of controlling the volume, neither of which could be done by the older method of reproduction.

The main feature of the electrical system of recording and reproducing is the fine quality that can be obtained. Music obtained from old-style records by old-style methods of reproducing is greatly lacking in the bass notes, and sounds thin and hollow. Very fine quality can, on the other hand, be obtained by the new methods. The tie-up between the radio and the phonograph has turned out to be very successful indeed.



SIMPLE EQUIPMENT FOR UTILIZING A. C. TUBES WITH AN EXISTING RECEIVER
The photograph shows the various components—adaptors, C bias resistors, and cables—of the Carter a. c. harness

Electrifying Your Present Set

By Zeh Bouck

THE introduction of the alternating-current tube has stimulated something in the nature of a mild radio revolution. The advantages of a.c. operation—reliability and economy—in the majority of possible installations, are immediately obvious. This presents the problem of what is to be done with several-hundred thousand receivers of general efficiency, the only deficiency of which is their inability to be operated directly from an alternating-current source of a hundred and ten volts.

From an engineering standpoint this, of course, is merely a mechanical problem. Its solution was a simultaneous by-product of the a.c. tube itself. Any receiver in the world can be rewired for the use of a.c. tubes. In the majority of cases the changes are relatively few and simple. But the actual alteration of a radio receiver, particularly a commercial job, is repugnant to the average fan, and it was up to the manufacturers to provide

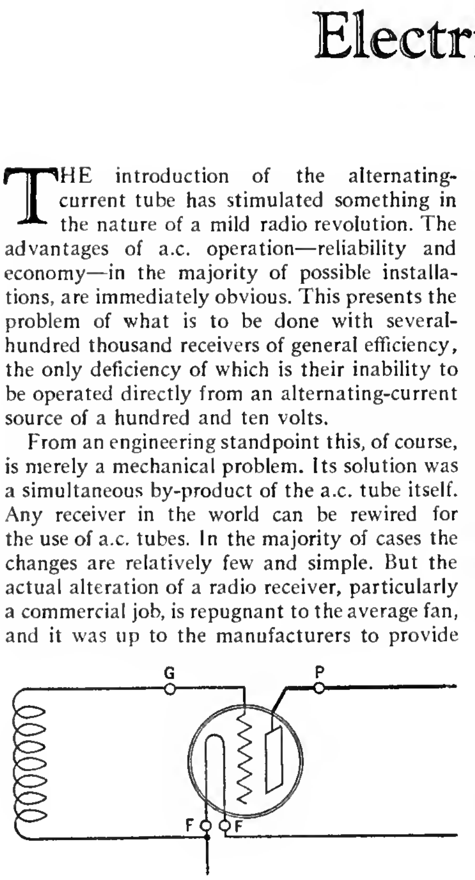


FIG. 1

suitable devices for the conversion of battery receivers with little or no alteration of the receiver itself. Almost simultaneously with the production of a.c. tubes—the Cunningham and R.C.A. 226 and 227 types, the Arcturus line, and a host of others—these desired devices appeared upon the market in numerous quantities.

By referring to Figs. 1 and 2 it is obvious that the mechanical and electrical requirements of the new tubes, in reference to receivers originally designed for battery use, can be satisfied by means of a simple adaptor, which will insulate the tube from the original filament terminals on the socket and at the same time provide two new filament or heater leads, and it was such adaptors that appeared on the market concurrently with the production of a.c. tubes. Fig. 1 indicates the familiar battery arrangement, while Fig. 2 suggests the electrical change effected by a simple adaptor. New filament leads have been provided for, while the former negative A post, to which the lower side of the grid coil or secondary is returned, remains open for biasing purposes.

The manner in which a typical adaptor fits between tube and socket is shown in the photograph, Fig. 3. The use of adaptors necessarily increases the effective height of the tubes which in some cases makes it necessary to slightly gouge out the covers of the receivers, before they can be closed, or with suspended tubes as in the Atwater-Kent Model 35, the receiver must be raised on short legs. In consideration of this occasional inconvenience, the Arcturus a.c. tube, designed for cable or "harness" use, obviates the necessity for the use of adaptors by means of two small screws, one on each side of the base, to which the heater leads are connected. The manner in which the Arcturus a.c. tubes and a.c. cable are mounted in the average receiver is shown in Fig. 4.

FOR the convenience of our readers we have collected together here the names of the manufacturers of apparatus for use in converting a receiver for a.c. operation. Many of these names are also mentioned in the text of the article although those of the manufacturers of filament-lighting transformers are an exception for they are not given specific mention in the article. Readers should realize that, to light the filaments of a. c. tubes, a step-down filament transformer is necessary, besides the adapters and harnesses mentioned in the article. A source of plate potential, and the necessary grid voltage are of course, also, required.

Manufacturers of A. C. Tubes:

Cunningham, R. C. A., Ceco, Arcturus, Sovereign, Televocal.

Manufacturers of Harnesses:

Arcturus, Carter, Eby, Naald, Cornish Wire, Harold Power, and Radio Receptor. The latter two companies sell combined A, B, and C power units and harnesses, as explained in the text.

Manufacturers of Filament Transformers:

Amertran, Dongan, General Radio, Karas, National, Samson, Silver-Marshall, Thordarson, and Ives.

"HARNESS" OUTFITS

THE use of adaptors alone solves only half the rewiring problem. The adaptors themselves have to be wired, so the majority of manufacturers producing adaptors are also providing

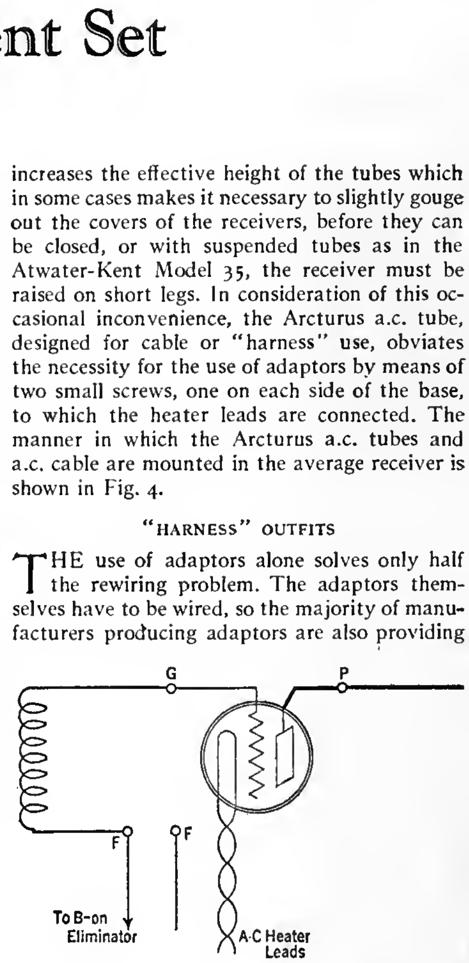


FIG. 2

connecting cables, usually referred to as "harnesses," in the form of braid-covered leads permanently connected to the adaptors. Other manufacturers sell the "harness" complete with an A, B, C power supply unit. Such devices are made in special and general types, prominent among which are those of the Radio Receptor company and Harold J. Power, Inc.

Radio Receptor makes three types of "Powerizers" (combining "harness," adaptors, and complete A, B, and C power supply outfit) designed especially for the Radiolas 20 and 28 and the Atwater-Kent models, which, however, are readily applied to an inclusive list of receivers.

Harold J. Power, Incorporated, manufactures an "A. C. Electrifier" which can supply A, B, and C potentials to any ordinary a.c. receiver. The filament potentials available are $1\frac{1}{2}$, $2\frac{1}{2}$, and 5 volts. Harnesses are available for electrifying the following receivers: Atwater Kent Model 35, Crosley "Bandbox" Model 601, Kolster 6, and universal harnesses for standard 5-, 6-, and 7-tube tuned radio-frequency receivers.

So far as the plain "harness" is concerned, we find that the Cornish Wire Company produces four types of "harnesses," all general designs, for five-and six-tube receivers with Arcturus a.c. tubes and for five-and six-tube receivers with the 226 and 227 type tubes.

The Arcturus Radio Company manufactures one general "harness" and six special "harnesses" or "a.c. cables," for use with the following receivers: The Freshman six-tube "Masterpiece," the Crosley "Bandbox," the Atwater-Kent models 30, 33, and 35, the Stewart Warner model 525, and the Kolster 6-D.

Other manufacturers of "harnesses," generally of a universal type and designed for R.C.A. and Cunningham type tubes, are given in the list on page 416.

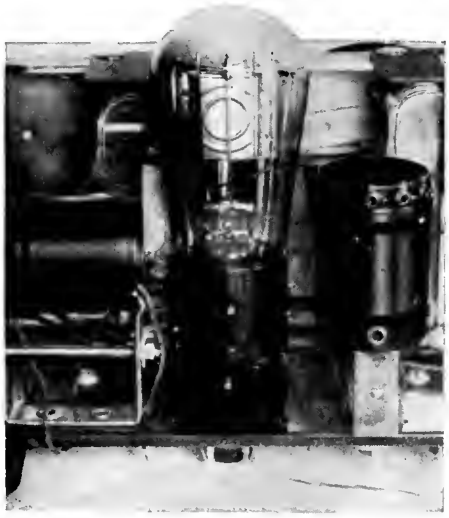


FIG. 3
A close-up showing how the adapter plugs into the existing socket and the a. c. tube into the adapter

equivalent substitute. The B and C potentials must still be supplied by either batteries, a power supply device, or a combination of the two. It is only by the use of a B and C socket power unit, in conjunction with a.c. tubes, that the receiver becomes completely electrified. For operation from a house lighting socket, the following apparatus may be used in combination with a battery receiver:

A.C. TUBES, PLUS:
(1.) Filament-lighting transformer, an efficient B power device, and the necessary resistors to supply two C potentials.
Or (2.) a combination power-supply outfit, combining the necessary a.c. and d.c. potentials in a single unit.

THE RECEPTRAD "POWERIZER"

THE Receptrad "Powerizer," mentioned before, is a fine example of a complete power unit. The description given here of the installation of a "harness" and "Powerizer" in an Atwater-Kent receiver is indicative of the general procedure. Details regarding the conversion of other receivers are contained in the direction sheets with the different harnesses and cables.

Fig. 5 illustrates the circuit arrangement of the "Powerizer." Rectification is effected by a UX-280 (CX-380). A 210 type power amplifying tube is an integral part of the "Powerizer," the input of which is fed from the secondary of the second audio transformer in the receiver itself. There is no audio transformer in the "Powerizer," as the diagram shows.

The resistors, R_1 and R_2, are particularly interesting, as the voltage drop across them supplies the C bias potentials to the power tube and

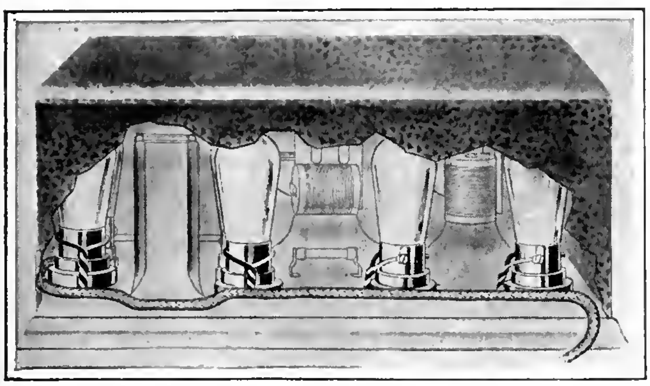


FIG. 4
The Arcturus tube, and a.c. cable installed in a hypothetical receiver. No adapters are required with Arcturus tubes

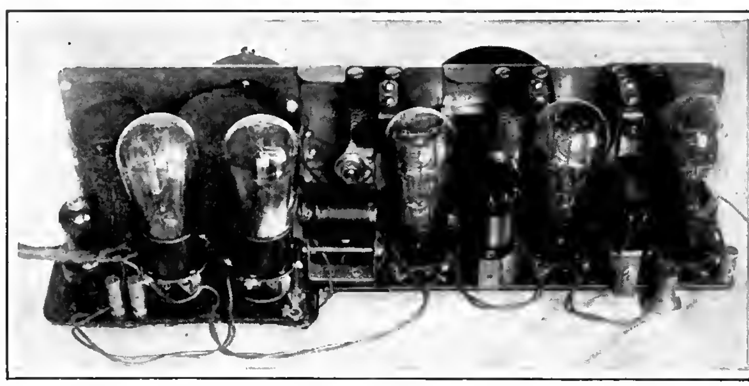


FIG. 6
An Atwater Kent model 35 receiver with a.c. tubes. The "Powerizer," shown on the next page, is used for power supply

VOLUME CONTROL AND ACCESSORIES

VARIOUS accessories are furnished with the "harness" outfits in accordance with the manufactuer's ideas of his obligations. In almost every instance some form of volume control applicable to a.c. circuits is included in the cable equipment, with the exception of such cases designed for particular d.c. arrangements already provided with an adequate control. The volume control generally consists of a specially tapered 0-to-25,000-ohm potentiometer, the element of which is connected across antenna and ground and the variable arm to the grid of the first tube. This type of volume control is easily attached.

Several manufacturers include C biasing resistors, center tap resistors, and bypass condensers, while others consider this auxiliary equipment a part of the power supply unit rather than a component of the adapting system.

COMPLETE ELECTRIFICATION

THE installation of a.c. tubes does not necessarily mean that a receiver is capable of being operated from the house lighting source without additional assistance. The use of a.c. tubes merely eliminates the A battery, or its

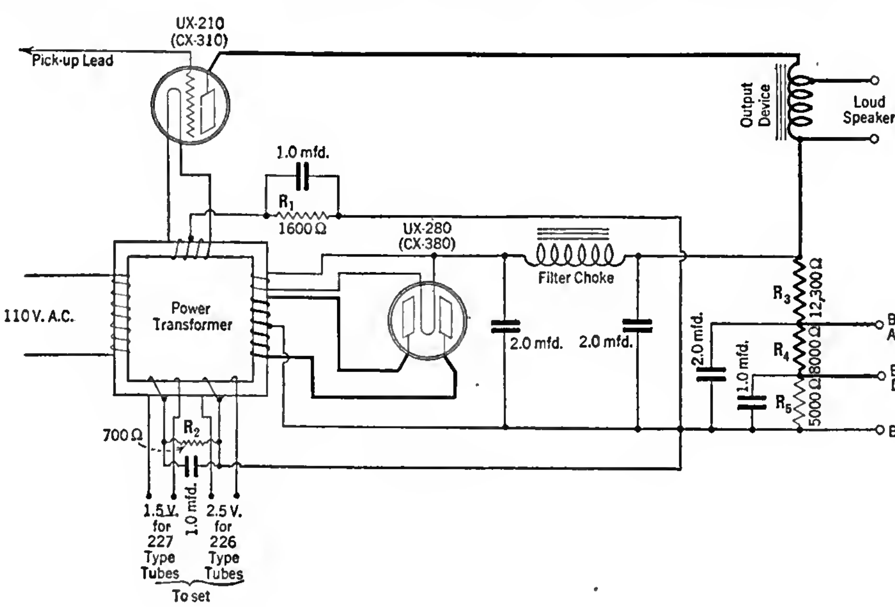


FIG. 5
The circuit diagram of the "Powerizer"

the r.f. amplifying tubes respectively. A resistor connected between the center filament tap of any a.c. tube and B negative, will bias the grid of the tube negatively, providing the grid of the tube is returned (through a secondary or leak) to B negative.

Fig. 6 shows the adaptors and tubes mounted in the Atwater-Kent 35 receiver, and Fig. 7 shows the "Powerizer" itself. The rheostat panel on the Atwater-Kent was removed and a special volume control, supplied by Receptrad, was mounted in its place. An external form of volume control could have been employed.

The following are the steps taken in installing the "Powerizer," along with the time consumed for each operation:

Demounting the Receiver . . .	10 Minutes
Installing Volume Control . .	30 Minutes
Installation of Adaptors and Tubes	5 Minutes
Reassembly of Receiver . . .	12 Minutes
Connection of "Powerizer" . .	2 Minutes
TOTAL TIME	59 Minutes

This time would be reduced to 34 minutes by using the external form of volume control.

The result is a thoroughly up-to-date receiver, capable of delivering remarkable volume with fine quality, with a reliability of operation achieved only by complete "electrification."

Fig. 8 shows a Radiola 28 superheterodyne in which a somewhat similar installation has been made with the Receptrad type 28 "Powerizer."

SPECIAL STABILIZATION

WITH some receivers, special devices (generally resistors in the grid circuits) must be employed, aside from the volume control, to achieve a satisfactory degree of stabilization. The following list considers various receivers that have been successfully adapted for a.c. operation, employing the Receptrad type of "Powerizer" and harness, with notes on special requirements:

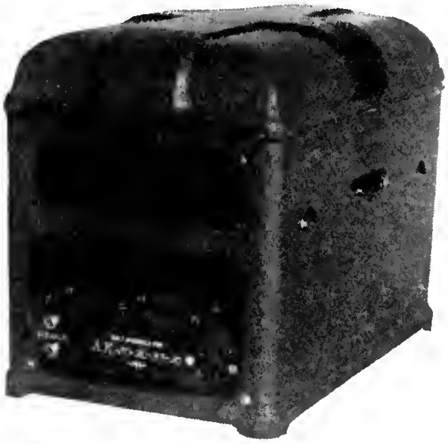


FIG. 7
A neat unit—the "Powerizer"

ATWATER-KENT, Models 20, 30, 32, 33, 35: For external control no change is needed.

BOSCH "CRUISER:" Regular harness. Requires re-neutralization. Uses external volume control.

BOSCH, Model 46: Simply plug in adaptors. No volume control necessary.

BOSCH, Models 66 or 76: Requires 400 ohms in grid circuits of r.f. tubes. Also requires re-neutralization. No volume control necessary.

BREMER-TULLY "COUNTERPHASE" 6-37: Requires standard harness. May need re-neutralization or grid resistors. External type volume control.

BREMER-TULLY "COUNTERPHASE" 8: Requires standard type of harness with special distances between adapters. May require re-neutralization or the use of grid resistors. External volume control. A high resistance of 50,000 or 100,000 ohms should be shunted across the secondary of the 2nd audio transformer.

CROSLEY "BANDBOX:" Simply plug in standard harness. Control may be had by "accuminators" or external. In some cases re-neutralization is necessary.

DAY-FAN 6 JR: Plug in standard harness. External volume control.

FADA SPECIAL 6, 265 A. R. P. 65: Standard harness. External Volume control.

FADA 7 — 475 A-S.F. 45/75: Remove tube housing. This is held in place by 6 or 8 screws. Put in standard harness for seven-tube set with distances between adapters slightly longer. External control.

FADA 8—480 B-S.F. 50/80 B: Requires the use of 1600-ohm resistors in the grids of all of the r.f. tubes. Standard harness for eight-tube set with special distances between the adapters. A high resistance of the order of 50,000 or 100,000 ohms should be shunted across the secondary of the 2nd audio transformer. External type of volume control.

FRESHMAN, Three Dial Type: 1600 ohms in r.f. grid circuits. Special UV harness. External control.

GREBE MU-1 (5): 700 ohms in grids. Standard harness. Requires re-neutralization. External type control.

GREBE 7: Special distance harness. External type control.

KOLSTER, Model 6D: 700 ohms in grids of r.f. tubes. Standard type harness. No control needed. Sensitivity control on set O.K. Must have very good ground.

PFANSTIEHL 32: Standard harness. External type control which may replace old switch volume control. Connections to switch joined together and leads to old volume control soldered together separately from switch connections. Accomplished by connecting 50,000 ohms between grid and old filament wiring.

RADIOLA 16: Plug in standard harness. External control.

RADIOLA 20: For external control no change is needed.

SILVER-COCKADAY: Requires 3200 ohms in grid of r.f. stage. Standard harness.

SPLITDORF 6: 400-ohm resistors in grids of r.f. tubes. Special distances between adapters. External control.

STEWART-WARNER 525: Standard Harness. No changes. No volume control other than one in set needed.

STEWART WARNER 705: Special distances. No control needed.

STROMBERG-CARLSON 501-A: Special distances. Re-neutralization required in some cases. External control.

THERMIODYNE T.F. 5: Special UV adapters. External type control.

ZENITH, Models 7, 8, 9: Special UV adapters, 400-ohm grid resistors. No volume control needed. All C batteries must be removed and gaps shorted.

ZENITH 11 or 14: Special length harness. External control.

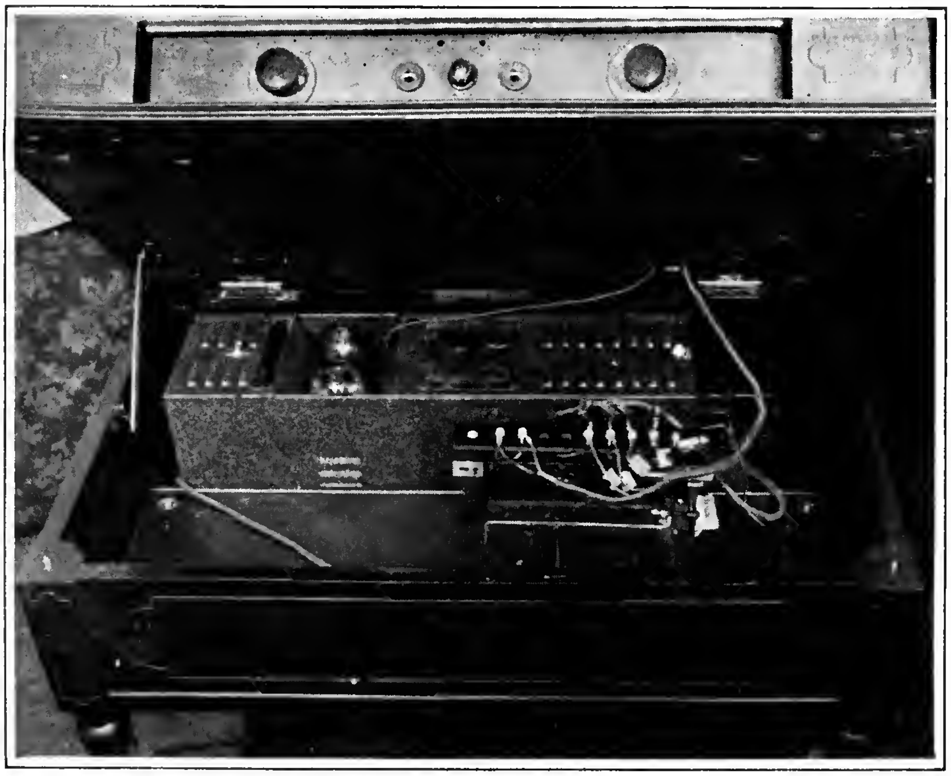


FIG 8
A "Radiola" Model 28 super-heterodyne with a "Powerizer" mounted in the battery compartment. This installation uses a 210 type power tube, doubly modernizing the receiver. It takes about forty-five minutes to make the revision

The Listeners' Point of View

RADIO MUST BE MADE A NECESSITY

By JOHN WALLACE

MR. H. A. BELLOWS, manager of WCCO and former member of the Federal Radio Commission, can generally be counted upon to say something sentient when he speaks about radio. In a talk before the National Electrical Manufacturers' Association last winter he made several suggestions. One of the most important was that if radio is to be a stable institution it must become a necessary institution. This idea seems to us basic. He says:

"Improvement in broacasting must follow two distinct lines, one of them being better presentation of musical programs. The other is, I think, still more important. Look for a moment at the history of the automobile. For years the automobile was a luxury, and its market was limited to those who felt they could afford luxuries of a rather costly nature. The thing that has made the automobile business what it is to-day is the conversion of a luxury into a necessity. People who would never own a single car as a luxury now own two or three because they regard them as absolute necessities, since our entire mode of living has readjusted itself to this new type of transportation.

"The real future of radio reception lies in a similar conversion of broadcasting service from a luxury into a necessity. This can never be done by programs of musical entertainment alone. You can never persuade the mass of the people that they *must* be able to hear the New York Symphony Orchestra once a week. You can come nearer it with reports of baseball and football games and of boxing matches. The stations in the farm belt of the Middle West have done it admirably, for a part of their audience, with their market reports. For the people in the cities this service feature of radio—this creation of a new necessity—is still largely in the embryonic stage.

"Of course I like to get letters praising our musical programs—we all do—but what I really value is the letter which tells me that thanks to our market service some farmer up in North Dakota has saved two hundred dollars on a shipment of wheat, or the letter saying that some family in Minneapolis has come to find our morning comment on the day's news just as essential a part of the day's routine as the morning newspaper.

"Can we develop some form of centralized teaching so that radio will establish itself in all our schools? Can we coöperate with the great news agencies so that, without competing with the newspapers, radio can be made a dependable and instantaneous means for sending out news flahes? Can we make broadcasting a legitimate agency for communicating between our governing bodies—national, state, and municipal—and the people who pay the taxes? What, in a word, can we do to make radio a necessity?

"Once again, let me cite an illustration. You all know the horrible tedium of civic association annual banquets—the indigestible food, the entertainment half drowned out by clattering waiters, and the dreary reports. We are trying the experiment of holding such an annual meeting by radio. The members of the civic association in question are being cordially invited to dine at home, to listen to reports carefully boiled down, and to do the necessary voting at the close of the meeting by mail.

"'Radio must be a necessity, not a luxury.' This I believe, is the solution of the future of the radio industry, and it is for you to play a large and active part in bringing it about. Constantly improving network service will help, but it will not be enough. The broadcasting stations must vastly strengthen their local programs, above all in the matter of the type of local service which carries radio out of the field of mere entertainment and into that of household necessity."

OSKAR SHUMSKY AT WBAL

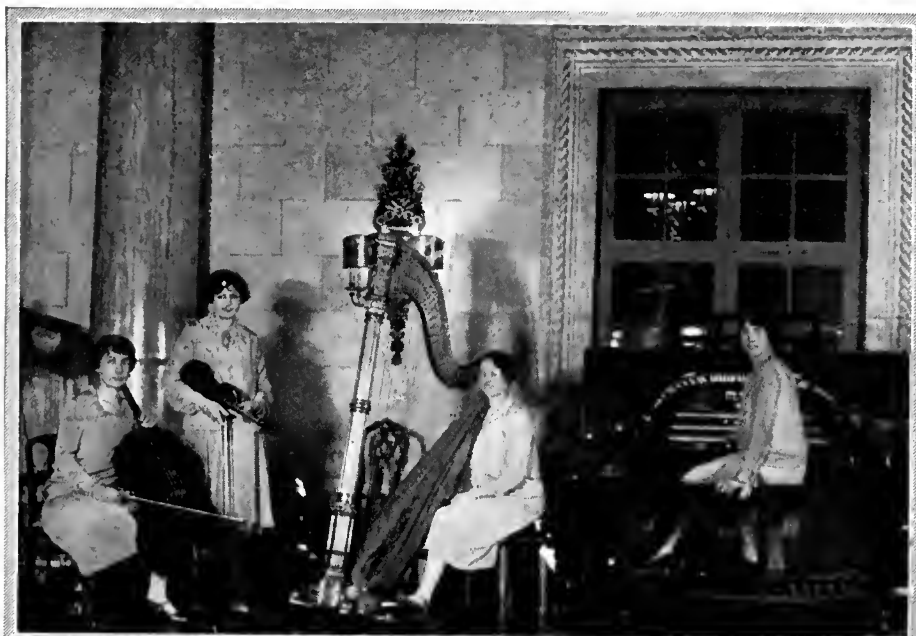
Here is your chance to say you heard him "way back when"—provided he turns out to have the kind of future his press agent promises him. At any rate, Oskar Shumsky, whose playing and composition ability have already been praised by none other than Fritz Kreisler, will be heard from WBAL Sunday evening, March 18, at 8, eastern time

Mr. Bellows remarks were aimed primarily at the radio manufacturer. He said earlier in his speech: "I do not need to remind you gentlemen that you are all engaged in manufacturing a commodity which of itself is entirely worthless. The finest receiving set in the world is no better than the broadcasting which comes within its range. You do not have to be told what would happen to the radio manufacturing industry if the public should ever become really bored with broadcast programs."

This must have sent the cold chills coursing through the veins of his hearers, all of them with their entire capital and future prosperity inextricably tied up in radio. Particularly since the situation, if not probable, is at least conceivable. The public is notoriously fickle, and if it decided to become bored with broadcasting, all the king's horses and all the king's men couldn't change its whim. Where are the petticoat manufacturers and ostrich plume vendors of yesteryear? How can the man who invests in radio stock to-day be certain that by 1938 the public will not have capriciously shifted over to some other mode of entertainment, that the broadcasting stations will not be abandoned crumbling ruins even as—alas—are the breweries to-day!

Certainly if the radio manufacturers are to have any feeling of security they must see to it that radio becomes a utilitarian device as well as the entertainment device that it now is. If it can be made an indispensable utility like the telephone its longevity is practically assured. But while it remains in the luxury class, like the phonograph, its future is a gamble. The talking machine business, as is well known, almost went on the rocks a little while years back; the new fad which threatened its existence was radio itself.

Mr. Bellows mentions four ways in which radio can be practically utilized: Service to farmers; dissemination of news; agency of communication between governing bodies and the public; and centralized teaching for the schools.



A REGULAR FEATURE AT WGR, BUFFALO

The Hotel Statler Concert Ensemble, which is heard daily from WGR in a program of luncheon music

The first mentioned, service to farmers, is already a tried and proved function of radio. A survey recently conducted by WLS shows that the value of radio as a means of entertainment has been equalled and exceeded by its economic utility as a daily aid in the production and marketing operations of the far . It has taken its certain place as an instrument of farm education and has proved its dollars and cents value many times over in the transmission of market news, weather forecasts, and other items of immediate importance to the farmer. "If you had to give up either music or talks on the radio which would you prefer to retain?" was a question put up to a number of farmers by the United States Department of Agriculture. "We will keep the talks," answered 2358, while 1538 answered "music." The most recent government estimates place the number of radios on farms at 1,250,000. The number is now doubtless more than a million and a half. The radio farm and market service has already done much in solving the venerable problem of market gluts, with their resulting demoralization of prices and wrecking of values. Tens of thousands of farmers or their wives hear and tabulate the market returns every day on the particular product in which they are interested, and plan their marketing accordingly.

Anent the second mentioned method, Mr. Bellows asks: "Can we coöperate with the great news agencies so that, without competing with the newspapers, radio can be made a dependable and instantaneous means for sending out news flashes?" The answer is probably no, not without competing with the newspapers. But why should that consideration enter into it? If there is some sort of lively instantaneous news which radio can put over better than the newspapers and in which dissemination it is fore-ordained to supplant the newspaper, let the supplanting start at once. Conservative maneuvers on the part of the news agencies, and on the part of the newspapers, can only succeed in postponing the inevitable, not in suppressing it.

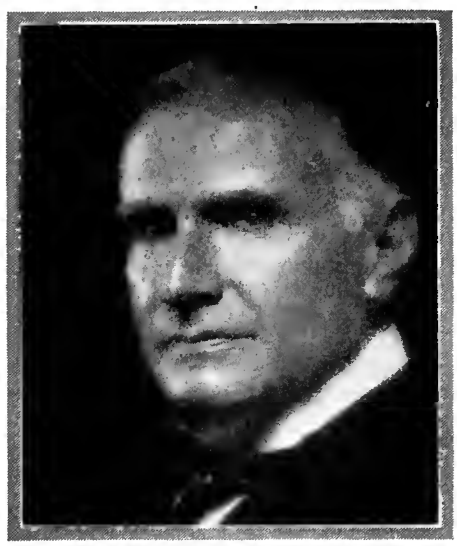
Concerning the third suggested method of giving radio a permanent utilitarian function we can say very little. Our knowledge of the workings of municipal, state, and national administrative bodies is too sketchy to be revealed here in its nakedness. But we see no reason to believe that radio will not some day be an official mouthpiece for governing bodies. And by official we mean Official—that is, there will be certain prescribed governmental broadcasting hours during which time certain prescribed individuals or bodies of individuals will be expected, by duty of their office, to listen-in and make prescribed findings. (Which is about as near as we can get to the jargon of law making.) Anyway we venture to prophesy that before ten years have passed radio will be in some way, if only in a minor way, tied up with governmental administration.

It is in the fourth suggested means of stabilizing radio that we are most interested. The propounder of the idea asks: "Can we develop some form of centralized teaching so that radio will establish itself in all our schools?" The answer is yes; the opportunity is now upon us.

We have made disparaging remarks about radio education in the past and lest we should seem to contradict ourself (not that we object to contradictions; our opinion happens to be still the same) let us reassert that as an "educating" medium radio is the bunk. It is next to useless as far as teaching such stuff as economics, horseshoeing, sociology, or play-writing goes. But we have always believed that radio is peculiarly well adapted to teaching music appreciation and still think so.

Its possibilities in this field have long been recognized and from time to time during the past couple of years rumors have become current that something was going to be done about it. Mr. Walter Damrosch has been particularly active in keeping the idea before the public. It is one of his pet hobbies. And now, as the result of much scheming and labor on his part, he has carried the idea through to the point where it becomes a live issue.

His plan, as you doubtless already know, is to broadcast a series of his music appreciation lectures next winter over a network of stations during some daytime hour, the talks to be illustrated by his own piano playing and by an orchestra, probably the New York Symphony. So much, in brief, for his end of the arrangement. The other end is where the difficulties come in. Each one of the many thousands of schools throughout the country would have a first-rate receiving set, in perfect operating condition, available in its assembly hall or in one of the larger class rooms. Into this room, at the scheduled hour, would be herded all those pupils who had "Music Appreciation" on their program of courses. They would be provided with advance notes on the lecture, sent to their teachers through the mail by Mr. Damrosch, and each lecture-concert would be followed by a written "quizz," also furnished from the central headquarters of the "course."



MR. WALTER DAMROSCH

Who for very many years was leader of the New York Symphony Orchestra and now frequently conducts that organization in the capacity of of guest conductor. His experiments in broadcasting musical appreciation courses to schools has caused considerable favorable comment

There is no especial practical difficulty in the way of carrying out this end of the scheme. The rearranging of the schedules to embrace this new hour of school work once every two weeks, or perhaps once a week, could be done with little trouble. Someone on the premises with sufficient intelligence to supervise the upkeep and proper operation of the receiving set could easily be found. Furthermore, receivers and loud speakers of adequate quality to reproduce the lectures satisfactorily are available.

The obstacle to be met with is the difficulty in arousing nation-wide interest in the idea to the point where boards of education and school trustees will undertake the red tape involved in officially adopting the course and appropriating funds for the necessary equipment.

Of course the obvious way to "sell" the idea to the school masters throughout the country would be by a campaign of publicity and propaganda. But this would involve an enormous expenditure of money. And where is it to come from? All Mr. Damrosch has to offer is the idea and his own time and effort. Who is going to sponsor it?

By way of giving the idea some publicity Mr. Damrosch, with the coöperation of the Radio Corporation of America and the National Broadcasting Company, has already broadcast experimental programs. We think they proved conclusively that Mr. Damrosch will be able to carry off satisfactorily his part of the arrangement if the plan is ever put through. The first program was as follows:

PART I

For Children of the Grammar Schools

(1.) Allegretto from Symphony No. 8.................. Beethoven
(2.) Entrance of the Little Fauns.... Pierne
(3.) Scherzo from Symphony in B flat..................... Glazounow

PART II

For Students in the High Schools and Colleges

(1.) Overture to "A Midsummer Night's Dream"...........Mendelssohn
(2.) Andante from Symphony No. 5...................... Beethoven

Before each of the numbers Mr. Damrosch gave an introductory talk and called attention to certain things to be watched for in the music, much in his familiar manner, except that he modified his material in accordance with the age of the prospective youthful listeners.

You may not be thoroughly in accord with Mr. Damrosch's method of explaining music (we, for instance, think he lays a misleading emphasis on the "story" content of non-program music) but nevertheless he has had some forty years' experience in giving such lectures and ought to know what he's about. Besides we can think off-hand of no one better fitted for the job; no one who combines, as he does, the qualities of authority on the subject, wide and popular renown, distinctive and intriguing personality. We opine that it will be radio's distinct loss if it finds itself unable to take advantage of these rare qualifications while they are available. Pedantry over the radio simply will not work. The pedant needs the help of bodily presence, and often too the help of school regulations, such as the one forbidding sleeping in class, to keep his audience attentive. A radio course in music will succeed or fail according to the personality of its spokesman. If Mr. Damrosch's eminently suitable personality is not made use of it may be a long time before another such personality turns up.

We have said nothing here about the desirability, in theory, of such a course, mostly because we are confident that its desirability is already granted. Heaven knows, the young hopeful is having enough stuff drummed into him during his school years to "fit him for later life." In this age of educational progress he is given opportunity to take most anything in "extra" courses from carpentry and cooking to tire repairing and dentistry. These vocational extras are useful. They make for remunerative work hours after he leaves school. But lamentably little attention is paid to equipping him to enjoy his non-working hours in later life. Out of every ten children exposed to eight years or so of such musical training, at least one would discover that he actually liked the stuff. And that, it seems to us, would justify the whole business.

"Our Readers Suggest—"

"OUR Readers Suggest. . ." is a regular feature of Radio Broadcast, *made up of contributions from our readers dealing with their experiences in the use of manufactured radio apparatus. Little "kinks," the result of experience, which give improved operation, will be described here. Regular space rates will be paid for contributions accepted, and these should be addressed to "The Complete Set Editor,"* Radio Broadcast, *Garden City, New York. A special award of $10 will be paid each month for the best contribution published. The prize this month goes to William C. Ducr, Denver, Colorado, for his suggestion entitled "Eliminating A.C. Hum."*

—The Editor.

Testing an Audio Amplifier

I HAVE used the following method for localizing trouble in audio-frequency amplifiers with considerable success.

The average manufactured receiver, as well as most home-built sets, make no provision for outputting the detector circuit to telephone receivers. Thus it is difficult to locate definitely a fault in either the radio- or audio-frequency channels. The system I am recommending will indicate immediately in just which section of the receiver the trouble exists.

Secure a hand microphone. If one is not available, a transmitter button may be used with equally good results if it is backed to a diaphram so that vibration will actuate the button moderately well. Connect this microphone, through a push-button, in series with the primary of a 25 to 1 induction coil, such as is available from any junked telephone set, and a six-volt battery. The regular filament battery of the set may be used. The secondary of the induction coil has two leads, with clips, soldered to it for convenience in setting up. The following is the method of operation:

Disconnect the detector plate-voltage lead from the B battery or power-supply device, and attach one of the clips mentioned to the detector plus post on the set. Connect the other clip to the point on the battery or power-supply device on which the lead to the set was formerly connected (22.5 or 45 volts), as shown in Fig. 1. Now push the button in the microphone circuit and speak into the microphone. Speaking into the microphone causes a varying current to pass through the primary of the induction coil. This induces current variations in the induction coil secondary, which, being in series with the detector plate lead through the primary of the first audio transformer, in turn affects the battery current in this winding, producing a variation in the balance of the audio-frequency circuit. Speech will be reproduced in the loud speaker as the microphone is spoken into. If the audio circuit is not functioning properly, no speech, or at most, a distorted voice, will issue from the loud speaker, thus indicating the trouble to be in this part of the set.

W. J. Morrow,
Macon, Georgia.

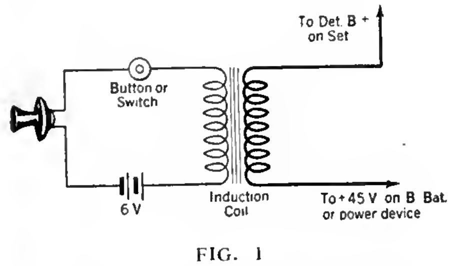


FIG. 1

An interesting circuit arrangement which may be used for testing an audio amplifier

STAFF COMMENT

THE method suggested by Mr. Morrow provides a convenient means of testing the audio-frequency channel of a receiver. For experimental and entertainment purposes a greater response can generally be secured to voice variations by inputting the secondary of the modulation transformer or induction coil to the grid circuit of the detector tube. This is easily accomplished by connecting the secondary terminals across the grid leak, which is generally an accessible portion of the receiver.

Sources of Power-supply Hum

THE output of many receivers taking some of their power from the mains is marred by an excessive 60-cycle hum.

Investigation in many instances reveals the trouble to be due to sources often unsuspected. In the case the writer has in mind, a non-technically trained friend bought a socket-power kit about a year ago, and assembled and wired the device himself. It was less satisfactory than battery power because of the intensity of the hum, which defied all efforts made to eliminate it. He asked the writer to look the outfit over.

Upon opening the output circuit it was found that only part of the hum came from the loud speaker. The laminations in the power transformer were so loose that the resulting vibrations could be heard ten or twelve feet away in a quiet room.

Further examination disclosed that the voltage-divider section consisted of a number of adjustable resistors of the carbon-pile type. Operating the equipment with the power transformer removed from the socket-power baseboard confirmed the belief that a portion of the hum was due to the microphonic action of the carbon-pile resistors brought about by the vibration transmitted from the transformer through the baseboard.

The transformer case was opened and, after the transformer had been warmed up cautiously to about 100° C, was filled with molten battery compound. The primary was energized while the compound was still liquid so that the latter could penetrate between the vibrating laminations. The hum soon fell to a slight murmur, inaudible six inches from the transformer.

As an additional precaution, the carbon-pile resistors were replaced by the wire-wound type which are now generally available.

Herbert J. Harries.
Pittsburgh, Pennsylvania

STAFF COMMENT

THE microphonic effect caused by loose carbon-pile resistors is unusually interesting. The department editor has run across several such cases in his own experience. Microphonic hum will generally be eliminated when the adjustment of the carbon-pile resistors is tightened.

An R. F. Volume Control

OWNERS of three-dial five-tube radio receivers who live near one or more powerful local stations often find that they have such strong reception that the last audio tube, or even the detector, is overloaded. Even where there is no overloading there is often too much volume for ordinary use, or control, by the usual methods.

This difficulty may be remedied and at the same time more economical operation secured by the addition of a switch so connected in the circuit that the first radio-frequency stage of the set may be laid aside, so to speak, at the desire of the operator. When the first stage is not being used, one tube will be automatically turned out and it will become unnecessary to adjust the first tuning dial. The switch can be installed in any commercial or home-made receiver, and its use will result in no loss of stability or efficiency.

The author recommends a Yaxley radio jack switch No. 60 for this purpose, but any compact double-pole double-throw switch may be used with complete success. The switch may be mounted securely at any convenient place on

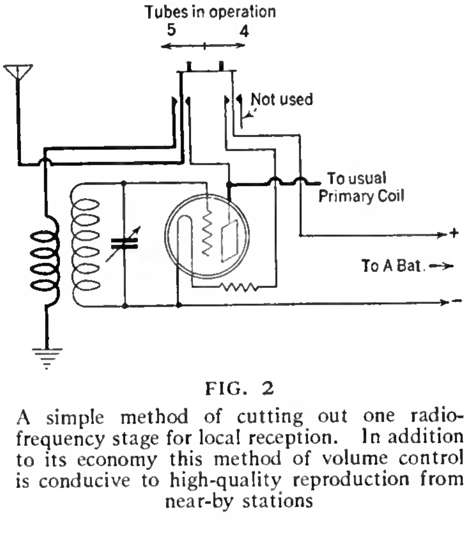


FIG. 2

A simple method of cutting out one radio-frequency stage for local reception. In addition to its economy this method of volume control is conducive to high-quality reproduction from near-by stations the panel, preferably near the first tuning dial. If a separate rheostat or ballast resistance is not used in connection with the first tube of the receiver, it will be well to obtain a resistance of the proper value for the type of tube in the first stage.

Connect the switch as shown in the diagram, Fig. 2. In one position, all five tubes should light and the first tuning dial should be in operation. In the other position, the first tube should not be lighted, and the first tuning dial should be out of operation. For local work, and when extreme selectivity is not desired, the latter position will be found ideal, since it simplifies operation and prevents the unnecessary use of one tube with resultant extra load on the batteries. This switch will be found to be a very effective, though rough, volume control. Instead of tending to cause distortion, as some volume controls do, it helps to prevent distortion, by preventing tube overloading.

Albert R. Hodges,
Clinton, N. Y.

STAFF COMMENT

IN SOME cases a similar degree of volume control can be obtained merely by turning off the filament of the first tube, a switch being provided for this purpose. In some receivers, merely removing this tube from the socket will effect the desired control, sufficient energy being fed through various inductive and capacitative channels to supply an adequate signal on local stations.

Eliminating A.C. Hum

IN SPITE of the many improvements incorporated in the modern socket power device, a.c. hum has not been eliminated in many receiver-power combinations in use to-day.

After trying various methods of getting rid of this nuisance and achieving no real results, I hit upon the hook-up shown in Fig. 3, which really eliminated that a.c. hum.

The filter used was an output device designed to keep the high d.c. current out of the loud speaker windings. It was rated at 30 henries.

By hooking up the 2-mfd. condenser as a shunt across one side and using three of the four posts of the filter, the desired result was obtained. Many of these "tone filters" already contain condensers integral with the choke, which further simplifies the hook-up. Fig. 3 shows the condenser as part of the filter, and is self-explanatory.

William C. Duer,
Denver, Colorado.

STAFF COMMENT

THERE seems to be no end of the possible uses of the output device. Here we have an interesting and logical use distinct from the original purpose of the unit. Mr. Duer's suggestion recommends the use of a filter circuit in addition to that already provided as a part of the power-supply device, which, as our correspondent suggests, is occasionally inadequate.

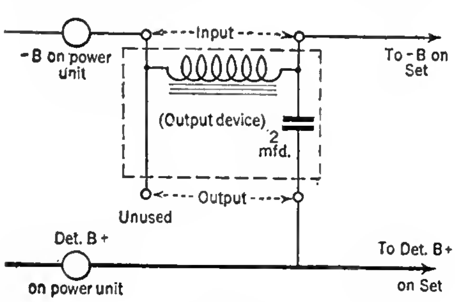


FIG. 3
An arrangement of apparatus which has been successfully applied in the elimination of a. c. hum

Phonograph Pick-up Switch

I AM using an electrical pick-up in conjunction with my phonograph and radio receiver. The pick-up is of usual design calling for the removal of the detector tube from its socket and the substitution of a four-prong plug. This arrangement is rather clumsy mechanically so I devised the simple switching arrangement shown in Fig. 4, using a Yaxley No. 60 switch, which is mounted on the panel of the receiver. An extra socket is placed in the receiver into which the pick-up plug is inserted. The switch throws the input to the amplifier from the detector circuit to the pick-up circuit.

Franklyn F. Stratford.
Jersey City, New Jersey

STAFF COMMENT

ASIDE from the convenience of Mr. Stratford's arrangement, the switch short-circuits the output of the detector when the phonograph is being used, and vice versa, of course, so that there is no danger of "cross talk"

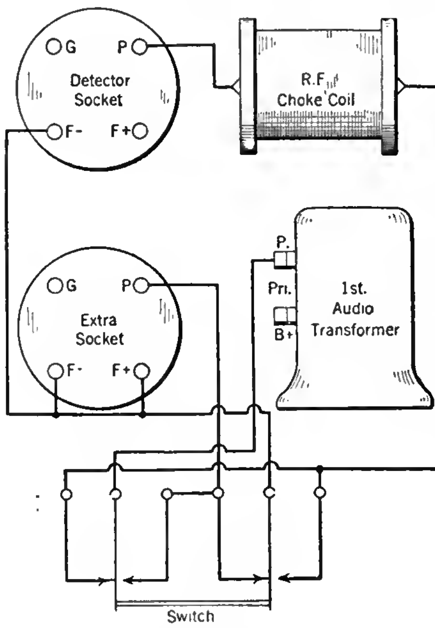


FIG. 4
A convenient switching arrangement for controlling phonograph and radio pick-ups

between two audio circuits. This is particularly desirable when the receiver is powered from the lighting socket, since leaving the detector output open, or suddenly throwing the amplifier to it, may cause oscillations.

Stabilizing With High-Mu Tubes

I HAVE been building and experimenting with a Browning-Drake receiver, and after trying a "Phasatrol" and different neutralizing condensers, I find that a CX-340 (UX-240) tube in the r.f. stage, with ninety volts on the plate, will neutralize easily. A small balancing condenser should be used. Considerable volume, with no sacrifice in efficiency of the set, will result.

Milton Hicks,
Rockville Centre, Long Island.

STAFF COMMENT

IT IS possible to stabilize many radio-frequency circuits in this manner. The fact that the high-mu tubes have a higher plate impedance than those generally employed in radio-frequency circuits in many cases more than counteracts the increased regenerative effect due to higher amplification constant of the tube, with the result that the circuit into which they are plugged is relatively stable. Also, in the cases of two or more tuned radio-frequency stages, the use of a single high-mu tube, preferably in the radio-frequency stage preceding the detector tube, will have a slight detuning effect upon the tandem circuits due to the introduction of a capacity discrepancy. In other words, one circuit will be slightly off tune, with the usual stabilizing effect.

It is always a good idea to switch the tubes around in an oscillating circuit in an endeavor to arrive at a combination giving the best results.

Another Output Arrangement

SEEING an article on output devices in a recent issue of Radio Broadcast, I have decided to send you a diagram of one which I have used for three years. I tumbled on it in fooling around with a choke output and find it is particularly satisfactory as it provides for a head-set without changing the loud speaker circuit.

It requires an amplifying transformer, two condensers (of 2-mfd. and 0.5-mfd.), and two open-circuit jacks.

It will be noted, from the wiring diagram, Fig. 5, that the output of the set is fed through the secondary of the transformer and that the 2-mfd. condenser and loud speaker (in series) are shunted in the usual manner. The variation from the conventional circuit lies in the primary side where you will note that a "jumper" is attached to only *one* side of the B circuit. This gives plenty of power for the headset without depriving the loud-speaker circuit of enough energy to decrease volume.

Another advantage peculiar to this output device is the fact that the total load on a power-supply device remains constant when the loud-speaker is removed from the circuit, thereby leaving all voltages on tubes the same, regardless of whether phones or loud speaker is employed.

I have made four of these in the past three years using different audio transformers and find that results are equally good; a relatively cheap transformer I found to be as satisfactory as an expensive one.

F. W. Woolway,
Newton Centre, Massachusetts.

STAFF COMMENT

THE average audio transformer secondary has a rather high d.c. resistance so that the voltage actually on the last tube plate will be quite a little below the terminal voltage of the B voltage supply. Experimenters can try reversing the transformer windings, i.e., keeping the primary in the plate circuit and the phones across the secondary.

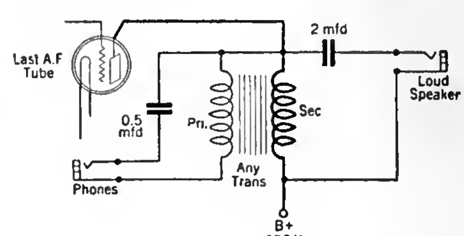


FIG. 5
A flexible output circuit

A SET-UP OF APPARATUS IN ONE OF THE "RADIO BROADCAST" LABORATORIES

The measurements which are outlined in the article were made with this equipment. Note the radio frequency oscillator at the extreme left. It is housed in a large tin wash boiler. The large loud speaker is the new Western Electric 560AW cone

The Four-Tube "Lab" Receiver

By Keith Henney

Director of the Laboratory

ALTHOUGH many receivers have come and gone since June, 1926, when the R. B. "Lab" circuit was first described in RADIO BROADCAST, the latter still represents the criterion by which all other receivers are compared in the Radio Broadcast Laboratory, and the measure by which all four-tube receivers are judged. There are several reasons for the continued popularity of the "Lab" receiver; the most important lies in the fact that, with good component parts and a good layout of apparatus, four tubes in this circuit seem to require a minimum amount of energy from the ether to deliver any required loud speaker power.

The "Lab" circuit receiver is a member of that famous family which includes the Roberts and the Browning-Drake, to mention but two, and it employs, therefore, a single stage of neutralized radio-frequency amplification followed by a regenerative detector and the usual audio amplifier. Since June, 1926, few startling inventions or discoveries to do with circuits have appeared in the field of radio, so the circuit itself has changed but little. Experience has taught, however, just where the inductances and their related parts, condensers and tubes, should be placed behind the panel for most efficient operation, and this alone might be considered quite a big step forward so far as efficient design is concerned. A bad layout of apparatus can mean all the difference between poor and good reception.

The following article, which is preliminary to the publication of a constructional article on the "Lab" receiver, gives some useful information on how receivers are designed, how the component parts are measured, or what the voltage amplification of the detector or the amplifier may be. The information is available as a result of exhaustive tests conducted in the RADIO BROADCAST Laboratory, and although the measurements were made with the prototype of the "Lab" receiver scheduled for description next month, they should appeal to anybody interested in radio receiver design and measurements generally.

A certain amount of engineering data can be collected at home; to gather other data a laboratory equipped with instruments is necessary. A typical "armchair" investigation was described in the March RADIO BROADCAST. It told how one could calculate the voltages appearing at various points in an audio amplifier if one knew the electrical dimensions of his apparatus and the amount of power he desired from his output tube. The data presented below result from a definite series of laboratory experiments designed to learn what is going on between the detector output circuit and the antenna of a receiver; in other words, their purpose is to take up where the armchair engineer left off. As the investigation tells a great deal about the "Lab" circuit it should be interesting to those who already own such receivers, or those who are being introduced to it for the first time.

In the "Armchair Engineer," which was the title of the March article, we showed what voltages were necessary in an audio amplifier when a maximum of 700 milliwatts of undistorted audio power was to be delivered to a loud speaker of 4000 ohms impedance, which conditions obtain when a 171 type tube is in use, delivering its maximum quota of undistorted power. We have chosen 4000 ohms for the impedance of the loud speaker as representing the best value (twice that of the tube) for maximum undistorted power output. Seven hundred milliwatts of power is small compared to that taken by a 40-watt incandescent lamp with which we are all familiar, smaller compared to the 500 watts required by that common home apparatus, the electric iron, but is greatly in excess of the power that can be collected from one's antenna from a distant broadcasting station. In other words, between the antenna and the loud speaker, there must be considerable power amplification. How great is this amplification, how can it be measured? These are questions that a laboratory investigation can answer, and these figures enable a laboratory to form some kind of an opinion on the overall efficiency of a receiver.

In Fig. 1 is a two-stage audio amplifier which includes two transformers whose turn ratios, secondary to primary, are about 3 to 1 at 1000 cycles, a tube the amplification factor of which is 8 (about 7 of which can be realized), and a power tube with an amplification factor of 3. The voltages at several points in this system are given on the diagram, showing that about 0.42 volts must appear across the primary winding of the first audio transformer if a value of 700 milliwatts is to be delivered to 4000 ohms.

It will be noted that the voltage across any point is found by multiplying together the voltages appearing on the grids of tubes in the circuit, the amplification constants of these tubes, and the turn ratios of the audio transformers. Thus the voltage across the output of the second audio tube (note that its effective mu is 7 and not 8) will be approximately:

$$0.42 \times 3 \times 1.26 \times 7 = 8.8$$

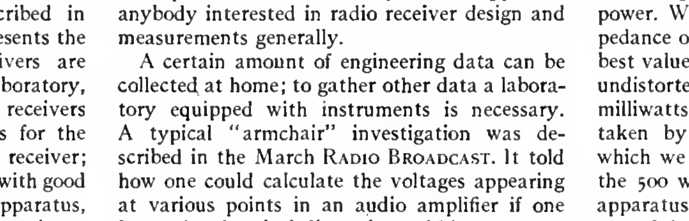


FIG. 1

In Fig. 1 it will be seen that the voltage appearing across the output of the final tube is not 26.5 x 3 (the grid voltage multiplied by the mu), since only two thirds of the a.c. voltage in this circuit is usefully employed across the output load. The output, then, is about 53 volts.

We resort to Ohm's law to prove that this value of 53 volts is adequate to give the requisite 0.7 watts of power, and in doing so we find that the current in amperes (output voltage divided by loud speaker impedance) is:

$$\frac{53}{4000} \text{ Amperes}$$

And that the power in watts (voltage multiplied by current in amperes) is:

$$\frac{53 \times 53}{4000} = 0.7 \text{ Watts}$$

Thus we have proved that a voltage of 0.42 across the primary winding of the first audio transformer is adequate for our purposes. Given the constants of the transformers, tubes, and loud speaker in an audio circuit, it is a simple matter, therefore, to calculate the requisite voltage for any given power output, across any point of the circuit.

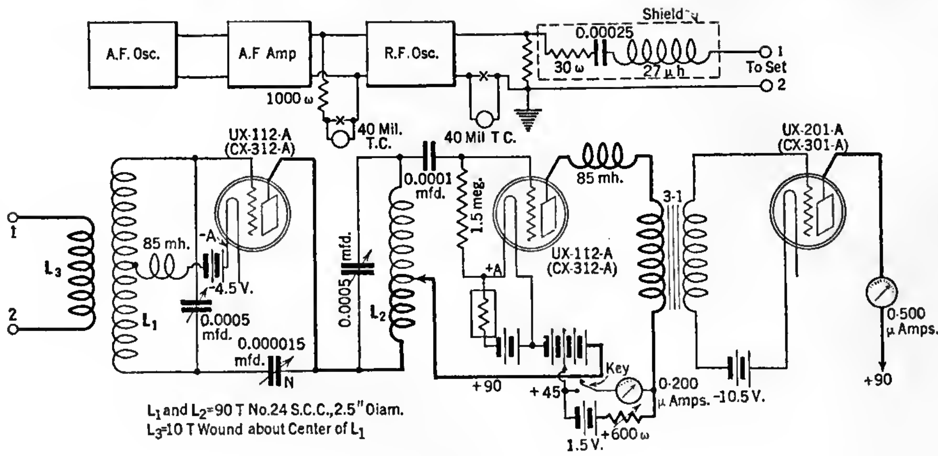


FIG. 2

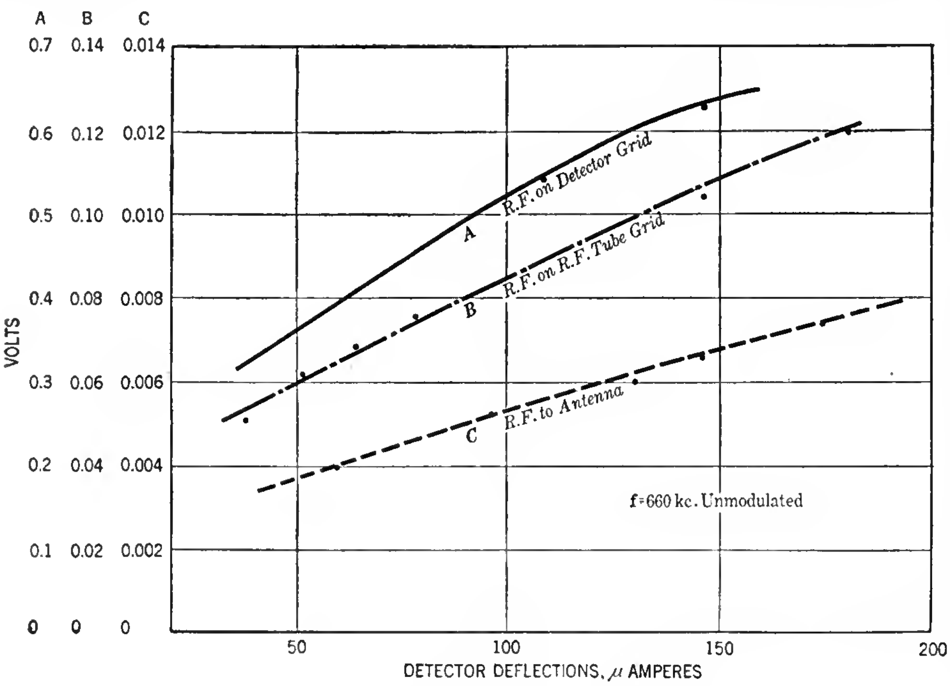


FIG. 3

THE DETECTOR CIRCUIT

HAVING decided that we require 0.42 volts across the primary of the first transformer, we must now set about producing this voltage. Up to the present time our calculations have been purely mathematical but from now on we shall require the help of laboratory instruments before we can conclude our calculations.

Because we desire maximum sensitivity in the new "Lab" circuit we shall use a grid leak and condenser detector the average plate current of which is about 1.3 milliamperes if a 112-A type of tube is used with conventional values of grid leak and plate voltage. We use this type of tube because it is much less microphonic than a 201-A tube, because of its lower plate impedance which gives us better low audio-frequency response, and because it is capable of somewhat greater amplification than its smaller brother tube.

This 1.3 milliamperes plate current will change when a signal is tuned-in. For example, WEAF, 8 miles from the Laboratory and with 50 kw. of power in the antenna, reduces the average plate current of this type of detector to the low value of 300 microamperes, in other words, produces a *change* of 1000 microamperes. Signals from WJZ, 30 miles distant with somewhat less power, cause a change of 100 microamperes. These changes in detector plate current are then, a measure of the strength of incoming signals.

We must know the voltage across the first audio transformer primary, produced by various r. f. voltage inputs to the receiver and what effect modulation at the transmitter has. We learn from Carl Dreher, Staff Engineer of the N. B. C., that the two stations mentioned above are modulated, on the peaks of the audio signals, to about 60 per cent., so that if we modulate a local oscillator, or generator of radio-frequency waves, to about 60 per cent. and impress known radio-frequency voltages upon our receiver, we can note the change in plate current and the voltage across the primary of the first audio transformer.

Instead of measuring the voltages across the primary, in the Laboratory, we measured those appearing across the secondary by using the first audio tube as a vacuum-tube voltmeter and then calculated that across the primary. This was done by biasing the grid of this tube to about 10.5 volts with 90 volts on the plate, when the plate current was about 30 microamperes, with no signal, and increased up to about 100 microamperes when there was a reading of 1.5 volts across the transformer secondary. Known audio-frequency voltages impressed across the input of this tube were plotted against plate current to calibrate it as a voltmeter.

The steady detector plate current of 1.3 milliamperes was balanced out by placing a battery and resistance across the microammeter, the battery being poled so that it opposed the flow of steady plate current. A key was placed in the microammeter circuit so that the latter did not read until the key was closed.

We then noted the vacuum-tube voltmeter

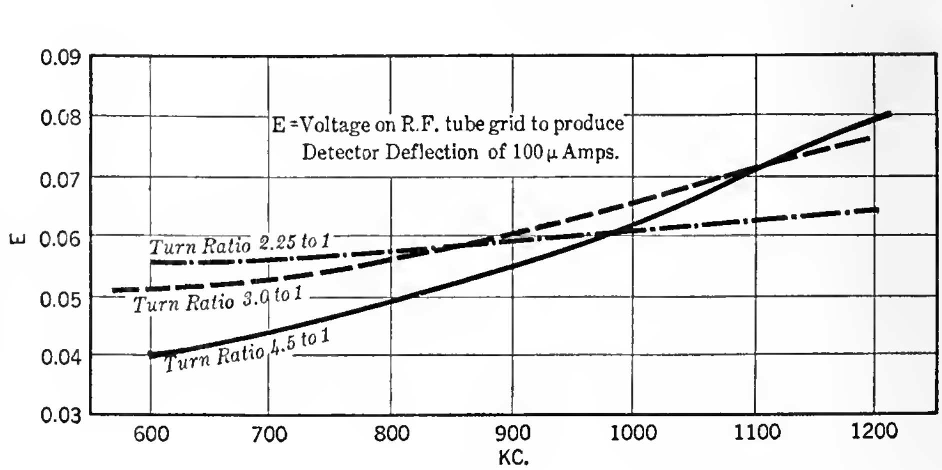


FIG. 4

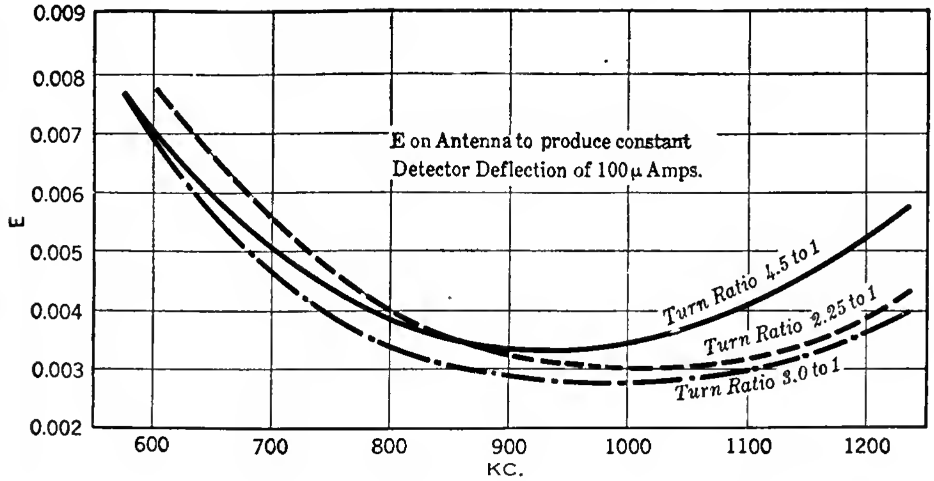


FIG. 5

deflections against input r. f. voltages and percentage modulation, and the change in detector plate current—which we shall call detector deflections—against r. f. voltages.

The set-up used is shown in the photograph at the head of this article, and in Fig. 2. It comprised an audio-frequency oscillator, a General Radio push-pull amplifier, and a radio-frequency oscillator, the latter housed in a tin wash boiler with a tight fitting lid. Across the output of the audio amplifier is a 40-milliampere thermocouple in series with 1000 ohms to act as a voltmeter for the 1000-cycle modulating energy. Across the output of the radio-frequency generator is a variable resistance in series with a thermocouple which measures the current through this resistance. The voltage drop, at radio frequencies, across this resistance, is utilized to drive our receiver under test. This voltage can be varied by changing the value of resistance used, or by changing the current through it. Large changes in voltage are produced by the former method, small changes by the latter.

These are crude methods of measuring voltage gain compared to the ultra refinements employed in the Crosley Laboratory for example, where an accuracy of better than 2 per cent. is possible, or in the General Electric Laboratory, but they are effective, as the following data will show.

Measuring the plate voltage of the oscillator we find that it is 69 volts, and noting that the current in its tuned circuit varies directly with the plate voltage we assume that the ratio between the fixed plate voltage and the low-frequency voltages from the amplifier fed into the plate circuit of the r. f. generator is a measure of the percentage modulation. The 1000-cycle voltages obtainable are from about 18 to about 35 r. m. s., which give us modulation percentages of from 36 to 71 approximately.

If the modulation is changed while a constant r. f. voltage is applied to the receiver in series with its artificial, or "dummy," antenna, and, secondly, if the modulation is held constant while the r. f. voltage is changed, the following facts are noted: the detector deflections are independent of percentage modulation, the a. f. voltages appearing across the secondary of the first audio transformer vary almost directly as the modulation and as the r. f. voltage applied, and the detector deflections vary approximately as the square of the input r. f. voltages.

We learn that a 660-kc. wave modulated 54 per cent. and producing a change in detector plate current of 100 microamperes produces an audio voltage of 1.67 across the secondary of the transformer. If this is a 3 x 1 turn ratio unit, the voltage across its primary will be 0.56, which will furnish ample power to the loud speaker from a two-stage transformer-coupled amplifier of the type shown in the photograph of the receiver upon which these measurements were taken.

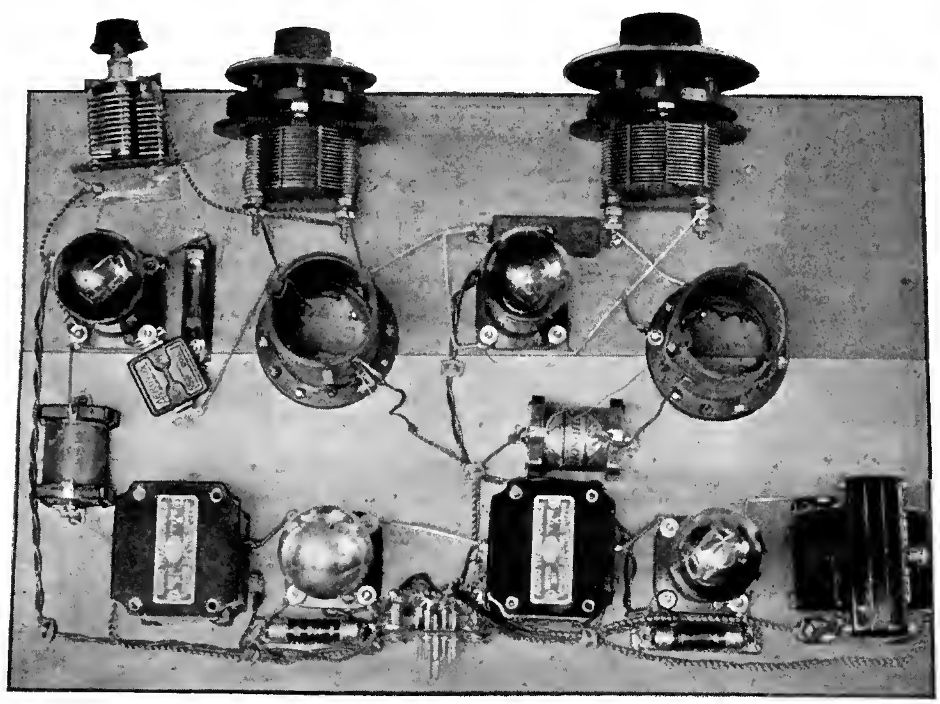
So far we have established several important points. We have determined the relation between detector deflections and detector output audio voltages; we have found out the relation between audio voltages and radio input voltages; and we have decided that to get about 0.5 volts across the input to the audio amplifier we need a radio signal, 54 per cent. modulated, which will cause a detector deflection of about 100 microamperes. We may now neglect the audio amplifier, and deal only with the part of the circuit between the antenna and the detector plate circuit. What we now desire is to get this 100-microampere deflection with the least input r. f. voltage to the antenna, the greatest amount of selectivity, and the best characteristic, that is, the most even amplification over the broadcasting band.

There are several variables that need investigating; for example, the number of turns included in the r. f. tube plate circuit must be determined. Let us start by placing various voltages at 660 kc. on the detector input directly, *i. e.*, without going through the tuned circuits or the first tube. Then we shall apply voltages to the grid of the r. f. amplifier, and finally to the artificial antenna. The result is shown in Fig. 3, and was obtained by applying the voltage drop across 20 ohms to the detector, that across 3.3. ohms to the grid of the r. f. tube, and that across 0.191 ohms to the antenna.

To get our 100-microampere detector deflection required about 0.5 volts when applied to the detector input, about 0.085 volts when applied to the r. f. grid, and only 0.005-volts when impressed across the artificial antenna. It is difficult to translate these differences in voltages into "gain," but it is interesting to note that a ratio of about 6 to 1 in voltage appeared by removing the driving r. f. voltage from the detector grid and placing it across the r. f. grid, and that an input voltage of five millivolts produced 100 microamperes detector deflection, and, therefore, if modulated about 54 per cent. produced our required 700 milliwatts of audio power.

Now let us vary the frequency of the impressed voltages and see what happens. The detector input has essentially a flat characteristic over the broadcasting band. Applying voltages to the r. f. grid gives the result shown in Fig. 4, in which various turn ratios between detector input and r. f. tube output are given. At a turn ratio of 2.25 to 1, where nearly one half of the detector coil is in the plate circuit of the previous tube, the curve is flat, and as the turns ratio is increased more input voltage is necessary at high frequencies to deliver the same detector deflection.

When voltages are impressed upon the "dummy" antenna, the characteristic changes, and becomes peaked, with maximum amplification near the middle of the broadcasting band, the ratio between the lowest and highest point in the curve being about two to one. This curve, Fig. 5, gives the input voltage required to give a



A FOUR-TUBE "LAB" RECEIVER

An experimental breadboard layout of the "Lab" receiver which will be described constructionally next month. The measurements outlined in this article were made with the layout shown here constant deflection of 100 microamperes, and when turned upside-down, gives an idea of the overall amplification characteristic.

Investigation of the artificial antenna and coupling coil, consisting of ten turns wound about the center of the r. f. input coil, shows that it resonates at about 900 kc. which accounts for part of the humped characteristic. Part of it is accounted for by the rising characteristic toward the higher frequencies noted in Fig. 5 and part by the looser coupling between antenna and r. f input coil at the lower frequencies.

Placing a coil and variable condenser in series with the antenna, so that the entire system may be resonated to the frequency desired, will bring up the overall amplification of the receiver as well as improve the characteristic. It necessitates an additional tuning control, and has the unfortunate habit of making necessary readjustment of the r. f. tuning condenser whenever any change is made in the setting of the antenna series condenser. For these reasons, and because a 2 to 1 characteristic such as shown in Fig. 5 is not bad enough to worry about, the antenna series resonant system has not been added to the "Lab" circuit. A further study of antenna coupling systems is under way and it is hoped that the result can be given to interested experimenters soon. The turn ratio of any good coil should be 3 to 1 since greatest amplification results thereby.

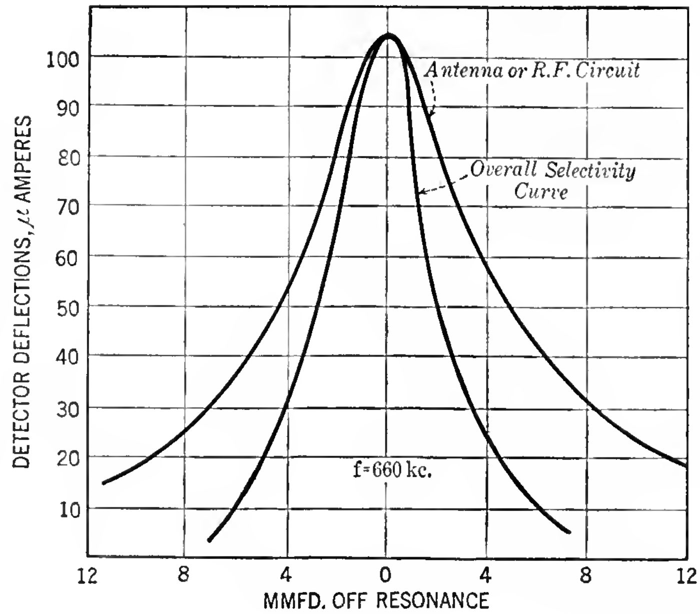


FIG. 6

SELECTIVITY

One thing remains to be investigated—the selectivity of the two tuned circuits and that of the receiver as a whole. A small condenser of 0.00005-mfd. capacity bridged across the main tuning condensers and varied through the point which resonates the circuit will give an idea of the selectivity. Fig. 6 shows both the selectivity curve on the r. f. circuit and the overall curve.

A word about the practical result of all this investigation may be interesting. In Garden City, 8 miles from WEAF, it is possible to receive WJZ 50 kc. away without interference. It has been easily possible to receive WJR when WJZ was on the air, a difference of 20 kc., and on the higher frequencies many stations outside of Manhattan, 15 miles distant with perhaps 30 local stations in operation, have been received regularly. In an Ohio town, 100 miles from a broadcasting station, a similar receiver has a choice of over 40 stations without appreciable interference.

In none of these experiments has regeneration been added to the detector, which, in fact, has been operating at poor efficiency, since it has a high-impedance plate circuit at high frequencies. As soon as the regeneration condenser is connected, partially bypassing some of the r. f. load, the detecting efficiency goes up, and adding regeneration increases the overall gain and selectivity at all frequencies, and improves the characteristic. Figs. 2 and 7 give all electrical constants for the two-tube "Lab" circuit. Owing to the superior gain produced by the 112 type of tube, we recommend it in both the r.f. amplifier and detector sockets.

As in all similar tuning systems, the efficiency of the circuit as a whole depends solely upon the quality of the apparatus (especially the coil) put into it, and their relative location behind the panel. Coil resistance is especially to be avoided in the antenna stage for here the losses in amplification and selectivity are directly proportional to the resistance in the tuned circuit.

Coils of small diameter may be placed as close together as shown in the photograph on page 425, although it will not be possible to neutralize the amplifier at one extreme of the broadcasting band and have it remain neutralized at the other. If neutralization is carried out in the middle of the band, it will be fairly complete at other frequencies and will not oscillate at any frequency. The parts used in the four-tube "Lab" receiver on which the above tests were made, are as follows:

LIST OF PARTS

2—0.0005-Mfd. Remler Condensers
1—0.000055-Mfd. Precise Condenser
1—Type N X-L Condenser
1—0.0001 Mfd. Averovox Condenser
1—0.001-Mfd. Aerovox Condenser
2—Aero Inductances
2—Samson 85-Mh.Chokes
4—Benjamin Sockets
2—Sangamo Type A Transformers
1—Ferranti Output Transformer
2—Amperites, 0.5-Ampere
1—Lynch Resister Mount
1—1.5-Meg. Aerovox Resistor
1—Yaxley 7-Wire Cable
2—CX-312-A (UX-112-A) Tubes
1—CX-371-A (UX-371-A) Tube
1—CX-301-A (UX-201-A) Tube

If the receiver is to be operated in a location where there are many stations, it will be well to shield at least the r. f. stage. In the layout shown in the photograph care has been taken to keep all amplifier apparatus to one side of a middle line, and all detector equipment on the other side of that line. This facilitates the introduction of a shield between the two circuits.

If the approximate layout shown in the photograph is followed, constructors should have no difficulty in making the receiver operate. Any good apparatus may be used; coil dimensions are included in Fig. 2 and commercial inductances from General Radio, Aero Products, Silver-Marshall, and Hammarlund have been used with complete success. An article scheduled for the next issue of RADIO BROADCAST will describe the construction of a four-tube "Lab" receiver in detail.

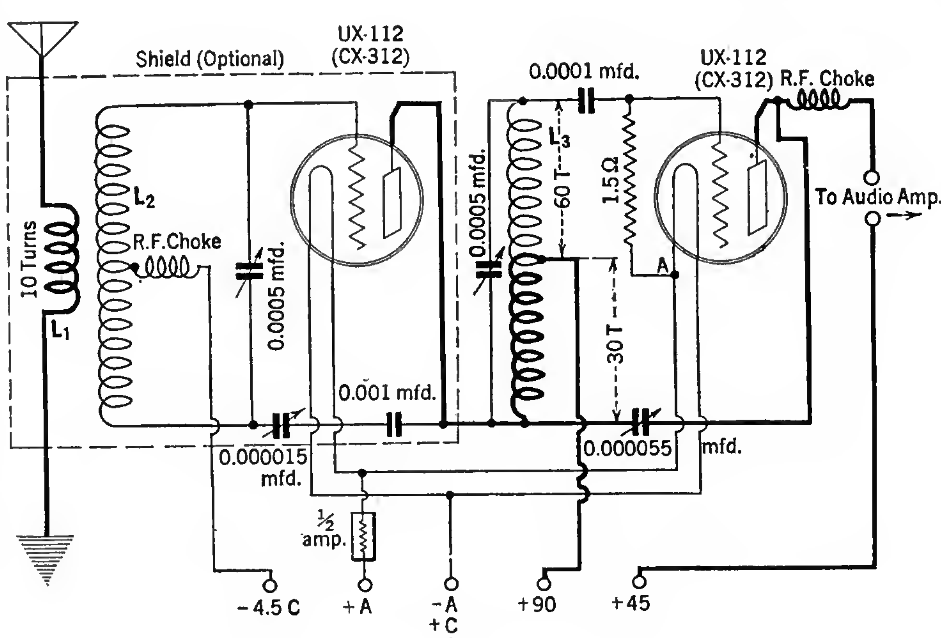
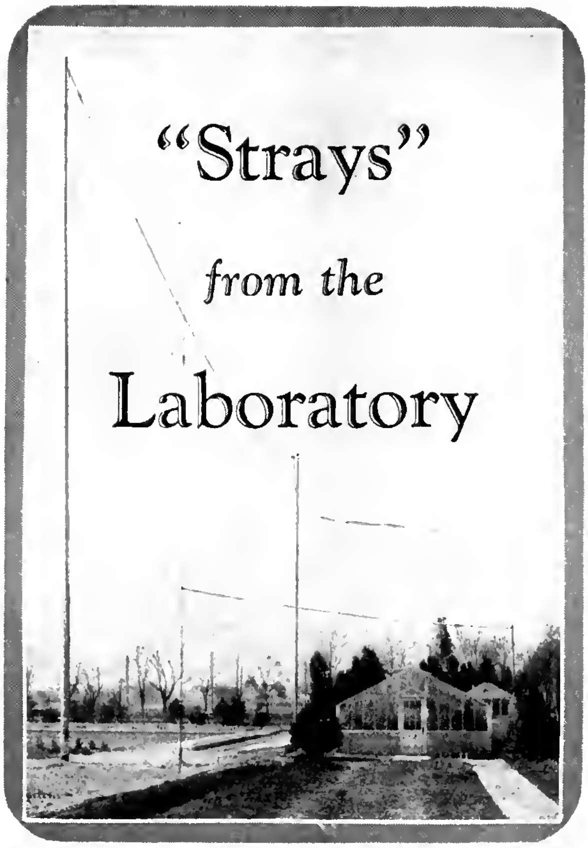


FIG. 7

This is the circuit diagram of the two-tube "Lab" receiver. As will we noted, the 112 type tube is used in both r.f. and detector stages and the gain will be greater than that possible were 201-A type tubes employed

"Strays" from the Laboratory



Music from the Ether

It is with considerable difficulty and some reluctance that we report the first public demonstration in America of Professor Léon Théremin's "Music from the Ether" on January 31st, 1927. We sat in the passing glory of the Metropolitan Opera House surrounded by a typical opera audience, all in evening dress, and watched and heard Professor Théremin and his associate, Dr. J. Goldberg, extract violin-like notes from two beating radio-frequency oscillators, and our emotions, we must admit, were mixed. Musically the demonstration was not good, but one cannot criticize an amateur who makes no effort to set himself up as a musician; as a scientific demonstration before a S. R. O. audience in no less a place than the Metropolitan, it was grand. The audience was enthusiastic, it applauded, and roared "bravo" and "heroique" and begged for more all because they had watched two men without any visible connection with the instrument they were playing, wave their hands before a slender rod standing vertically in the air, and heard the tremolo notes of "Ave Maria," "Song of India," and other old favorites.

We must admit that we were more interested in the audience than in the music or the musicians; we wondered how they would take it—those trembling notes, often off key; we wondered who they were, whether music critics, scientists, or merely curious people, amazed in any sleight-of-hand performances, or demonstrations of forces unseen. We were interested, too, in the electrical mechanism, which is so well known to all workers in radio frequencies, in the loud speakers, great triangular green boxes standing high above the stage and showing off very well against a black velvet drop.

Electrically, Professor Théremin's apparatus is simple. It consists, according to *La T. S. F. Pour Tous*, for December, 1927, of a crystal-controlled generator oscillating at a frequency, let's say, of 100,000 cycles per second, and another oscillator whose frequency may be varied continuously so that the beat note between these two generators, when fed into a detector and amplifier, will cover the entire audio range of tones. Because there is always an attempt on the part of two such generators to "pull together" when their frequency difference is small, some difficulty is noted in securing low or bass notes. An ingenious trick, also well known to radio experimenters, is used here in an attempt to avoid such trouble; the second harmonic of one oscillator is made to beat with the third of the other. In this way Professor Théremin got down pretty low in the frequency scale, but because his loud speakers began to rattle at these frequencies or because he was still bothered by his oscillators "pulling together," these notes were not good.

The loss in audio-frequency output occasioned by using harmonics instead of the fundamentals is not serious; the volume can always be brought up by proper amplification. In fact the audience seemed astonished at the volume produced by these beating generators of radio-frequency waves, for at times it was "sufficient to fill the Metropolitan." Of course the audience did not know, as our readers do, that volume much in excess of this could have been produced if needed; all that was necessary was additional amplification.

In Professor Théremin's cabinets, then, were two generators, one fixed in frequency, the other variable. Tunes are played by bringing the hand near a metal rod which is attached to the tuned circuit of the variable oscillator, the hand, which is connected to ground through the performer's body, serving to change the capacity of the tuning condenser—"body capacity," nothing less, the bane of all radio experimenters of a few years ago.

Volume is controlled by another conductor at right angles to the tone control and placed so that it can be approached by the other hand of the performer. It is a single loop of wire and constitutes part of the tuned circuit of the crystal-controlled oscillator. As is well known, when the tuned circuit of such an oscillator is properly adjusted, maximum power is produced, and at any adjustment different from this condition, less power is generated. Thus, bringing the hand near this loop detunes the closed circuit and reduces the power generated in the fixed oscillator, but because of the crystal, its frequency does not change appreciably.

The device is extremely simple to "play," there is no complicated fingering or bowing, as of a violin, and there is no labor on the part of the musician to get fortissimo passages, but in this very simplicity there are disadvantages. The violin gets its timbre because of the complex manner in which its strings vibrate; its notes are not pure, *i. e.*, good sine waves, but they are more or less complex at the will or skill of the musician. The violin, the tone of which the "Théreminvox" most nearly approaches, can be bowed on more than one string at a time, thereby producing a still more complex wave form, while the electrical instrument can hit but one note at a time, and that note ordinarily is quite pure, like that of a child's voice. By throwing a switch or two, the operator, or player, can bias grids differently and put into the output of one or both oscillators various harmonics, which results in a change of timbre.

The "Théreminvox" glides smoothly from one frequency to another; it cannot, in its present form, jump from one note to another an octave, more or less, distant. It cannot produce staccato effects, or those of plucked strings, nor can it produce any of the effects of percussion instruments.

Let us not be too harsh on Professor Théremin of the Institute Physico-Technique of Leningrad. He is not a musician. He is a physicist and has several inventions to his credit, inventions on such things as methods of measuring weak field strengths, and as early as 1926 made contributions to what has come to be called television. According to a Paris interview published in *La T. S. F. Pour Tous* he stated of his latest development:

> This is not at all a plaything for me. It is much more a concrete proof, an incontestable demonstration, of my conception of the arts and the sciences. The two are but one to me. I have always been disturbed by the disdain with which followers of art treat questions of science and of engineering. And conversely, how many times have these savants claimed that art was a word

PROFESSOR LÉON THÉREMIN "PLAYS" HIS "THÉREMINVOX" devoid of all meaning. To prove to the one that science can render the greatest services in the development of the arts, to demonstrate to the other the fertility of an intimate collaboration of the arts and sciences, is my aim.

Perhaps the orchestra of the future will consist of many of these oscillators and many men before them waving their hands. Certainly there will be plenty of engineers who can put all the harmonics into the tones the musicians desire, and perhaps then the timbre will be more pleasant to musicians.

It is reported that Rachmaninoff turned to a member of the private audience which first witnessed the demonstration of the apparatus, and said, when she shouted "Bravo:" "Madame, you exaggerate!"

A. C. Tube Troubles

From various sources comes the rumor that set engineers are more pleased with the heater type of tube, the 227 type, from the standpoint of lack of hum and of general operating characteristics, than they are with the straight a. c. filament tube. It is said that set manufacturers would like to use this type only and to forget the low-voltage, high-current tube. How we run in circles, we radio engineers. Three years ago a heater type of tube, the McCullough, appeared on the market after many demands from those (notably Professor Morecroft in Radio Broadcast) who knew the possibilities of a unipotential cathode tube. In Canada this tube became very popular; in this country the manufacturers sold a comfortable lot of tubes. But in general the tube people, independent and "corporate," have taken a "high hat" attitude about it. And now, perhaps, it will become the preferred tube after all.

Several readers have noted a strange periodic increase and decrease in filament current in a. c. tubes. These fluctuations are reflected, naturally, in signal strength. On one occasion a reader remarked about the fading he noted on his new a. c. set while his neighbors were not so afflicted. What is the reason? Perhaps it is the following:

If an a. c. tube has an open filament or heater, it frequently happens that the broken ends actually make contact so that when the tube is turned on current passes through the filament or heater, causing it to expand in such fashion that the ends are pulled apart. Thereupon the signals disappear and a cooling of the filament or heater takes place. After the cooling process is completed the ends may again come together and signals will be received until expansion causes the ends to part once more. It may happen, too, in some localities, that a severe overvoltage is applied to the heater or filament terminals, due to line fluctuations. The heater tube may get so hot that it refuses to operate. When the voltage goes down the tube cools off and it returns to normal functioning.

The a. c. tube presents a more severe problem than does that of combined B and C voltage supply units. Line fluctuations may cause such changes in the filament, or heater, terminal voltages that the life of the tube is decreased, while in a plate power outfit the increase in plate voltage is balanced by a corresponding increase in C bias and thus the tubes will not be impaired.

Incidentally, the Samson Electric Company take great pride in the production of a power transformer which has a regulation of 5 per cent. That is, the voltage across the secondary at no load is only five per cent. higher than at full load. We understand some transformers have regulations as poor as 50 per cent., which may explain why filter condensers in power supply units are prone to end their useful purpose at odd intervals.

Another peculiar case of "fading," which has nothing to do with a. c. tubes but is mentioned here as an interesting case of possible incorrect diagnosis, has been reported by A. H. Grebe and Company. An owner of a Grebe "Synchrophase" in Atlanta, Georgia, reported severe fading from WSB about two miles distant. A. Gilette Clark, the Grebe engineer who investigated the phenomenon, found that the fading took place in regular intervals, that the maximum signal did not increase beyond a certain value which was normal for a station of WSB's power and distance, but abnormal for a case of ordinary fading in which the peak values of signal strength might be somewhat high, and finally, after a little time, it was discovered that the fading coincided with the passing of a trolley car, starting as the car approached and continuing for some time after the car had passed. This gave a clue upon which to work.

"The most logical explanation that occurred to us," says Mr. Clark, "was that the trolley line, coming so close to the transmitter and receiver, acted as a conductor for 'carrier,' or wired-wireless, propagation of the WSB signals. Instead of coming in a direct line, the signals received by this set probably followed the wires. Now, in technical parlance, we find that if 'standing' waves were present on the trolley wire and track, in the fashion of Lecher wires, the trolley cars might act as sliders along the two parallel wires, reducing the volume delivered to the set as they passed through points of high potential and not affecting it when at the nodes.

"Further investigation with regard to the trolley car clue revealed that the lines of this car service ran directly parallel with the WSB antenna system in Atlanta and almost parallel to the set owner's antenna system, although the course altered slightly at about half way between the station and the point of reception. Since the nodes are one half a wavelength apart and the station's wavelength is 476 meters, the action should take place every time the car moves 238 meters, or about 785 feet."

"Gross Exaggerations"

Another wonderful new invention has come to the attention of the Laboratory. It costs but $4 and anyone wanting a good job can make from $150 to $300 a week selling the gadget to gullible radio listeners! It will:

(1) Eliminate 50 to 90 per cent. of static
(2) Increase volume
(3) Save 30 to 40 per cent. on batteries
(4) Separate short-wavelength stations
(5) Bring in distant stations
(6) Tune-out powerful local stations
(7) Add a stage of amplification to your set

We suspect it is a wave trap, consisting of less than a dime's worth of wire, a cheap variable condenser, a box, and two binding posts.

Interesting Technical Literature

Three booklets have arrived in the Laboratory recently. One is a handsomely bound treatise on Cunningham tubes. It contains, in eighty-four large-size pages, data on all tubes made by this well-known tube manufacturer; characteristic curves, as well as a considerable amount of information that will appeal to all who have read the tube articles appearing from time to time in Radio Broadcast, are also given. The book sells for $2.50.

"The Absorption of Sound by Materials" is the title of Bulletin No. 172 of the Engineering Experiment Station of the University of Illinois. In the Bulletin, Professor Watson describes methods of determining the absorption coefficients of many substances. The bulletin costs twenty cents and should be useful and interesting to studio designers and builders. The "Bureau of Standards Circular No. 300" describes similar data. This latter circular was issued in February, 1926, and can be obtained from the Government Printing Office for five cents.

Meters for Research Workers

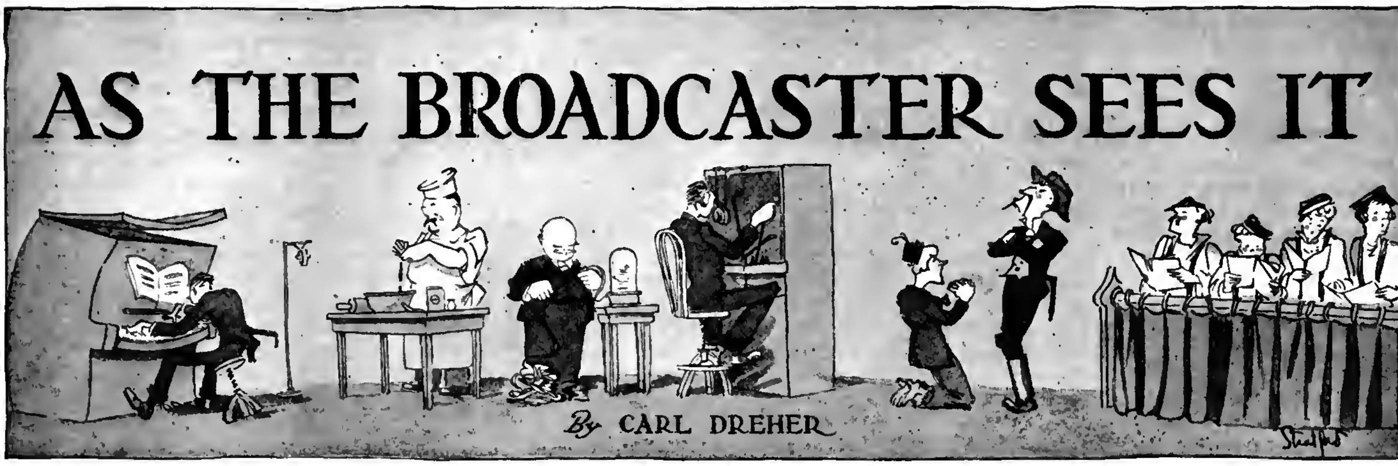
Every laboratory worker takes keen delight in handling beautiful instruments, be they meters for measuring millionths of amperes or Curie balances for weighing radium. A catalogue from the Sensitive Research Instrument Corporation has come to the Laboratory. We regret that we have not known this maker of precision meters before, and are glad to be able to recommend the Sensitive Corporation to readers who are engaged in research requiring microammeters, vacuum thermo-couples, radio frequency-voltmeters, resistances, etc. All direct-current meters from this corporation, even down to the very sensitive meter reading four microamperes at full-scale deflection, are protected by a specially developed fuse wire so that it is impossible to burn out the moving coil system. We feel sure that the makers of Sensitive Research meters will be glad to furnish readers with information regarding their products.

Short-Wave Notes

During the last few months we have listened to short-wave broadcasting from PCJJ, Eindhoven, Holland, and from the experimental station 5 SW at Chelmsford, England, as well as to occasional programs from American short-wave broadcasters. We must admit we are not enthusiastic. The quality is invariably poor, the fading severe, and the whole affair strongly reminiscent of the early days of broadcasting, when any signal was worth getting, so long as it was from a long distance. The quality from Europe may be due to the poor transmission, but more probably is due to what happens between transmitter and receiver, and under the best conditions is not worth listening to except as a stunt.

Ben B. Skeete, radio operator of the S. S. *Samuel Q. Brown*, in a letter dated at Balboa, Canal Zone, December 30, remarks upon the short-wave broadcasting from American stations and brings up one interesting point. This is the fact that fading does not seem to ruin reception of music, while it makes reception of sport events highly unsatisfactory. Perhaps it is because the ear supplies the missing measures of music, while no stretch of imagination will tell one what is happening in the final round of a closely fought boxing contest.

Mr. Skeete states that best reception is had from WGY's experimental transmission on 32.77 and 21.96 meters, that KDKA on 26 meters seems to tune so sharply that it is difficult to get the modulation, that the latter's 62-meter wave is strong but the modulation badly garbled, and that WLW can be heard better on the Pacific coast than in the eastern waters and that it is difficult to get the modulation although the carrier is strong. Perhaps WLW is not modulating the carrier to a very great degree? Station KDKA on 62 meters is heard with great strength and clarity in Garden City. The distance is about 300 miles.



R. F. In Vaudeville

SOME twenty years ago, when most of the great figures in the radio world of to-day were still in the pants business, or sending comments to each other in Morse across the barren acres of West Farms in New York regarding the excellence or otherwise of their "sparks," a popular type of vaudeville act was evolved from the work of Nikola Tesla on high-frequency currents. The Tesla coil consisted of two windings, with non-ferric coupling; the primary was part of a closed oscillating circuit, with a condenser and spark gap. The condenser was charged by a spark coil or high-tension transformer. The secondary of the Tesla coil usually led to a spark gap. The arrangement was no more or less than a wireless transmitter with the open, radiating circuit replaced by another spark gap. In the larger sizes the Tesla coil proper had to be immersed in oil, to control the corona. Very high voltages could be secured at radio frequency. Since the currents passed over the surface of conductors, including the human body, a man could allow potentials of a few million volts to leap to a metal ball held in his hand, without hurting himself, but scaring the wits out of anyone who did not know what he was up to. Hence the vaudeville application. I did it myself on a small scale, with a Tesla coil fed from a quarter-inch spark coil. I proudly published an article on this marvel which, I asserted without fear of contradiction, was the smallest Tesla coil in the world. The secondary was wound on a test tube, and protected by several layers of empire cloth from the primary, which consisted of a few turns of heavy rubber-covered wire. In its full glory the apparatus threw a half-inch spark which stung slightly when taken on the bare skin, but produced no sensation at all if allowed to jump to metal in contact with the body. I astounded my family and the neighborhood with it, at the age of twelve, while various "professors" were profiting by the same stunt at the sublimated nickelodeons, using much larger coils, of course. Incidentally, Doctor Tesla, at that time an electrical investigator of the highest renown, and in his productive period, was something of an amateur vaudeville actor himself, and once sent Sarah Bernhardt into hysterics by sticking his head into a ball of high-frequency fire generated in his laboratory. Bernhardt was harmed more than he was.

But to return to the vaudeville aspect. It sank into partial oblivion for a decade or two, apparently. It is now being revived. In *Variety*, the theatrical magazine, a review appeared a while ago under the following caption: "Bernays Johnson (4), Electrical Novelty, 18 Mins.; One and Full Stage, Hippodrome (V-P)." The review was by the talented "Abel." He put the seal of his approval on the act, devoting a full column to the task, and ending with this sentence: " nson is a natural for thrill exploitation." The grounds for this verdic are worth recounting.

After speaking of the stunt as a "dignified ballyhoo act," Abel pays tribute to Johnson as a "corking showman without being 'professional' or show-wise in his manner of speech or presentation," which begins with a "scientific" exposition before the curtain. Then follow some high-frequency demonstrations, such as the lighting of a lamp without wires, the frying of an egg ditto, and the transmission of the mysterious energy through a bowl of goldfish and the human body, "employing a comely woman for this demonstration." A beautiful girl will help sell anything, as the hosiery manufacturers know. There is also a "defiance-of-gravity" experiment, the idea of which, as explained by Mr. Johnson, is to improve transportation by allowing the traveler to get up into the air quite a way, whereupon the earth obligingly revolves beneath him, until he lets himself down where he wants to go. Jules Verne stuff.

But this is only the introduction. "The big punch in Johnson's act," Abel tells us, "is his billing as 'the man who defies the electric chair.'" The chair is stated to cost $6000. "Johnson announces that he will receive 350 amperes of current through his body, thrice the quantity necessary to electrocute a human being. Johnson states that it is fear which paralyzes an electrocuted person and not the actual juice that kills him, inferring that possibly the ensuing autopsy has something to do with the physical destruction of a condemned murderer. Johnson contends that by keeping cool and dry (perhaps a trying condition for the average death-house victim), one can withstand the shock. On that theory, Johnson presents its demonstration. To further prove that the juice is actually passing through his body, a bar of metal is burnt to white heat from a wire on his person, the dismembered piece is caught in a pan by a 'nurse.' Two male attendants in regulation prisoner's uniform complete the cast."

Of course if even an ampere of honest-to-goodness d.c. or low frequency a.c. passed through Bernays' bones his soul would fly to heaven with the speed of light (300,000 kilometers a second), and his body would fall, a veracious carcass, on the Hippodrome stage. But as he is working well up in the kilo- or megacycles he gets away with his fustian, and no doubt provides good entertainment for the customers. He doesn't let it get under his skin, to use the phrase literally. I am told, however, that he is unable to follow his own advice to the death-house inmates to keep cool and dry. At least, one close-up witness to Brother Johnson's demonstration told me that he (Johnson) was sweating copiously and looked uncomfortably scared while working his magic at the last radio show in New York. He may have been thinking of what would happen to him if his Tesla transformer broke down. Such misgivings would not be irrational. I wish Bernays luck, but, in my capacity as a consulting engineer, bestow on him gratis the advice that he had better filter and dry the oil in the said transformer frequently.

Rosa Ponselle Before the Microphone

I CAN see where singing before the microphone must be simpler in some ways for, say, an opera singer, than performing before an audience. Not as much voice need be used, and acting becomes unimportant. But if anyone thinks that, on the whole, singing for the radio is less complicated than doing it on the stage, he should watch Miss Rosa Ponselle modulate her way through a Victor hour, as I did recently. Lately I have become interested in how great artists get their effects, as far as one can judge outwardly, and wherein they differ from the amiable but depressing amateurs who helped us out in 1923.

Miss Ponselle is a handsome and robustly built young woman, who looks the prima donna and would get a seat in the subway, even in this unchivalrous age, if she ever rode in it. She does not appear at all nervous as she faces the microphone, although there is some tension in her attitude—mainly energy and determination. She stands about three feet from the microphone and not much farther from the conductor, who is one of the regular maestri from the Metropolitan. The orchestra of about thirty-five is behind her, and a mixed chorus of about the same number in back and to one side, fully thirty feet from the transmitters; but they come through very well. Miss Ponselle, when she is in action, does five things; she sings, acts the rôle in a modified way, varies her distance from the microphone, follows the conductor, and watches her own monitor or coach who signals to her from the control booth. Talk about coördination! The last stunt is accomplished as follows: The singer faces a side of the studio in which there is a large window through which she can see the group in the monitoring booth, consisting of a few engineers and program people, maybe a vice-president or two, and Miss Ponselle's assistant. The window is double glass, with an air space intervening, and those on the booth side hear only through a loud speaker. Miss Ponselle weaves back and forth as she sings, varying her distance from the microphone according to the loudness of the passages. During piano portions she advances to a point where her mouth is about eighteen inches from the transmitters, while when she wants to hit a note hard she may get as far away as four feet. By this device she sings the aria so that it sounds natural to her, and at the same time she compresses her volume range, as far as input to the microphones is concerned, for the best results on the air. The control operators have little to worry about, but Miss Ponselle has enough, because, after all, she does not hear the results of her divagations in a loud speaker. Her assistant supplies the loud speaker ear for her. When he considers that she is getting too close he moves his hands apart with the familiar "So big!" gesture of the fisherman; when she is too far from the pick-up he advances the parallel palms of his hands to within a few inches of each other, and when she is hitting it right the coach signals with a short vertical gesture, palms down, quite like an umpire saying "Safe!" to a runner who has just slid into a base. He also nods his head, to reassure the diva still more. Almost all the time she is right, but no doubt she gets considerable comfort from the signalled affirmations to that effect. It is very comical, as she goes more or less mechanically through the actions natural to the aria—clasping her hands on her chest and so on—to see her glancing constantly, with the hundred-thousand candle power eyes which are part of her operatic equipment, now filled with mute appeal quite apart from the beauty of the notes, to see whether she is treating the microphone properly. It is also impressive. Genius, it has been said, is an infinite capacity for taking pains. It is that, partially, and in a broadcast studio as much as anywhere. Maybe one of the obscure girls in the chorus started with a voice as good as Ponselle's, but was too easy-going to get very far with it. All that amounts to saying, of course, is that the difference between a successful opera singer and an ordinary artist is one of character as much as physical equipment, which is no doubt true, especially as no one can say where the one begins and the other ends, nor precisely how they interact.

Miss Ponselle does five things when she broadcasts. But those are only the main heads. Each one of them includes a multitude of minor coördinations. The singing itself, for example—breathing and voice production and diction and all the rest of it. The acting, as I remarked, is somewhat mechanical in a broadcast rendition, but the fact that the artist retains it even when her audience cannot see her shows how intricately such habit-formations are organized. She evidently feels that, if she dropped it altogether, her vocal expression might suffer. As one watches the headliners one realizes, if it was not plain before, that this business of singing and playing is a hard game, if one wants to excel in it. So many things must be done at once, and all timed to a split second. For myself, I return thanks that my feet were never set on that path. I should as soon think of walking a tight-rope stretched over Niagara Falls and at the same time demonstrating Green's theorem in mathematical physics to the newly-weds on the shore.

TWO OF THE 3 LO STUDIOS AT THE MELBOURNE STATION

The illustration on the right shows the main studio of the station. The studio is only partially acoustically treated and the presence of spectators in the wicker benches helps to deaden the room. In both these studios the use of an illuminated device for communicating with the performers while they are before the microphone is shown. This signal system has gradually been abandoned in the United States with the increase in the number of professional microphone performers

Among the Broadcasters

WAAM

WAAM of Newark, around this time of the year, is just getting through with its winter DX re-transmissions. The transmitter, situated in Newark, New Jersey, is fed for this purpose from a battery of receiving sets in a more rural location at Cedar Grove, presided over by no less a distance shark than Paul F. Godley. It was Paul Godley, as no good radio man has forgotten, who first received American amateur signals in Europe, something like six years ago. He sat in a tent on a beach in Scotland, and picked up the signals of U. S. hams on a Beverage wave antenna. The phones kept his ears from freezing. Now he listens in a sort of dug-out underneath a house—what might be called a radio cellar—and probably keeps more comfortable. The DX re-broadcasting starts at about 1 A. M. Several receivers are used, the main one being an eight-tube loop outfit using a.c. tubes, affording four stages of radio amplification, a detector, and three stages of double-impedance audio amplification. The receiver is coupled to the land line leading to the station, either through a transformer or by means of a loud speaker placed before a microphone. I should imagine that the transformer coupling would be preferable. A number of outdoor antennas are available. The procedure of listening and re-broadcasting is quite intricately systematized, there being a scouting operator who catches stations for Mr. Godley, the latter exercising his fine hand only on valuable prospects, such as West Coast broadcasting stations. Mr. Godley listens to the signals as they sound on the air after re-broadcasting, by means of a monitoring receiver tuned to WAAM. Special attention was paid to eliminating electrical noise in the neighborhood of the listening post, so that man-made static has been reduced to a minimum. The DX re-broadcast is said to be a popular feature on WAAM's programs.

WOC

The well and favorably known Davenport, Iowa station stays on its assigned frequency by means of a beat frequency indicator developed by the Washington Radio Laboratories, of Washington, D. C. This device mixes the output of a crystal oscillator, calibrated by the Bureau of Standards, with radio-frequency from the broadcast transmitter. The latter voltage is picked up by means of a small antenna. The two radio-frequency voltages are mixed in a compartment which is shielded from the standard oscillation generator. A beat frequency is produced in the output of a rectifier tube. This beat frequency indicates its presence in two ways. When it is sufficiently high it produces an audible note through a loud speaker. Below about forty cycles per second the indication is visual. A relay capable of following fluctuations up to forty per second lights a green light when the broadcast transmitter is radiating the same frequency as that generated by the standard oscillator. When the transmitter frequency deviates a red light glows, or the red and green lights flicker in alternation. If this frequency is above fifteen per second both lights appear to be lit continuously, owing to the well-known phenomenon of persistence of vision. The operator of course endeavors to keep the transmitter frequency so close to his standard that the green light glows alone, or the two lights alternate very slowly, corresponding to a beat note of only a few cycles per second.

AT PENNANT HILLS, SYDNEY, AUSTRALIA
The transmitting room whence broadcasting programs received in England, Canada, and the United States have issued. In addition to the broadcasting transmitters, there is a marine transmitter at the extreme left, while the other panels form the short-wave set

The device operates on batteries, the voltage of which must naturally be kept constant. Meters are provided for checking. The highest voltage required is 100. Storage batteries are recommended as a source. Like other piezo-electric controls, this indicator must be kept in a constant temperature box if its indications are to be relied upon.

3 LO, Melbourne

WE PRESENT photographs of the studios and control equipment at the Australian station, 3LO. The main studio, it will be noted, contains plenty of wicker settees for visitors. There is room for two hundred in the studio, which is therefore as much an auditorium as a broadcasting studio, and spectators are not merely welcome, but necessary. Every one adds a definite amount to the total absorption of the room, and when the place is filled the period of reverberation is markedly reduced. The platform for the performers is partly covered with carpet, as the picture shows, and the wall nearest the camera is draped. The absorption of this end of the studio is fixed, therefore, and with an audience in the body of the room the period is about right for broadcasting, there being enough reverberation to produce a lively effect, and not enough to set up standing waves and disturbing rattles.

The announcer, it would appear from the picture of the main broadcasting hall, sits at the table on the right and talks into his own microphone. The concert microphone is stage center. Each microphone box is surmounted with a signal lamp. There is also an illuminated device for communicating with the performers during a number; it may be seen hanging from one of the rafters, over the center aisle. This scheme was formerly used at some United States stations—WGY, for example—but with the advent of professional performers it is no longer very serviceable. At most of the large stations many of the artists are on the air several times a week, and they know precisely where to stand and what to do for given effects.

The photograph of the control room shows a good-sized PBX, and an amplifier panel not unlike the American layouts. The boxes on the table may be portable amplifiers.

Sydney, Australia

ANOTHER accompanying photograph gives one a good idea of the transmitting room at the Pennant Hills station whence broadcast programs received in England, Canada, and the United States, have issued. The control table with a monitoring receiver and apparently a small telephone switchboard is in the foreground, with a telegraph table to the right. The transmitter panels stand along the rear wall. The marine transmitter is at the extreme left; the other panels comprise the short-wave set. The design is a combination of panel and pipe-rack construction probably all right if the place doesn't catch fire.

Studio Scandal

MOST tenors start rehearsals with nicely starched collars and cute neckties, only to tear off both before they get halfway through. Few male singers appear in evening dress. The headliners, with occasional exceptions, dress very informally. Soft collars, in blue or some other fairly bright color, are the rule. When WJZ had its studio on Forty-Second Street in New York City one Italian tenor got down to his undershirt on a warm night. He wouldn't sing in his shirt, so what could the studio staff do? But ultra-modern studios are artificially ventilated, so that the air remains at sixty-eight degrees Fahrenheit, winter and summer, while the humidity is kept at the optimum figure of fifty. Thus the artists remain comfortable, although dressed. They are right, however, in taking off whatever incommodes them. The late Victor Herbert, in the year when he conducted the Stadium concerts during the summer in New York, used to rehearse the men clad in his white flannels from the waist down and only B.V.D's from the waist up, on hot mornings. He was a fine old Berserker, and looked better with his chest bared to the zephers than when he appeared, starched perforce, before the *haute monde* in the evening.

Studio Slang

THE operators used to yell, "You're on the air!" when handing the program over to studio or to the field forces. This phrase has changed. "Take it away!" is now *de rigueur*. "It" refers to the program, of course. This phrase seems very picturesque to me and I get a certain kick out of hearing it. The NBC slang for "field" or "outside" annoys me, on the contrary. It is "Nemo" and was originally adopted for purposes of camouflage in some obscure and forgotten contractual tangle. But now that it has become a habit it cannot be eradicated and I expect to hear it for the next forty years, unless broadcasting kills me earlier.

When Orchestra Leaders Sing

THE best conductors seem to have the worst voices, and when they sing a bar to show the musicians what they want even the page boys around the studio snicker behind their handkerchiefs (when they have any). Mr. Setti, the brilliant maestro of the Metropolitan Opera Company who frequently broadcasts incognito, should be excepted. He has a good voice and sometimes sings right through a selection, accompanying the orchestra. He may have been

CONTROL ROOM OF 3 LO, MELBOURNE

an opera singer himself once, before he started conducting for them. Now and then he goes flat, but it does not bother him, for after all his singing is supererogatory. He annoys the control operators, who maintain that his singing interferes with their getting a balance during the rehearsal. But none of them has ever had the nerve to go out and tell him so. They are right; but if a man wants to sing it is generally dangerous to interfere with him. He will let you criticize his wife, his children, and the shape of his head before he will let you stop him from singing when the spirit moves him.

An Engineer's Embarrassment

IT IS true that the more a man is educated, soundly, the less he is surprised at anything. And conversely, if he knows little, he is frequently astonished at perfectly rational behavior which happens to be beyond his comprehension. In the last few months I have had occasion, quite often, to venture into unfinished studios where painters were at work, there to warble various notes or to clap my hands to get some idea of the reverberation. The results have been almost as dreadful as when Mr. Hanson and I invaded a church for a similar purpose, as recounted in these columns a while ago. Some of the painters have nearly fallen off their scaffolds, causing me no small amount of anxiety lest I should give rise to a damage suit against my company. Others have apprehended that I was mocking them, and the looks they directed toward me said as much as that they were ready to paste me in the eye or to go on strike. In most cases I have slunk out after banging my hands together much fewer times than I had intended. Then the painters would glance at each other, and I knew as soon as the sound-proof door closed they would say, "The poor nut!" Well, they may be right, but not on the grounds they thought. What I was doing was just as rational as painting.

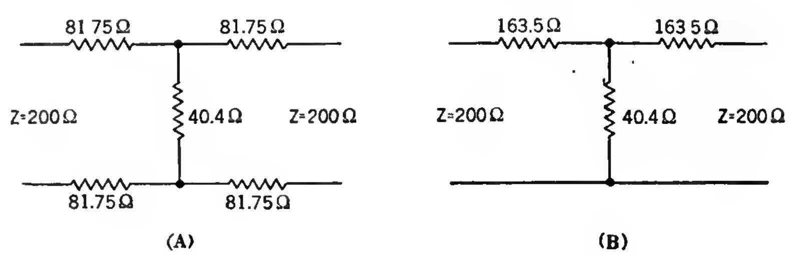


FIG. 1

Radio Inspectors—Fine Fellows

WITHOUT doubt there is something magical about radio. Have you ever considered the remarkable infrequency of bureaucrats among the government employees in the business? The fact that where I have my office now no transmitting apparatus exists, so that the radio inspectors do not visit the place, has made me think of them. The men in the U. S. Supervisors' offices are a fine lot of fellows. It is rarely that an operator is high-hatted by one of them. On the contrary, the inspectors and their assistants frequently go out of their way in order to help some boy in difficulty about his ticket. They form a marked contrast to the poisonous snobs in the naturalization offices, for instance. Maybe part of the difference is due to radio; I like to think so, anyway.

Commercial Publications

THE Daven Radio Corporation, of 158 Summit Street, Newark, New Jersey announces "Super-Daven" resistance units, wire wound, available in values from 10,000 to 3,000,000 ohms, and accurate to within one per cent. The inductance is given as "practically negligible," with the distributed capacity likewise minimized. The temperature coefficient is 0.0001. At a slight additional cost, resistors are furnished with a closer tolerance than one per cent. and with zero temperature coefficient. These units mount in clip holders. The line is offered for use as laboratory standard resistors, voltmeter multipliers, plate and grid resistors, high-voltage regulators, and in telephone and telephoto work. No doubt broadcasters will find uses for them.

J. E. JENKINS & S. E. Adair, of 1500 North Dearborn Parkway, Chicago, describe in their Bulletin No. 5 a wire-wound gain control, Type GL 35. This instrument contains 11 separate resistance units, each wound non-inductively with enameled Nichrome wire. The total resistance is 350,000 ohms, arranged in logarithmic steps, resulting in a straight-line TU variation. The resistance values are good to less than one per cent. The housing is an aluminum shield, the end pieces being three inches square; a depth of $4\frac{3}{4}$ inches is required behind the panel.

IN MARCH we started a review of the pamphlet entitled *Samson Broadcast Amplifier Units*, issued for limited distribution by the Samson Electric Company of Canton, Massachusetts. This detailed review will now be continued. On Page 18 we find a discussion of the design of a volume control arranged in 2-TU steps, with a maximum resistance of 100,000 ohms. The 2-TU drops may be secured by tapping off 79 per cent. of the voltage each time, or 79 per cent. of the resistance, as long as the voltage is proportional to the resistance. The first tap would therefore be at 79,000 ohms. The description is not entirely clear in the pamphlet, and there is an error in that the first tap is given as 59,000 ohms. On Page 19 there is further discussion of gain controls, and the design of one covering a range of 10 TU in 1-TU steps is given. This starts with a minimum, or first tap value, of 161,000 ohms, and continues in progressively increasing steps until the whole 10 TU have been covered. Another potentiometer affords a range of 50 TU in 10 steps of 5 TU each. The total resistance of each device is 500,000 ohms. One of these may be used across the grid and filament of one tube of an amplifier and the other across the input of a succeeding tube, thus providing fine and coarse regulation of gain as required.

The material presented under "Pad Design" will prove extremely useful to many broadcasters although there is no attempt to derive the formulas given nor to adhere to a conspicuously logical sequence in the discussion. The relationship between the impedance on either side of a conventional resistive T- or H-network, the impedances of the legs, and the TU loss introduced, are given at length and worked out to a practical conclusion in the form of a table (Table III). From this tabulation, knowing the TU drop desired, one may read the value of Z_1 and Z_2 for Z equals 200 ohms and Z equals 600 ohms. Z is the impedance on either side of the pad (only bi-laterally symmetrical pads are discussed); Z_1 is the total value of the series or X-legs; Z_2 is the value of the shunt or Y-member. For example, if one requires a 20 TU pad presenting 200 ohms each way, one finds from the table that Z_1 must be 327 ohms, while Z_2 is 40.4 ohms. The result, for an H-network, would be the pad of Fig. 1-A, while if a T-network with the same electrical characteristics is chosen the arrangement will be that of Fig. 1-B. Numerically the difference is simply one of splitting Z_1 into four parts or into two parts, for the corresponding number of legs, depending on whether a balanced network is required or not.

On Page 21 there is apparently an error, L_1 and L_2 having been printed for Z_1 and Z_2, respectively. The article as a whole seems to have been written by an engineer who knew what he was about but had no unusual skill in presenting the subject for the education of others. This defect is not extremely important, inasmuch as most of the people who consult the pamphlet will be more interested in the results than in the procedure required to reach them. In some ways the treatment is more extensive than that given in the article devoted to the same subject in this department for September, 1927, particularly in the working out of the table, but in other respects it is less thorough than the latter, and readers who are much interested in pad design might go back to the September, 1927, RADIO BROADCAST article after reading the Samson pamphlet, and also to the discussion of the General Radio write-up on pads in the January, 1928, RADIO BROADCAST.

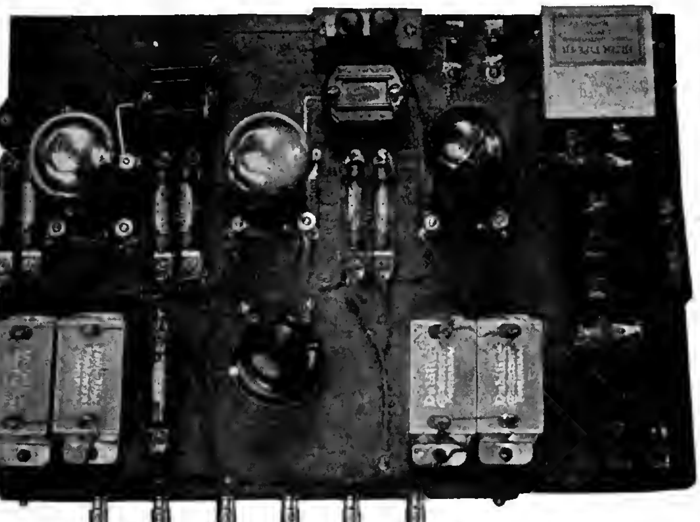
The limits within which all these pad designs hold good are well stated in the Samson booklet, which broadcasters may secure by writing for it on their letter-heads; this portion is well worth quoting:

"It is assumed that the transformer is ideal, that is, that it has a negligible resistance in its windings, and an infinite input impedance with the output windings open-circuited, and vice-versa. It is also assumed that the line or other circuit element into which the transformer is working has pure resistance of the impedance value given as the impedance which the transformer is designed to match. It is also assumed that the transformer has no leakage reactance, that is, that all magnetic flux which links one winding links the other. In order that all these different things may hold, it is necessary that the consideration be based on a certain range over which the transformer practically meets all these conditions, and where those not depending on the transformer hold. Of course, as the frequency is reduced more and more, or as it is increased more and more, below and above this range respectively, these assumptions must fall down. Therefore, it must not be thought that a 'pad is a pad' over all ranges of frequencies. However, over the range that the circuit element is designed to work, these ideas hold very closely, and the simple addition of the attenuation of individual pads to obtain the total attenuation gives the desired working result, and that is the justification for its wide use in communication circles."

No "Motor-Boating"

A Quality Audio Amplifier Which Will Not "Motor-Boat"

By H. O. Ward



RADIO BROADCAST Photograph

A HIGH-QUALITY RESISTANCE-COUPLED AMPLIFIER

The two condensers and the resistance in the lower left-hand corner prevent the amplifier from "motor-boating." The loud speaker connects to the two Fahnestock clips alongside of the output condenser; the two similar clips in the lower right-hand corner are used to read the plate current of the last tube

SEVERAL years ago the resistance-coupled amplifier was much in vogue, and justly so, for it is an excellent type of audio amplifier and is capable of giving practically equal response over the entire audio-frequency range. Its popularity at that time was comparatively short-lived—just why, it is hard to say. Since the introduction of the 240 type tube some time ago, however, there have been indications that the resistance amplifier will stage a comeback.

The amplifier described in this article has a flat frequency response curve from 60 cycles up to about 6000 cycles, it will not "motor-boat" when operated from any ordinary B power unit, and it has a voltage amplification of about 400 from the input of the amplifier to the grid of the power tube. A curve showing the frequency response curve of the amplifier is given in Fig. 1. In Fig. 2 is given the circuit diagram of the amplifier. There is nothing unusual about this amplifier with the exception of the anti "motor-boating" circuit which we have indicated by enclosing it in dotted lines. This anti "motor boating" circuit originated in the engineering department of the E. T. Cunningham Company a short while ago, and the circuit, tested in RADIO BROADCAST Laboratory, has proved very satisfactory. It should be noted that the circuit is arranged so that the plate current of the detector and first audio tubes must pass through resistance R_1.

To test the circuit the amplifier was connected to a B power unit and with the resistance R_1 short-circuited the amplifier immediately began to "motor-boat." As soon as the short-circuit was removed the "motor-boating" stopped. It was found that the value of R_1, necessary to produce stable operation of the amplifier, varies with different B power units. With some power units a resistance of 20,000 ohms is sufficient, while with other power units a resistance of 100,000 ohms is necessary. Since the latter size resistance seems to be effective in all cases, it is suggested that those who construct the amplifier use this value of resistance.

As the plate current of the first tubes in the amplifier and the detector tube must flow through this resistance, it might be thought that there would be an excessive loss in voltage across it. Such is not the case, however, as the following data will show.

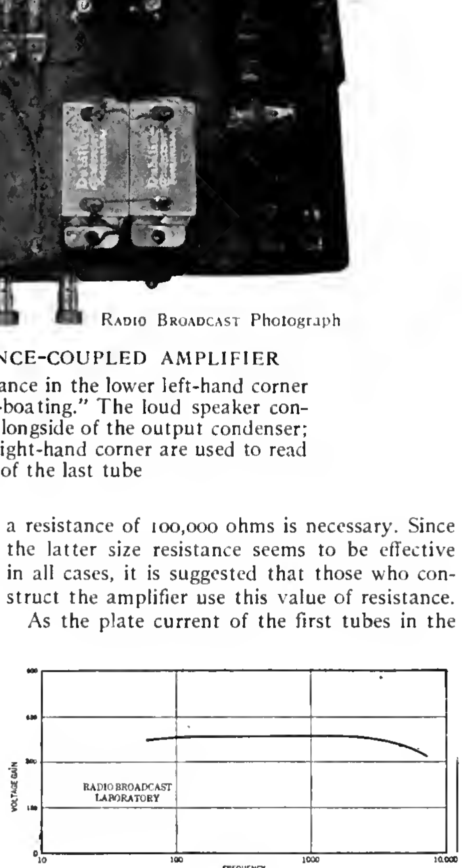


FIG. 1

For this test the amplifier was set up with a detector circuit connected ahead of it. The detector tube used was also a 240 type tube and the same voltage was applied to the detector tube as was applied to the first and second audio tubes in the amplifier.

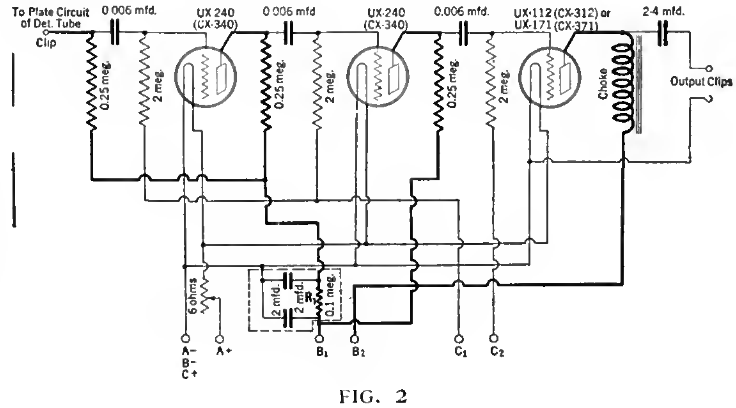


FIG. 2

This table indicates the voltage actually at the plates of the detector and first audio tubes for two different values of applied voltage. A difference of 10 or 20 volts at the plate of a tube will not change the characteristics of the amplifier and since the loss in voltage due to the resistance R_1 is of this order, it is evident that the amplifier will not be affected.

The following data were obtained:

APPLIED VOLTAGE	R_1 OHMS	VOLTAGE AT PLATE: DETECTOR	FIRST AUDIO
135	0	45	83
135	100,000	40	95
190	0	55	115
190	100,000	43	93

The reason that the detector plate voltage is lower than that of the first audio stage for the same values of resistance is because the current drawn by the latter is less than that drawn by the detector.

The recommended values of plate and grid resistances and coupling condensers are as indicated in Fig. 2 and the frequency response curve shows that the values specified give the desired flat characteristic. If larger values of resistances are used the gain of the amplifier will fall off at the high-frequency end. Larger values of coupling condensers tend to better the response at low frequencies but since the response is satisfactory with the values given, it is a waste of money to use any larger condensers unless you have them on hand.

The correct voltages to use on the grids and plates of the three tubes of the amplifier are given below. The letters B_1, C_1 and B_2, C_2 in the table below refer to similar notation in Fig. 2.

1ST AND 2ND AUDIO Tubes

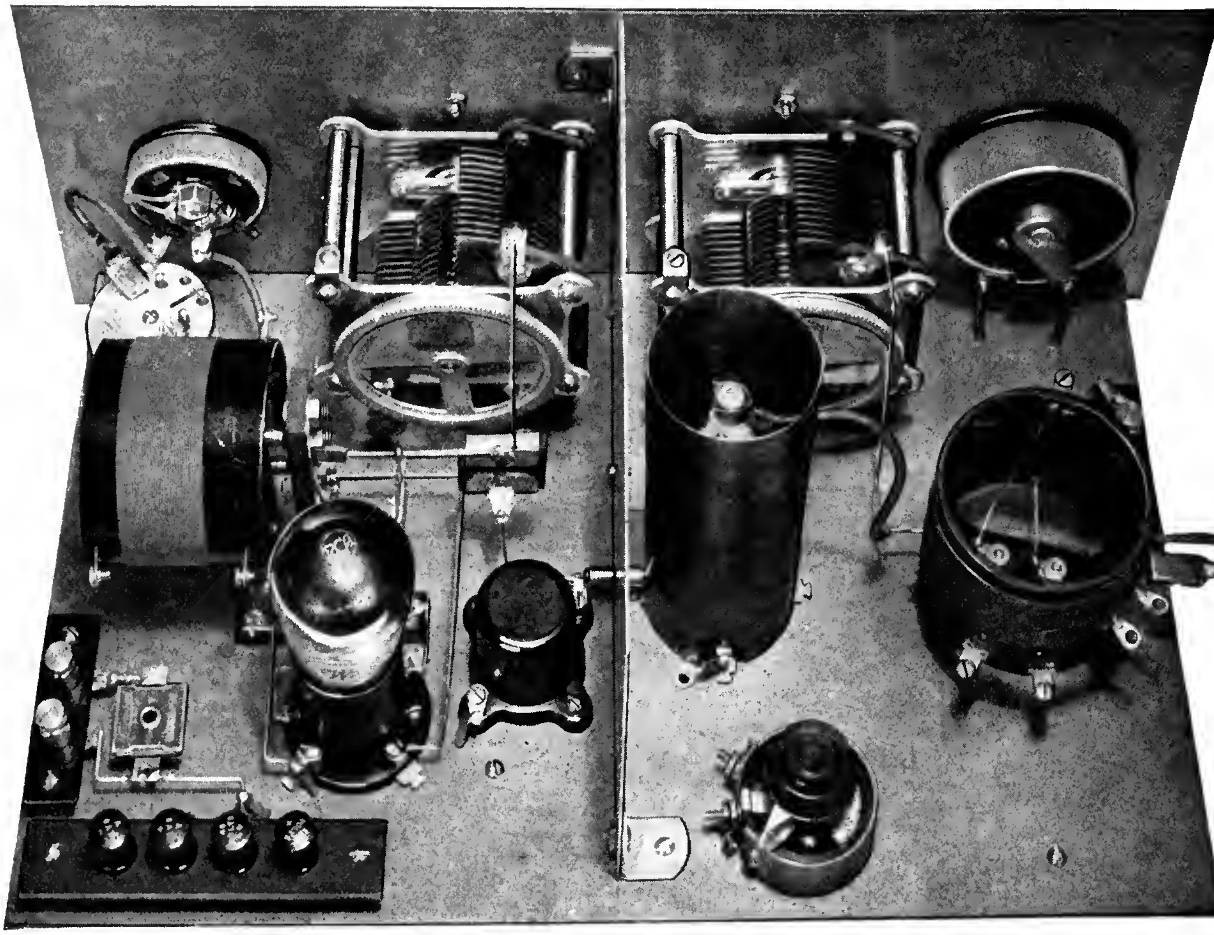
Grid Voltage C_1	*Plate Voltage* B_1
1.0 to 1.5	135
1.5	157
3.0	180

POWER TUBE

112 TYPE *Grid Voltage* C_2	112 TYPE *Plate Voltage* B_2	171 TYPE *Grid Voltage* C_2	171 TYPE *Plate Voltage* B_2
6	90	16.5	90
9	135	27	137
10.5	157	33	157
		40.5	180

The following parts were used in the amplifier:

1—Durham 0.1-Megohm Resistor
3—Durham 0.25-Megohm Resistors
3—Durham 2. 0-Megohm Resistors
3—Sangamo 0.006-Mfd. Fixed Condensers
6—X-L Binding Posts
3—Benjamin Sockets
1—4-mfd. Tobe Condenser
1—Amertran Choke Coil, Type 854
5—Fahnestock Clips
1—6-Ohm Pacent Rheostat
4—1 Mfd. Dubilier Bypass Condensers
3—Lynch Double Resistor Mounts
1—Lynch Single Resistor Mount



A TWO-TUBE SCREEN-GRID RECEIVER

Maximum efficiency is obtained by using metal front and sub-panels while there is also a metal plate between the r.f. and detector tube circuits. The active parts used in this receiver are listed on page 435, and the circuit diagram is also given there. A copper cylinder is used to shield the tube

An Experimental Screen-Grid Receiver

Charles Thomas

THE introduction of the screen-grid tube is most opportune for that section of the radio world which is constantly in search of a new plaything. The UX-222 (CX-322), or screen-grid tube, offers the advantage of an extremely high gain per stage when used with the inside grid as control grid and with a steady polarizing voltage impressed on the screen. As is to be expected, the high amplification factor is accompanied by a very high plate impedance, necessitating a high impedance in the coupling unit if the advantage of the high amplification factor is to be realized to its fullest extent. While the screened-grid tube requires no neutralization, careful shielding is necessary, particularly if several stages are used.

Elaborate shielding is not required if only a single stage is used. For this reason, a single-stage amplifier adapts itself to preliminary experiments with the new tube. The set described here is purely experimental and no claims are made as to the results obtainable. Tests have shown that it is stable, and results in operation approach those obtained with three tuned circuits and fixed input in a three-stage amplifier using standard tubes. The selectivity without regeneration is comparable to that obtained in a normal two-circuit system but the figure of merit of both circuits is somewhat reduced because the first circuit is coupled to the antenna and the second feeds the detector. Two-circuit selectivity is insufficient for broadcasting reception in this country, hence the detector is made regenerative. Regeneration more than compensates the losses in the tuning unit feeding the detector and improves both selectivity and sensitivity.

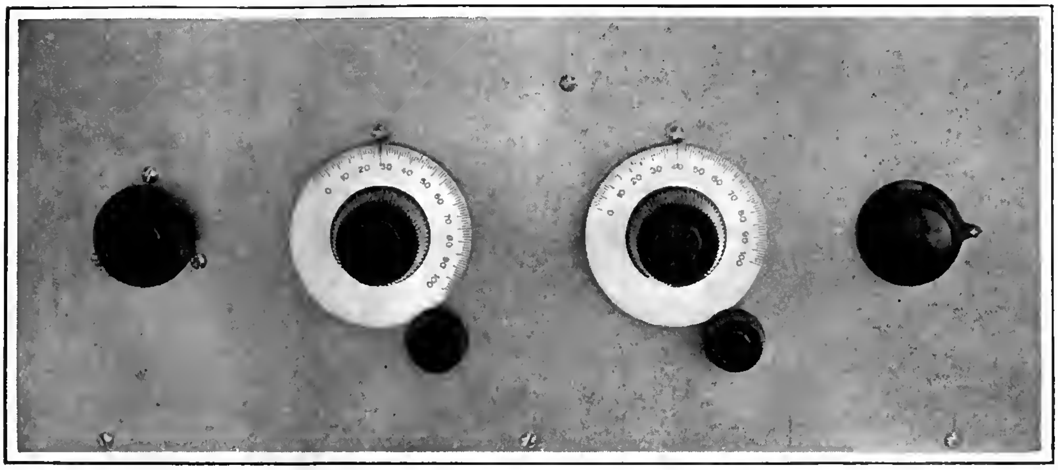
WITHOUT a doubt the screen-grid tube is attracting the attention of every serious experimenter and engineer in the radio field. Readers of RADIO BROADCAST *are by this time familiar with the theory of this tube, and something of its operation and application has already been included in the contents of this magazine. The following brief description of a two-tube tuning unit, to which may be added any audio amplifier, is the forerunner of a construction article telling exactly how to build the receiver. This article, and the completed receiver, which is being thoroughly engineered, are products of a well-known engineer, whose real name, unfortunately must be hidden with a pseudonym. Articles on the new screen-grid tube appeared in* RADIO BROADCAST *as follows: "Applications of the Four-Electrode Tube" December, 1927; "The Screened-grid Tube" January, 1928; The Screened-grid Tube" February, 1928; "A Four-Tube Screened-grid Recever" March, 1928*

—THE EDITOR.

The shielding required, as shown in the photograph, is not very elaborate. Brass panel and baseboard are used, and a brass partition between the two stages is also advisable. The screen-grid tube is enclosed in a copper cylinder which fits closely around the tube and extends about half an inch above it. It is also necessary to shield the short lead between the plate of the screen-grid tube and the detector. In general, shielding is required between all parts of the plate circuit and all parts of the control grid circuit.

The circuit of the experimental set, which includes only detector and radio-frequency amplifier, follows conventional lines. The antenna is coupled through a tapped coil to the control grid of the screen-grid tube. The position of the tap controls to a certain extent the gain and selectivity of the set. Its position must be determined experimentally. The plate of the radio-frequency amplifier is coupled to a tuned impedance. Parallel coupling is used, the d. c. plate circuit going through a radio-frequency choke to the plate supply.

The method of regeneration control is somewhat unusual. The regeneration coil L_4 is not appreciably coupled to the grid circuit. Re-

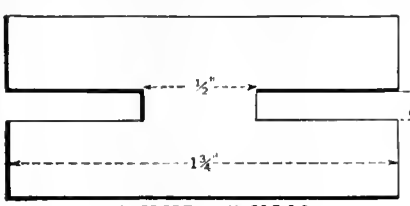


THE FRONT PANEL OF THE TWO-TUBE SET

The two variable condenser dials are made by Genera Radio and they come with the condensers. The smaller knobs provide for vernier tuning. The panel is of aluminum and is 7 x 14 inches in size.

generation is controlled by varying the effective inductance of the plate circuit. The effective value of L_4, shunted by the resistance, is varied by changing R_1. In this type of plate circuit the effective inductance increases with increasing wavelength, which tends to minimize the range of adjustment of the regeneration control as the tuning is varied. So far as sensitivity and selectivity are concerned a plain variometer might be used in the detector plate circuit, or a fixed inductance with a small variable condenser coupling back to the detector grid.

As shown, the circuit is wired for use with a 6-volt battery and 201-A. type detector tube. Satisfactory operation using the method of obtaining regeneration described was not obtained with a 199 type tube as detector. The UY-227 (C-327) a. c. type tube may be used as a detector if a transformer of proper voltage is used to feed the heater. This tuning and detector unit should be satisfactory for use with alternating-current screened-grid tubes when, as, available. The parts used in the receiver shown in the accompanying photographs are as follows:



L_4,93-95 Turns No.30 D.C.C.

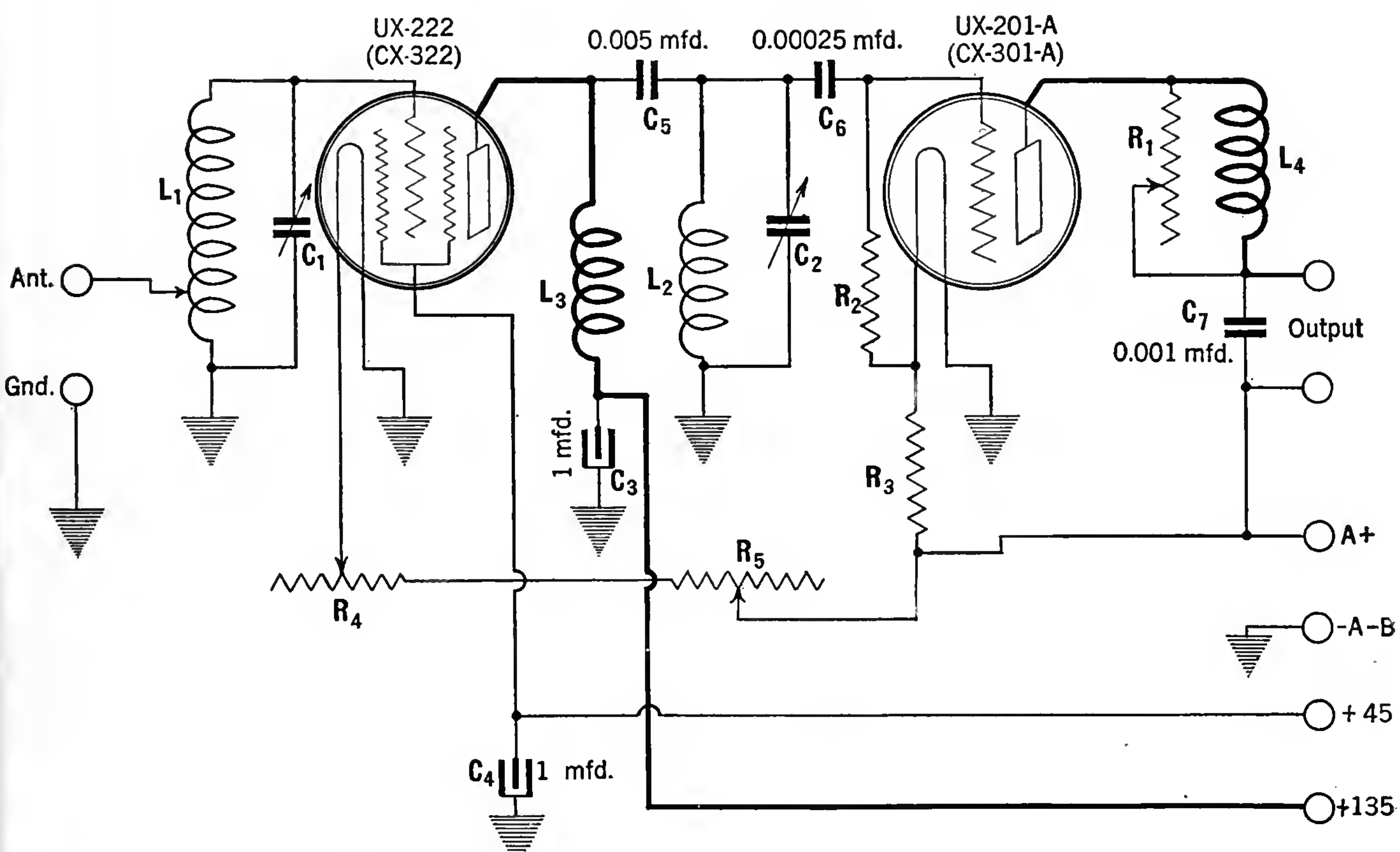
FIG. 1

LIST OF PARTS

L_1 L_2—45 Turns No. 26 D. S. C. $2\frac{3}{4}$'' Diameter
L_3—General Radio No. 37 Choke of 60 Millihenries
L_4—Regeneration Coil (Constructional Data Below)
C_1, C_2—General Radio Type 334 or 247 500-Mmfd. Variable Condensers
C_3, C_4—1-Mfd. Bypass Condensers
C_5—0.005-Mfd. Fixed Condenser
C_6—0.00025-Mfd Fixed Condenser
C_7—0.001-Mfd. Fixed Condenser
R_1—Carter 5000 Ohms, Variable
R_2—3-Carter Megohm Resistor
R_3—4-Ohm Fixed Resistor
R_4—General Radio Type 214 50-Ohm Variable Resistor
R_5—General Radio Type 301 30-Ohm Variable Resistor
Two Sockets
Eight Binding Posts
One Copper Shield for Tube, 2'' Inside Diameter and $5\frac{1}{2}$'' High
One UX-222 (CX-322)
One UX-201-A (CX-301-A)
One Aluminum Front Panel, 7'' x 14''
One Aluminum Sub-Panel, 13'' x 9''
Hardware, Etc.

The construction of the regeneration coil, L_4, is shown in Fig. 1. The coil form is a wooden spool with an inside winding diameter of $\frac{1}{2}$'' and a groove $\frac{1}{8}$'' wide. An outside diameter of $1\frac{3}{4}$'' provides sufficient winding space. A coil wound with 93–95 turns of No. 30 d. c. c. will be found sufficient for the general run of 201-A tubes. Coils L_1 and L_2 may be General Radio coils type 277C with 10 turns removed.

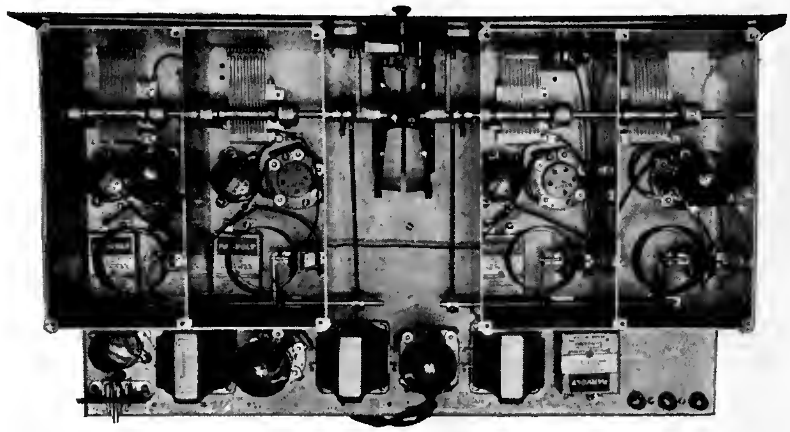
If loud speaker operation is desired, any standard d. c. audio amplifier or a. c. power audio amplifier may be used with this unit.



A SCHEMATIC DIAGRAM OF THE TWO-TUBE SCREEN-GRID RECEIVER

Electrifying the "Hi-Q"

By F. N. Brock



THE "HI-Q" WIRED FOR CUNNINGHAM OR R.C.A. A.C. TUBES

THE Roberts receiver, of which the Hammarlund "Hi-Q" is a semi-commercial model, was first introduced to the radio public by RADIO BROADCAST so many years ago that the author has neither the ambition nor time to go through his files to determine just when Dr. Roberts presented his first article. This momentary reminiscence perhaps has little in common with the point to be discussed in the present writing, but there is significance somewhere in the thought that this is the only circuit, of the many hundreds introduced in broadcasting's nebulous days, that has remained standard and popular to the present time. Simple efficiency is responsible for this consistent popularity.

The 1927–1928 Hammarlund Roberts "Hi-Q," described in RADIO BROADCAST for October, 1927, departed somewhat from previous models in mechanical and electrical design, though the ultimate effects are consistently in line with previous designs. The last two models of the "Hi-Q" receiver have incorporated variable coupling between the radio-frequency primary and secondary circuits. The possibilities of such an arrangement were pointed out by Zeh Bouck in an article appearing in the September, 1926, issue of this magazine, entitled "Higher Efficiencies in R. F. Amplifiers." The argument, in brief, is as follows:

> At every frequency or wavelength there exists an optimum value of coupling between primary and secondary circuits—a value of coupling which provides the maximum signal intensity compatible with quality and stability. This optimum degree of coupling varies, however, with the frequency. To maintain optimum conditions over the entire tuning range, therefore, it is desirable that the coupling be varied with the wavelength. This is accomplished automatically in the Hammarlund-Roberts receiver.

The general characteristics of the Hammarlund "Hi-Q" receiver remain unaltered in the adaptation of this receiver for the use of a. c. tubes, as comparison of the circuits shown in Figs. 1 and 2 with the direct-current arrangement illustrated in the October, 1927, RADIO BROADCAST, will indicate.

The changes effected have merely been in the nature of the substitution of heater type a. c. tubes for the d. c. ones, accompanied by slight alterations in the constants of the circuit to compensate changes in tube characteristics.

The receiver has been redesigned for the use of two different makes of a. c. tubes, the R. C. A. 227 (Cunningham 327) type and the Arcturus a. c. amplifier, detector, and power tubes. The selection of two types of tubes has been suggested by motives of general convenience.

The use of the R. C. A. tube in the "Hi-Q" receiver will be first considered.

The following is a list of the essential parts employed in the construction of the receivers:

- 1 Samson "Symphonic" Transformer
- 1 Samson Type HW-A3 Transformer (3–1 Ratio)
- 4 Hammarlund 0.0005-mfd. Midline Condensers
- 4 Hammarlund "Hi-Q" Six Auto-Coupled Coils
- 4 Hammarlund type RFC-85 R. F. Chokes
- 1 Hammarlund Illuminated Drum Dial
- 1 Sangamo 0.00025-Mfd. Mica Fixed Condenser
- 1 Sangamo 0.0001-Mfd. Mica Fixed Condenser
- 1 Pair Sangamo Grid Leak Clips
- 1 Durham Metalized Resistor, 2 Megohms
- 3 Parvolt 0.5-Mfd. Series A Condensers
- 6 Benjamin No. 9040 Sockets
- 3 Eby Engraved Binding Posts
- 1 Yaxley No. 660 Cable Connector and Cable
- 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.)

For the construction of or adaptation of an existing "Hi-Q" receiver to one employing the 227 type tube the following additional parts were used in the adaptation:

- 5 Benjamin Green Top A. C. 5-Prong Sockets
- 1 Thordarson Type 2504 Filament Transformer (or Karas AC Former)
- 1 T200 Electrad Variable Resistance to Permit Temperature Regulation
- 1 0.5-Mfd. "Parvolt" Series A Condenser
- 1 200-Ohm "Truvolt" Grid Resistance (Electrad)
- 1 Samson 30-Henry Choke or a Samson Type O Output Impedance
- 1 2- or 4-Mfd. Series A "Parvolt" Condenser
- 1 Electrad Type J Resistance for Volume Control
- 5 R. C. A. UY-227 or Cunningham C-327 Tubes
- 1 UX-171-A or CX-371-A power tube.

CONSTRUCTIONAL DETAILS

THE construction of the receiver remains practically identical with that of the direct-current models. The general layout of the parts and the mechanical mountings have been described in detail in articles on the d. c. set and in the Hammarlund Roberts "Hi-Q" Six Manual.

The five-prong sockets are mounted in the same places and with the same screws as the old sockets. An extra hole for the cathode lead must, however, be drilled just under the K or cathode terminal. In the a. c. models of the Hammarlund "Hi-Q" the right-hand control (the rheostat in the battery-type receiver) may be used to control a 110-volt line switch, such as the Carter "Imp" type 115.

The similarity of the a. c. and the d. c. mechanical layouts is evidenced by comparing the accompanying photographs with those of the d. c. models which have frequently appeared.

The circuit of the Hammarlund Roberts "Hi-Q" Six receiver employing type 227 tubes is shown in Fig 1, in reference to which the following points are worthy of mention:

All filament or heater wiring should be made with a twisted conductor. It is desirable that consistency be observed in the socket connections with these power leads. In other words, it is preferable that the same heater terminal on each socket be connected to the same heater lead. This is most readily accomplished by employing a twisted pair of two colors. Corwico flexible red and black Braidite is a convenient recommendation.

The red and green leads on the Yaxley cable are not used.

Heater tubes are employed throughout the circuit (with the exception of the output amplifying stage) due to the simplicity and consist-

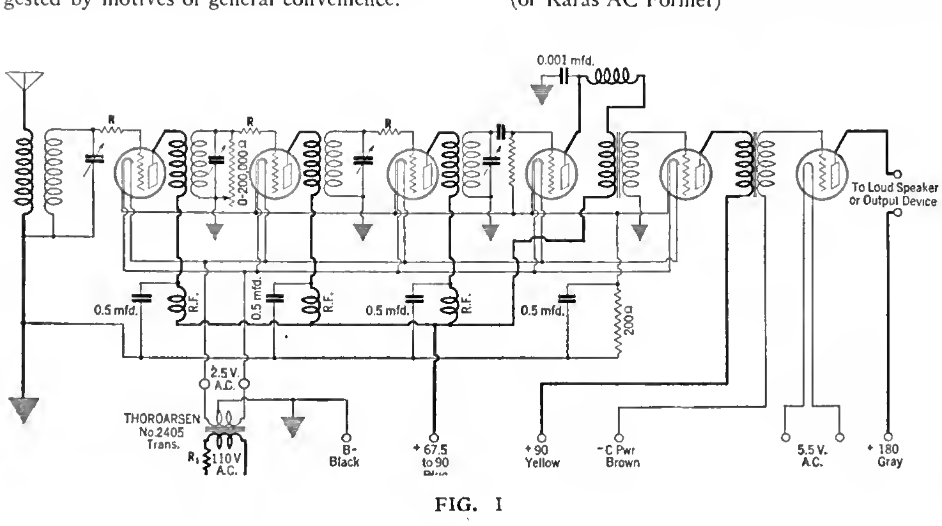


FIG. 1

ency of the circuit arrangement and the low hum characteristics of these tubes.

The Electrad T200 variable resistor is wired in series with the primary of the filament lighting transformer to provide a desirable amount of regulation of the secondary potential. The heaters of the 227 tubes should be operated at as low a temperature as will insure satisfactory reception. With the proper adjustment of the primary resistor it will take about 55 seconds for the tubes to reach an efficient operating temperature after the current is turned on. The life of the tubes will be considerably abbreviated if more than the rated operating filament potential is applied.

The bias to the radio-frequency and first audio transformer tubes is supplied through the drop across the Electrad 200-ohm grid bias resistor.

The pilot light is connected in parallel with the 171-A tube filament.

One side of the 0.5-mfd. bypass condenser across the grid biasing 200-ohm resistor is grounded to the chassis.

Sensitivity and selectivity may be controlled, in the usual manner, by varying the mechanical adjustment controlling the height of the primaries, particularly in the case of the last r. f. stage and the detector stage. Selectivity will also be considerably affected by the tightness of the antenna coupling. In order to attain satisfactory sensitivity and selectivity on the higher frequencies it will occasionally be desirable to use lower values of grid suppressor resistors than those recommended in the d. c. circuit, due to the alteration in the radio-frequency characteristics occasioned by the lower input impedance of the heater cathode type tube. The sensitivity of the receiver may also be increased by employing a higher resistance grid leak. The value of this resistor should, however, be increased cautiously with the possibility of overload on local stations in mind. In the case of a rewired d. c. receiver, originally operating with a radio-frequency plate potential of 67.5 volts from a B supply device, it is desirable to raise the voltage to about 80 to compensate the increased drain. The type J 200,000-ohm resistor is used for a volume control. This is mounted in the left-hand panel hole in the place of the filament switch employed in the battery set. The last three or four turns on the volume control (on the clockwise end, that is) should be clipped in order to give an "open" or maximum volume position.

The potentials, other than the a. c. voltage for the heaters of the tubes, indicated in Fig. 1, may be supplied either from B batteries or from an adequate B supply device, such as the Hammarlund Roberts "Hi-Q" Six power supply described in the Hammarlund Manual. The Thordarson 2504 filament transformer and this power unit will take care of all A, B, and C potentials.

USING ARCTURUS TUBES

FROM an electrical point of view the "Hi-Q" receiver rewired for the use of Arcturus a. c. tubes is practically identical with the 227 type tube design. Mechanically, the Arcturus system offers certain advantages which particularly recommend it for the adaptation of existing battery receivers. Arcturus a. c. tubes are of the four-prong heater type and they plug into the standard UX sockets without the use of adaptors and which, therefore, necessitate neither the use of special sockets nor a comparatively elaborate mechanical rearrangement.

In addition to the essential "Hi-Q" apparatus listed earlier in this article, the following extra components will be required in the adaption or construction of the Arcturus model:

- 1 Electrad Royalty Type J Variable Resistor
- 4 Arcturus Type A. C. 28 Amplifier Tubes
- 1 Arcturus Type A. C. 26 Detector Tube
- 1 Arcturus Type A. C. 30 Power Tube
- 1 Step-Down Transformer, Having a 15-Volt Secondary, Such as the Ives Type 204, or the Thordarson TY-121.

A receiver employing Arcturus tubes is illustrated diagramatically in Fig. 2 and in the accompanying photograph. Referring to Fig. 2, it will be noted that the following alterations have been made on the original d. c. circuit:

The three fixed and one variable filament resistors are eliminated. Similarly all connections between grid returns and filament circuits are broken. The connection between ground and A minus is likewise removed. These changes are best made by completely rewiring the filament or heater circuits with flexible Braidite—red and black wires—twisted into a single pair. Connect the red wire consistently to the positive filament terminals on the sockets. These two leads are wired to the filament lugs on the Yaxley cable post, the red wire being soldered to the plus terminal (polarity, however, being meaningless at this point). Another pair can be led to the switch on the "Hi-Q" which later is connected in series with the *primary* (or 110-volt lead) of the filament lighting transformer for turning on and off the tubes. The switch must not be wired in the conventional manner, *i. e.*, in series with the tubes themselves.

A fifteen-volt pilot light bulb can be secured from any store dealing in electric trains, and should be screwed into the socket provided for this purpose, and wired parallel to the tube circuit.

The grid returns from the radio-frequency amplifier, detector, and first audio-frequency secondaries are brought down to a common lead connected to ground, and this post should also be designated as "C Minus 1.5 volts." The 0.5-mfd. bypass condensers connected from the lower side of the radio-frequency primaries to the filament circuit in the original arrangement should be returned to the plus filament or cathode posts of the respective sockets.

The detector grid leak is disconnected from the A plus terminal of the socket and is brought down to a separate lead or post to be designated as "D Plus 4.5 Volts." The detector r. f. grid return, *i. e.*, the low-potential end of the secondary coil, is wired, as already indicated, to the common radio-frequency grid return

The grid return from the first audio-frequency amplifier is rewired as described, to the post marked "C Minus 1.5 Volts," which is grounded on the receiver. No change is made in the power tube socket.

A separate wire is led to the plus filament or cathode terminal of the detector tube, designated as "B Minus, C Plus, and D Minus."

The zero to 200,000 ohms Electrad Royalty or any other satisfactory variable resistor is connected across the secondary inputting to radio-frequency tube number two, and mounted in place of the rheostat.

Arcturus type a. c. 28 tubes are used in the first, second, and third r. f. stages and in the first a. f. stage. A detector tube, type a. c. 26, is plugged in the detector socket, and a power tube, type a. c. 30, into the power stage, which feeds the loud speaker.

OPERATION

THE operation of the a. c. "Hi-Q" receiver is practically identical with that of the d. c. model. The indicated connections to batteries and transformer should be made.

A. C. heater type tubes do not function efficiently as soon as the heater current is turned on. With the correct voltage (15 volts) applied to the heater terminals of the Arcturus tubes, it requires just 30 seconds for the tubes to heat to the proper operating point. The filament potential should be adjusted by means of the taps on the transformer until satisfactory operation is obtained. It is needless to say that the heaters must be given three to four minutes to cool before making additional adjustments of this nature. It is desirable, wherever possible, to utilize an a. c. voltmeter for the adjustment of the heater potential.

Any efficient B and C socket power device may be substituted for the indicated battery potentials. Briggs and Stratton are marketing an efficient A, B, and C power unit supplying all the necessary potentials for the operation of Arcturus tubes.

The various points mentioned in the recommended adjustments effecting selectivity and sensitivity in the 227 type tube receiver apply equally as well to the Arcturus arrangement.

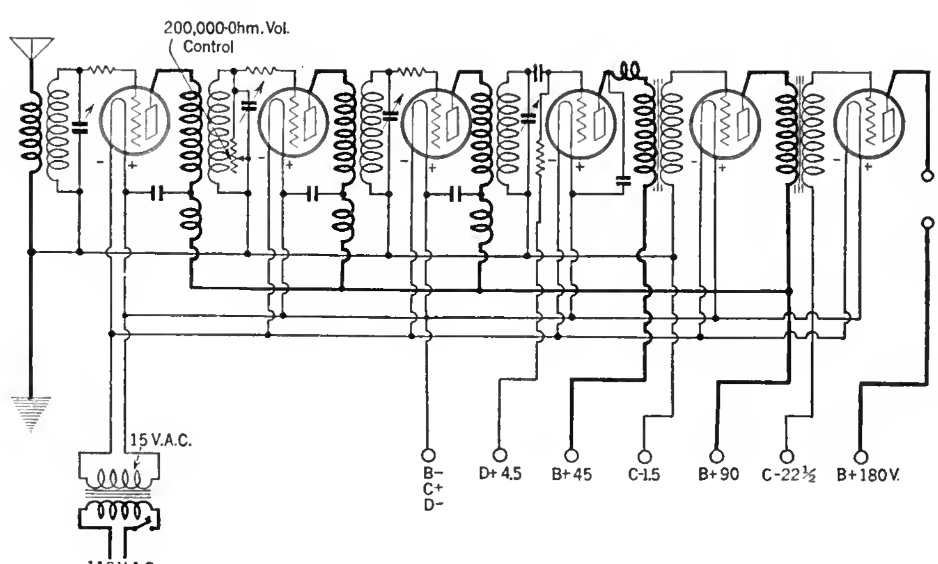


FIG. 2

A COMMERCIALLY AVAILABLE LOFTIN-WHITE RECEIVER
The Arborphone 37-AC set employs 3r.f. stages, detector, and two audio stages. The output audio stage is a push-pull one

An A. C. Loftin-White Receiver

By John F. Rider

PROMPTED by the great interest which hinged on the announcement of the Loftin-White circuit several months ago, the writer has endeavored in this article to describe in brief the outstanding features of a commercial receiver which makes use of this interesting circuit. The receiver in question has much to commend it, not the least important of its features being the fact that it is designed to use the new a.c. tubes.

The Arborphone 37–AC set, for that is its name, comprises three stages of tuned radio-frequency amplification, a non-regenerative detector, and two audio-frequency stages. The last audio stage, as will be seen by reference to the accompanying circuit diagram, is a push-pull one, making use of two parallel 171 type power tubes.

The radio-frequency stages use tuned transformers and a stabilizing system developed as a result of the combined efforts of Messrs. Edward H. Loftin, former Lieutenant-Commander, United States Navy, and S. Young White, a well-known radio engineer. The arrangement used in this receiver is really a modified version of the original, but in its function, is very similar.

This radio-frequency amplifying system accomplishes two things. In the first case it stabilizes the circuit, or the individual stages, whichever way we wish to view it, and secondly, it affords a certain uniformity of response over the tuning frequency spectrum.

A glance at the wiring diagram of the receiver shows the plate supply of the r.f. tubes being fed to the tube through a choke, and the plate coupling coil coupled to the plate through a variable condenser, C. This condenser, because of its function, is greatly responsible for the stabilization of the stage. Its purpose is to change the phase of the alternating potential in the plate circuit due to the a.c. signal impressed upon the grid of that tube, so that it will not combine with the a.c. signal in the grid circuit. The maximum capacity of the phase-shifting condenser employed in such systems is approximately 0.0005 mfd., and it is usually adjusted to a point where the phase shift is such that the stage operates with a definite amount of feedback, or regeneration, which amount, however, is less than that required to cause a continued state of oscillation. The inductance value of the plate feed choke is of such proportion that, when resonated by its distributed capacity, its fundamental is above the longest wavelength which can be tuned-in with the receiver.

Referring to the method of obtaining what is called "constant coupling" between the plate and grid circuits of subsequent tubes, we find the system used differing somewhat from the original Loftin-White arrangement. An idea of the operating principle of the system can be gleaned from a study of the wiring diagram.

The plate and grid coils of the r.f. stages being inductively coupled, a certain amount of mutual inductance exists between the two coils. This mutual inductance is the path of energy transfer between the two coils, but the magnitude of energy transfer varies with the frequency of the signal. The higher the frequency (the shorter the wavelength) the greater the amount of energy transferred. The lower the frequency (the longer the wavelength) the less the energy transferred. But the coupling between the plate and grid circuits is not obtained solely through the mutual inductance between the two coils. The fixed condensers in series with the grid circuits also function as coupling capacities, but their coupling value is governed by the ratio between their own capacity and the capacity of the variable tuning condensers in the grid circuits. Now mutual capacity behaves in a manner opposite to that of inductance, being more effective on the longer wavelengths and less effective on the shorter wavelengths. As the capacity of the tuning condenser is increased when tuning for the longer wavelengths, the effect of the fixed condenser is increased. The converse is true when the receiver is tuned to the shorter wavelengths and the value of the variable condenser is decreased.

A graphical representation of the energy transfer by means of mutual inductance and mutual capacity for a single stage is shown in Fig. 1. An idea of the overall energy transfer as a result of the combined coupling mediums is also shown in Fig 1. The response curve of one stage with the combined coupling mediums is not a perfectly straight line, but has a depression around 300 meters and slightly higher response on the lower end of the broadcast spectrum than on the higher end. These data were obtained after several measurements of different installations which employed the Loftin-White system. The greater amplification on the shorter wavelengths is probably due to inherent regeneration. The complete response curve, however, is of very good formation. The usual capacity of the variable condensers is 0.0005 mfd. and that of the fixed coupling condensers is 0.004 mfd.

The use of a push-pull audio output stage affords certain advantages not obtained when only one tube is employed in the output. First,

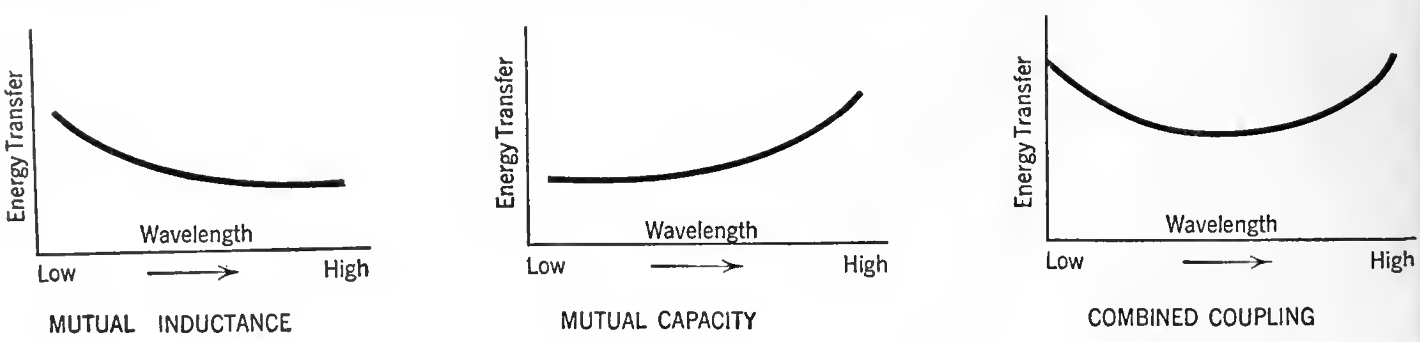
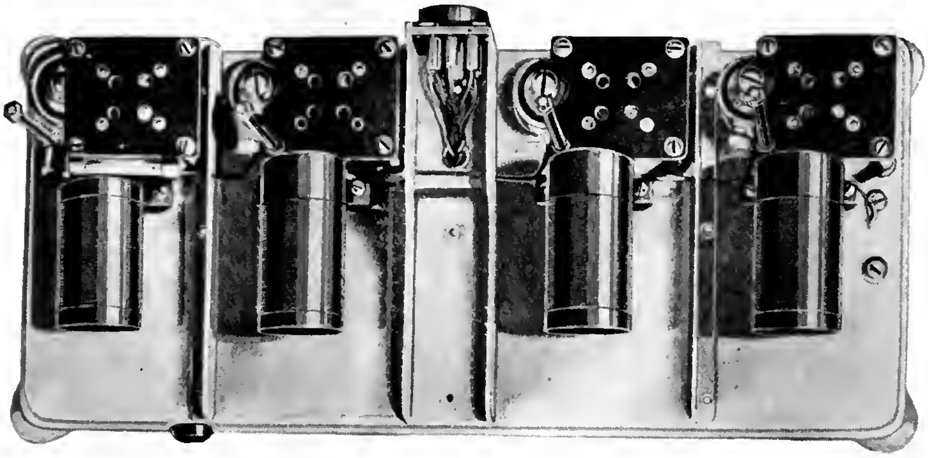


FIG. 1



THE SHIELDED STAGES OF THE RECEIVER

it affords a greater signal output with much less distortion. Secondly, the increase in signal output is greater than the proportion of 1 to 2 tubes because somewhat greater input voltage can be tolerated without overloading or distortion. Thirdly, a push-pull output stage minimizes "hum" due to the use of a.c. on the filaments.

The receiver utilizes 226 type tubes for three radio-frequency amplifiers and the first stage of audio. The detector tube is a 227 and the push-pull output tubes are 171's.

Physically, the receiver is an interesting unit. In the first place the radio-frequency and detector systems are completely isolated from the audio and B power supply units. Each tuning stage is individually shielded, the whole forming one large can. The audio and power supply systems combine to form another shielded unit, thus precluding reaction between the two amplifying systems and minimizing radio-frequency reaction between the power unit and the radio-frequency amplifier. The shielding material is $\frac{1}{32}''$ aluminum of high conductivity and low mass resistance; there is a double thickness between stages. The chassis of the radio-frequency system forms one part of the can and is grounded.

Each can contains the chokes, plate and grid coils, the necessary phase shifting and coupling condenser, and the tube socket. Single-layer solenoids are used for the radio-frequency transformers and are placed parallel to each other. Reaction between these inductances is eliminated by means of the shielding. The phase shifting condenser and its associated radio-frequency choke are located adjacent to the socket connected thereto. The adjustment of the capacity of the phase shifting condenser is accomplished by means of a protruding screw head.

The inductances are wound on bakelite tubes and the turns are spaced 0.002" by means of a machine, as the coil is wound. A layer of collodion sprayed upon the turns keeps them in place. The inductance value of these coils is such that, with the condensers used, the wavelength range is from 200 to 550 meters (1500 to 545 kc.)

The plug located between the two inner sockets and in the groove reserved for the drum dial, carries the connections for the plate and filaments of the tubes in the radio-frequency and detector portion of this receiver. The female portion of this plug is located in the container housing the audio amplifier and the power supply, and the power is fed to the r.f. system by means of this plug.

Rigid sockets are utilized for all tubes, thus showing that very little concern is placed upon the necessity of cushion sockets in the modern receiver. It seems as if we have very little to worry about microphonic tubes. A rigid socket appears satisfactory for the detector tube.

Four tuning condensers are used, one for each stage of radio-frequency amplification. All four are simultaneously controlled from one point and are actuated by means of a small knob attached to a drum dial. The four condensers are divided into two groups of two each, the rotors of each group being on one shaft. The two groups are then coupled together by means of a steel coupling unit. The condenser which tunes the input stage is so arranged that its rotor operates in conjunction with the other rotors, but its stator is located on a rocker arm, which can be actuated by means of a small knob located on the receiver panel. In this way it is possible to make easy adjustment to compensate antenna variations.

The condensers are of the straight wavelength-line type and are very accurately and rigidly made. The bearings are of fabricated bakelite on steel. The condenser plates are wedged into grooves in the side spacers. All grooves are simultaneously milled with a gang cutter, hence the spaces are uniform. Supplementing this design, in the effort to obtain accurancy, short, stubby plates are used in place of long, thin ones. Bakelite end plates are used on the condensers and this material is used for insulating the rotor from the stator.

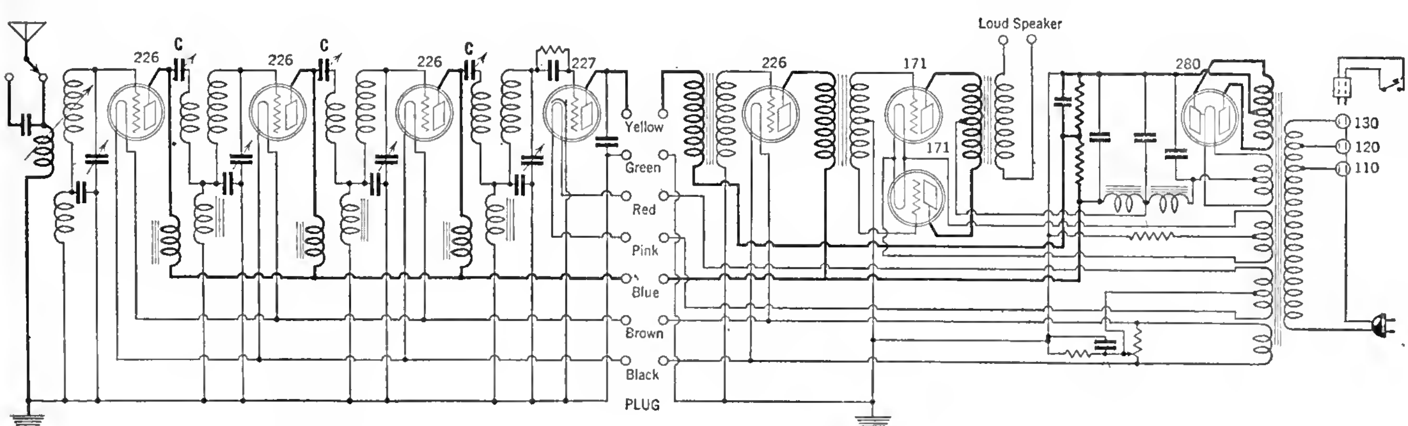
The method of testing the variable condensers and the inductances is novel and precise. Two radio-frequency oscillators are adjusted for beat note resonance. One unit is maintained as the standard. The condenser to be tested is applied to the other. Perfect uniformity would mean a zero beat. The tolerance value is a 200-cycle beat note.

The B supply comprises a full-wave rectifier employing a 280 tube. One transformer carries the windings necessary to supply the filament voltages for all the tubes used in the receiver. One winding supplies the 1.5 volts required for the 226's; another winding supplies the 2.5 volts for the 227; a third supplies the 5 volts necessary for the 171's; a fourth supplies the filament voltage for the 280 tube; a fifth supplies the plate voltage for the rectifier tube.

The primary winding of the power transformer is tapped for 110-, 120-, and 130-volt supply. A short-circuiting plug shorts a portion of the winding when the line supply is 110 volts. The entire winding is used for 130-volt systems. All filament windings, with the exception of the 226 winding, are mid-tapped right in the transformer, thus eliminating necessity for mid-tap resistances and adjustments. The 226 winding is equipped with a potentiometer shunt, whereby the correct electrical center can be obtained.

The B supply utilizes a two-section filter, incorporating two chokes and three reservoir condensers. The plate current for the 171's is caused to flow through only one choke, the filtering action of this one section being sufficient for the push-pull tube plates. The voltage reducing resistance is, therefore, a single mid-tapped unit arranged as a potentiometer across the power-unit output. The high end of this resistance supplies the 90 volts required for the plates of the first audio stage and the three radio-frequency amplifiers. This tap is fixed in the process of manufacture. The mid-tap of this resistance supplies the 45 volts for the detector tube plate.

All C bias voltages are obtained directly from the B unit. Because of the heavy plate current drain of the two 171's (approximately 38 to 40 mils.), it is necessary to isolate the loud-speaker winding. This is accomplished by means of an output transformer.



THE CIRCUIT DIAGRAM OF THE LOFTIN-WHITE RECEIVER DESCRIBED IN THIS ARTICLE

Radio Folk You Should Know

3. Lester L. Jones

AS PRESIDENT of the Technidyne Corporation in New York, Lester L. Jones plays an important rôle in radio research and laboratory investigation. His academic training as an engineer was received at the College of the City of New York, which, during the years when Alfred N. Goldsmith was a professor there, probably ranked as the foremost scholastic source of radio engineering personnel in the country. Mr. Jones graduated in 1913 with the degree of Bachelor of Science, *cum laude*. During the summer following his graduation he pursued special work at the College laboratories in various problems of radio engineering, including determination of the action of underground antenna systems, studies of the heterodyne system, using a Poulsen arc, and investigation of the characteristics of the then modern German quenched spark transmitters. The heterodyne tests were conducted in part with the Bush Terminal station of the National Electric Signaling Company, and presumably Mr. John V. L. Hogan was present at the Brooklyn end of the circuit.

In the winter of 1913 Mr. Jones was engaged as a civilian inspector of electrical and radio materials at the Brooklyn Navy Yard. He was responsible for the testing of all the radio transmitting and receiving equipment purchased by the Navy Department and delivered to the New York yard. In about a year this work led to Mr. Jones's promotion to the position of Expert Radio Aide, which included not only the former inspection responsibilities, but also the planning and testing of complete radio installations on battleships, destroyers, and submarines. While he was engaged in these specialized tasks Mr. Jones did not neglect the other branches of radio engineering, and the early issues of the "Proceedings of the Institute of Radio Engineers" frequently contain his name as a participant in the discussions, which were recorded at that time by the devestatingly charming Miss Nan Malkind, the only skilled and accurate radio stenographer who has ever appeared in the art. In the 1914 "Proceedings," for example, there appeared a learned discussion by Mr. Jones on the subject of why the audion bulb causes a click in the receiving telephones when the filament current is shut off. Dr. Lee De Forest, the author of the paper that evening, observed laconically, "This is probably the correct explanation," a remark which must have been pleasing to the younger engineer, and which has been preserved for posterity in the "Proceedings," together with many words of contrasting asperity.

As an Expert Radio Aide Mr. Jones was not confined to the New York Navy Yard. At various times his duties carried him to outlying land stations of the Navy Department, such as the post at Guantanamo, Cuba, to suggest improvements and to supervise installations of new apparatus. The position also included design of transmitting equipment for the special conditions of naval radio communication, supervision of manufacture, installation, and testing of models, and the preparation of specifications under which contracts were let for the furnishing of sets in quantity by commercial manufacturers.

The New York yard was primarily a transmitter-developing base. In 1917 Mr. Jones was transferred to the Washington yard, which specialized in naval receiver design and investigation. During the year and a quarter Mr. Jones spent at Washington, he was the civilian in charge of development of naval receiving equipment for use on battleships, submarines, and airplanes, including the well-known two-stage audio amplifier with non-ferric transformer coupling, which became the despair of many a graduate of the Harvard Radio School, although it was probably the best thing in its line at that period. The Washington Yard, incidentally, has some claim to rank with Brant Rock, the Aldene factory of the Marconi Company, and the G. E. test shop at Schenectady, as a nursery of famous radio men. Besides Mr. Jones, at various times during the war period Professor Hazeltine, William H. Priess, Joseph D. R. Freed, and others worked there on the SE line of naval receivers and auxiliary apparatus.

In addition to these more or less orthodox radio duties, Mr. Jones was charged with investigation of war-time devices offered to the government by inventors confident that the offspring of their brains was required to beat the Germans. Machines for detecting submarines and killing the magnetos of aeroplanes were among them. Some of the ideas were insane and others offered practical possibilities. Only scientific analysis could separate the chaff from the wheat. But Mr. Jones did not spend all his time on radio development and related investigations at the Washington yard. At intervals he made observation trips in naval craft, in connection with submarine signaling, search-light communication, and other special problems.

Mr. Jones left the service of the Navy Department in the spring of 1918 and spent a short time in the employ of commercial radio companies which were supplying apparatus to the Army and Navy. In 1919 he established himself as a consulting engineer specializing in radio. Among his clients (in 1920–21) were the Mackay interests, then contemplating establishing their own transatlantic radio circuits on behalf of the Postal Telegraph-Commercial Cable system. The developments considered at that time have only recently been projected anew in the announcement of the Postal Company that long- and short-wave radio channels are to be operated as adjuncts to the cable circuits of the company.

Mr. Jones has patented numerous radio inventions at home and abroad. In December, 1925, he was elected a Fellow of the Institute of Radio Engineers. His career is an illustration of the value of broad technical training and experience in the radio engineering field. For every prominent radio man in the technical end who entered the business when broadcasting began to agitate the ether in 1920, there are ten who spent years in developing radio telegraph communication, while wireless telephony was still a poet's dream.

The Month's New Phonograph Records

Pagliacci—No Pagliacci Non Son! (Leoncavallo). By Giovanni Martinelli (Victor). Martinelli's powerful tenor voice combined with his dramatic ability fit him eminently to sing the emotional Leoncavallo music. He handles these two glorious selections magnificently.

Andrea Chenier Improvviso—Come un bel di, Parts 1 and 2 (Giordano). By Arnoldo Lindi (Columbia). An imported recording of a fine Italian tenor who just misses being better than that.

Mazurka in B Minor (Chopin) and *La Campanella* (Liszt-Busoni). By Ignaz Friedman (Columbia). We would like to enthuse over this record because the Columbia Company has done an excellent job of recording Mr. Friedman's fine display of piano technique in *La Campanella*, but how *can* one enthuse over passionless music?

Dubinuschka and (a) *Old Forgotten Waltz* and (b) *Bouran* by the A. & P. Gypsies (Brunswick). If there is aught of the spirit of Terpsichore in you these gypsyish rhythms will make you yearn to express yourself in dance. Meaning: our grading of this offering—50 per cent.

Traumerei (Schuman) and *Mazurka in A Minor* (Chopin-Kreisler). By Max Rosen (Brunswick). Adequate violin solos unemotionally delivered.

Don't Miss These New Records

Andante Cantabile (Tschaikowsky) and *Theme and Variations* (Haydn) played by the Elman String Quartet (Victor).

Pagliacci—Vesti la Giubba and *Pagliacci—No Pagliacci Non Son!* (Leoncavallo) sung by Giovanni Martinelli (Victor).

Cradle Song (Brahms-Grainger) and *Molly on the Shore* (Grainger) played by Percy Grainger (Columbia).

Voices of Spring and *Enjoy Your Life* (Strauss) played by Johann Strauss and Symphony Orchestra (Columbia).

Dubinuschka and (a) *Old Forgotten Waltz* and (b) *Bouran* by the A. & P. Gypsies (Brunswick).

'S Wonderful and *My One and Only* (Gershwin) by the Ipana Troubadours and Clicquot Club Eskimos respectively. (Columbia).

My Heart Stood Still and *I Feel at Home With You* by George Olsen (Victor).

I Live, I Die For You and *Eyes That Love* by the Troubadours (Victor).

Beautiful Ohio and *Missouri Waltz* by Paul Whiteman and His Orchestra (Victor).

A Shady Tree and *Dancing Tambourine* by Paul Whiteman and His Orchestra (Victor).

WE ARE beginning to comprehend vaguely the extent of the phonograph industry. That we had not done so before is due to the fact that we never could visualize figures. Units, tens, and hundreds we can manage very well but when the thousand mark has been passed our brain reels, and the very numbers jump before our eyes. And so, although we knew that some sixteen hundred recordings were made annually by the Victor, Brunswick, and Columbia companies, we were not impressed because the figure was meaningless. Now we have a dim idea. An average of thirty-four records a month have been reviewed in this department for the last four months. Our statistical department reports that this totals one hundred and thirty-six records. These records occupy a considerable portion of our apartment, to be exact, a couch, a large mahogany office desk, one stool, and three chairs, not to mention the overflow on the floor. Walking has become dangerous and sitting is well nigh impossible. In another four months the records will have reached the kitchen and we will be forced to take our meals out. If we ever review *all* the records each month we will move into Carnegie Hall. Nice little industry!

Many of these we could lose without a tear. Then again there are those we will cherish forever. Already we have formed a permanent attachment for some of this month's supply: two selections from *Il Pagliacci* sung by Giovanni Martinelli, a Percy Grainger record, two delightful numbers by the Elman String Quartet, two old and one new waltz from the Whiteman organization, and several better-than-usual dance numbers by the usual dance orchestras. These have gone into our library. Into the ash can we would like to put a Ted Lewis record and an Al Jolson song. The rest are chiefly dance records which will provide good entertainment for the moment.

We welcome the appearance of eight waltz numbers. We hope that means that the waltz is coming back but there have been so many false alarms already that we refuse to send out searching parties for our old waltz partners, yet. In the meantime we waltz alone in the privacy of our home.

More or Less Classic

Andante Cantabile (from String Quartet, Op. 11, by Tschaikowsky) and *Theme and Variations* (from *The Emperor Quartet* by Haydn). By the Elman String Quartet (Victor). Delicate chamber music exquisitely played by Mischa Elman, Edward Bachmann, William Schubert and Horace Britt. Both performances are richly colored by the beautiful tone of the Elman violin.

Pagliacci—Vesti la Giubba (Leoncavallo) and

Cradle Song (Brahms--Grainger) and *Molly on the Shore* (Grainger). By Percy Grainger (Columbia). To realize how thrillingly alive piano music can be one should hear the vibrant beauty of Grainger's rendition of *The Cradle Song*. *Molly on the Shore* is the familiar Irish reel, jovially played by its composer.

La Boheme: Musetta's Waltz Song (Puccini) and *Mignon: Connais-tu le Pays?* (Thomas). By Maria Kurenko (Columbia). One moment we like this soprano voice exceedingly and the next it develops a harsh pinched nasal quality which is most unpleasant. In spite of this shortcoming we liked *Mignon*.

Voices of Spring and *Enjoy Your Life* (Strauss). By Johann Strauss and Symphony Orchestra (Columbia). Strauss waltzes beautifully played. Need we say more?

Do You Call That Religion and *Honey* by the Utica Institute Jubilee Singers (Victor). Two of the best songs in the repertory of this Negro quartet, sung with the subtle harmony which only Negro voices can achieve.

"Popular" and Such

'S Wonderful by the Ipana Troubadours and *My One and Only* by the Clicquot Club Eskimos (Columbia). *'S Wonderful* now holds first place in our own personal Best Number of the Year Contest. It is a swell Gershwin song and the Troubadours have done it full justice. The Eskimos were not quite as successful with the other Gershwin number but it is worth honorable mention.

My Heart Stood Still and *I Feel at Home With You* by George Olsen (Victor). The A side is runner-up in our contest but the B is a comedown.

(Note: If you want to be a social success you can't afford to be without both the above-mentioned records.)

Together, We Two and *Give Me a Night in June* by Johnny Johnson and His Statler Pennsylvanians (Victor). Despite their age these two numbers remain vigorous, due to the excellent Johnson rejuvenation.

A Shady Tree and *Dancing Tambourine* by Paul Whiteman and His Orchestra (Victor). Your neighbors will cry for, not at, this record. The waltz with its haunting melody is our favorite.

Beautiful Ohio and *Missouri Waltz* by Paul Whiteman and His Orchestra (Victor). Beautiful revivals of the fittest.

I Live, I Die For You and *Eyes That Love* by the Troubadours (Victor). Both these numbers from "The Love Call" have good tunes as backgrounds. Vocal refrains by Lewis James help put them across.

There's One Little Girl Who Loves Me by the Ipana Troubadours and *What'll You Do?* by Leo Reisman and His Orchestra (Columbia). Two melodious dance numbers with a good chorus by Scrappy Lambert in the first.

'S Wonderful and *Funny Face* by Bernie Cummins and His Orchestra (Brunswick). This orchestra unfortunately misses most of the Gershwin subtlety and messes up the Gershwin time, but they can't completely ruin either of the songs.

I'm in Heaven When I See You Smile—Diane and *Worryin'* by the Regent Club Orchestra. (Brunswick). Two good languorous waltzes with old fashioned whistling effects.

The Hours I Spent With You and *An Old Guitar and An Old Refrain* by Roger Wolfe Kahn and His Orchestra with vocal refrains by Franklyn Baur (Victor). The first is a fair waltz. The second is called a fox trot but it cries out to be tangoed to!

Up in the Clouds and *Thinking of You* by Nat Shilkret and the Victor Orchestra (Victor). Hot and snappy in the usual Shilkret manner.

There's a Cradle in Caroline by Nat Shilkret (Victor). Why didn't Mrs. Victor let Shilkret show the rest of them how to do it at the beginning? *The Song is Ended* by George Olsen and His Music. A good interpretation of a good waltz with a vocal chorus that's terrible!

Down the Old Church Aisle and *Is Everybody Happy Now?* by Ted Lewis and His Band (Columbia). The first number stirs unpleasant memories. Has Ted Lewis been robbing the song cemetery? If so, he'd better replace the corpse. And, oh, Mister Lewis! lay the second number beside the first, while you're at it.

From Saturday Night Till Monday Morning and *She'll Never Find a Fellow Like Me* by Ted Weems and His Orchestra (Victor). At last, a new idea in lyrics! *And* a catchy tune well played. We refer, of course, to the first number; the second is just a really good song on the old, old idea.

Dear, On a Night Like This by Cass Hagan and His Park Central Hotel Orchestra and *I'll Think of You* by Al Lentz and His Orchestra (Columbia). Two smooth, gliding fox trots, if you know what we mean.

Thinking of You and *Up in the Clouds* by Harry Archer and His Orchestra (Brunswick). Direction without enthusiasm.

Where Is My Meyer? by Nat Shilkret and the Victor Orchestra and *Blue Baby* by George Olsen and His Music (Victor). Fast-moving numbers handled by experts.

Make My Cot Where The Cot-Cot-Cotton Grows and *Sugar* by Red Nichols' Stompers (Victor). Why, this orchestra must have been up all night! Or, how do you explain the monotony?

Wherever You Are and *Headin' For Harlem* by Nat Shilkret and the Victor Orchestra (Victor). Franklyn Baur helps the orchestra make the best of two fair numbers.

Worryin' by Don Voorhees and His Orchestra and *Where in the World* by The Cavaliers (Columbia). If they got rid of their worries they might play better, or perhaps it's the song. The other number is not much better.

The Song Is Ended by the Columbians (Columbia). "But the melody lingers on." And why not? It's a good one and well treated by the Columbians. *There Must Be Somebody Else* by the Radiolites. Nice orchestration and a good vocal chorus by Scrappy Lambert, formerly one half of the Trade and Mark combination.

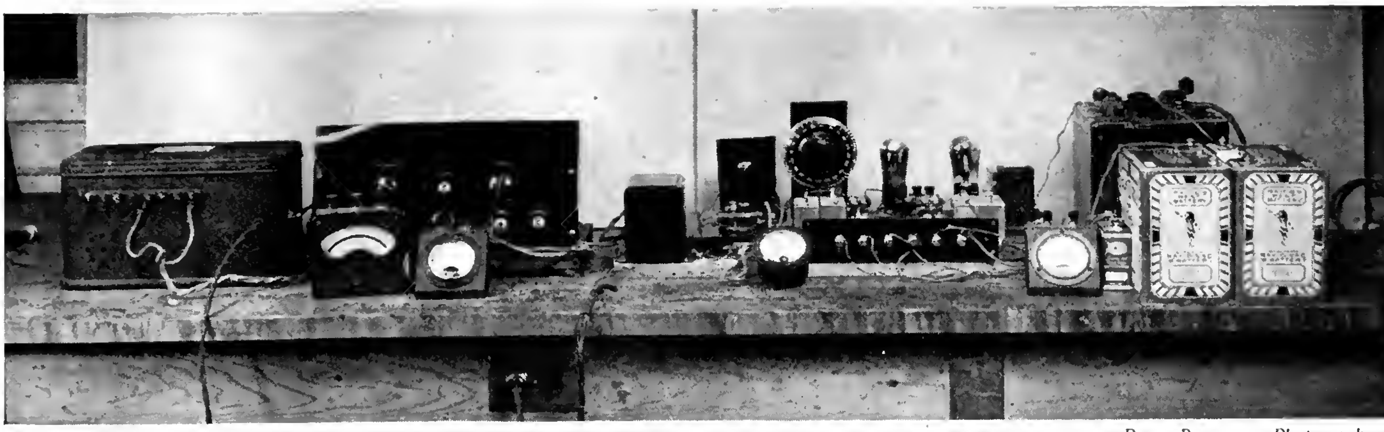
Mother of Mine, I Still Have You and *Blue River* by Al Jolson and William F. Wirges and His Orchestra (Brunswick). Just your mother's boy, aren't you, Al?

Two Black Crows, Parts 5 and 6, by Moran and Mack (Columbia). More an' more Moran and Mack.

Good Records of Operas You Have Heard

DURING the current radio season, parts of many great and popular operas have been heard in the Balkite Hour, relayed from Chicago with the Chicago Civic Opera Company. And on the N. B. C. Networks, many well-liked operas have been done in tabloid form by the National Grand Opera Company. New electrical recordings of some of the most popular operas are offered by the leading phonograph companies. Some of these listed below are new, some not so new, but all are excellent and worth adding to one's collection.

	Aida (Verdi)	
Celeste Aida	Giovanni Martinelli	*Victor*
Celeste Aida	Ulysses Lappas	*Columbia*
Ritorna vincitor / *O patria mia*	Elisabeth Rethberg	*Brunswick*
La fatal pietra / *Morir! si pura e bella!*	Ponselle-Martinelli	*Victor*
Grand March	Columbia Symphony Orchestra	*Columbia*
Nel fiero anelito / *O terra addio*	G. Arangi-Lombardi and Francesco Merli	*Columbia*
	Faust (Gounod)	
Air des Bijoux	Edith Mason	*Brunswick*
Le Roi de Thule	Florence Easton	*Brunswick*
Parlate d'amore	Margarete Matzenauer	*Victor*
Ballet music (four parts on two records)	Sir H. J. Wood and the New Queen's Hall Orchestra	*Columbia*
Soldiers' Chorus	Victor Male Chorus	*Victor*
Serenade Mephistopheles	Marcel Journet	*Victor*
Duet from Garden Scene	Vessella's Italian Band	*Brunswick*
	Il Pagliacci (Leoncavallo)	
Prologo, Si puo / *Prologo, Un nido di memorie*	Lawrence Tibbett	*Victor*
Selections	Creatore's Band	*Victor*
Ballatella—"Che volo d'augelli"	Florence Easton	*Brunswick*
No Pagliacci non son! / *Vesti la Giubba*	Giovanni Martinelli	*Victor*
	La Traviata (Verdi)	
Di Provenza il mar	Giuseppe Danise	*Brunswick*
Prelude	Capitol Grand Orchestra (Mendoza conducting)	*Brunswick*



Radio Broadcast Photograph

A SET-UP OF APPARATUS FOR MEASURING CHARACTERISTICS OF A AND B UNITS
It is not a difficult matter to measure the voltage output of A and B devices at different loads—This article explains. More complicated equipment is necessary, however, to determine the amount of hum in the output

Testing A and B Power Units

By Howard E. Rhodes

Laboratory Staff

THE testing of radio power-supply devices sent to Radio Broadcast by manufacturers has, for some time, been an important part of the Laboratory's work. What these tests are, how they are conducted, and what apparatus is used to make them, should be of general interest to our readers, and it is the purpose of this article to explain the procedure adopted for these tests. The information given here will also be helpful to manufacturers who, perhaps, contemplate sending power units to our Laboratory and are therefore interested to know to what tests their devices will be subjected. The tests described are applicable to either A power or B power units and the apparatus used in the tests is illustrated in the photograph at the head of this article.

It was the desire of the Laboratory staff to make the tests such that the data obtained would be most useful from the standpoint of the *user* of the device. With this point in mind the following tests were decided upon:

(a.) Determination of the maximum output of the device at various current drains.
(b.) Determination of the amount of hum in the output at various current drains.
(c.) Determination of the cost of operating the unit.

With this information available we can determine whether a device is capable of supplying sufficient current at the correct voltage for the operation of any particular receiver, whether or not the device has a good filter system in it (determined by the amount of hum in the output), and how much it will cost to operate any receiver from a particular power unit. In the following paragraphs we will explain how these tests are made. Although they will be explained separately, all the tests are made at the same time in the Laboratory.

DETERMINING THE OUTPUT

THE circuit used in determining the output of a unit at various current drains is given in Fig. 1. If the unit under test is an A unit, then the resistance R consists of a heavy-duty Carter rheostat with a maximum resistance of 6 ohms so that with the resistance all in the load of the unit will be about 1.0 ampere, which will be indicated in the ammeter A. The voltmeter, V, used to measure the output voltage, may be a Weston Model 301 meter with a maximum reading of 10 volts. By moving the arm on the rheostat the load may be varied so that the A unit is placed under actual working conditions, the load (read on the ammeter) corresponding

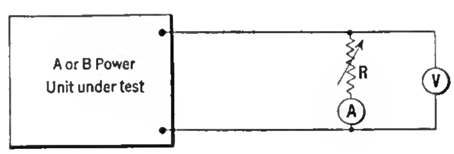


FIG. 1

to what would be drawn by the tube filaments were the A unit to be actually connected to the A posts of a set. At each setting of the resistance R, the voltage control knob on the A unit under test should be so adjusted that the voltage on V reads six, which is the value that the unit will be called upon to deliver under actual conditions of operation. At a certain reading of the ammeter it will be found that the voltage shown by the voltmeter is not as high as six, indicating that the A device is being overloaded. The maximum current output of an A device at rated voltage, which is six, can therefore be determined by setting the voltage control knob on the device at maximum (which will boost up the voltage to a figure above six at low values of current) and adjusting the resistance R until the voltmeter reads just six. The ammeter reading then represents the maximum permissible drain of the unit. When the A device is being used in conjunction with a receiver consuming less than this maximum current output, the voltage control on the device is of course turned to a lower tap, otherwise the voltage output will be excessively high. Data of this kind obtained on three A power units recently tested in the Laboratory are given in the second and third columns of Table 1.

From these data we are able to determine whether an A power unit is capable of supplying filament current to any particular receiver, provided we know the filament current drain of the receiver. Since this merely depends upon the number and type of tubes used in the set, it is easily determined.

If the unit being tested is a B power device, the same circuit is used but instead of the rheostat there is used a variable high resistance—a power Clarostat. The meter M becomes a 0–100 milliammeter and the voltmeter is generally a Westinghouse high-resistance meter with a maximum reading of 250 volts and a resistance of 1000 ohms per volt. Some sample data on four B power units are given in the columns of Table 2.

If we know the total plate-current drain of a receiver we can easily determine from the figures given in Table 2 the maximum voltage the various units will supply at this load. For example if a receiver uses a 171 type tube in the output, on the plate of which we desire to place 180 volts

Unit No.	Load in Amperes	Volts Output	Watts Input	Hum Voltage	Per cent. Hum
1	0	7.3	20	Too small to Measure	
	0.5	6.0	23		
	1.0	6.0	26		
	2.0	4.3	40		
	3.0	4.2	54		
2	0	8	18	0.015	0.187
	1	6	28	0.015	0.25
	2	6	44	0.015	0.25
	3	6	62	0.015	0.25
3	1	6	60	0.007	0.12
	2	6	71	0.007	0.12
	2.7	6	101	0.017	0.17
	3	5.2	100	0.065	1.1
	3.5	2.8	109	0.45	7.5

TABLE 1

and the total plate current drawn by the receiver is 50 milliamperes, then unit No. 3, supplying only 120 volts at this current drain, would not be satisfactory. Units Nos. 1 and 2 would be more satisfactory as they deliver considerably higher voltage at the current drain specified. Although they do not supply quite as much as 180 volts, a matter of 20 or 30 volts less than 180 on the plate of the power tube does not make a difference sufficient to be noticeable in the output of the loud speaker.

These data also give us the "regulation" of the unit, which is generally specified as the voltage drop per milliampere of load. For example, taking the following data from unit No. 1, Table 2:

	Load mA.	Voltage
	10	216
	40	182
Difference	30	34

and dividing the difference in the voltages by the difference in the loads, we obtain a value of 1.13, which is the voltage drop per milliampere load. This is quite a good value for the regulation. Compare it with the value obtained from unit No. 3, which figures out to be 4.3. Power units with good regulation have the advantage that the voltage they deliver will be more nearly constant at all loads.

Hum

IT IS the function of the filter system in an A or B power unit to filter the output of the rectifier so that the output at the end of the filter system will be as free as possible of any hum or "ripple." Even from a comparatively poorly designed power unit the hum is too small to measure directly. Consequently, it was necessary to construct an amplifier for this test so that the hum voltage could be amplified sufficiently so as to be readily measured. A three-stage resistance-coupled amplifier is being used in the Laboratory for this purpose. Two 240 type tubes are used in the first and second stages and a 201-A type tube is used in the last stage. The circuit diagram is given in Fig. 2.

When an A or B power unit is to be tested for hum the input of the amplifier is connected to the power unit under test, and switch S_1 is thrown to point A. This causes the hum voltage from the power unit to be impressed across the input of the amplifier (note that the d.c. voltage is blocked by the 0.01-mfd. condenser). The amplified hum causes the plate current of the last tube in the amplifier to increase and this increase is indicated by the meter M in the plate circuit. The gain control (a 0.5-megohm potentiometer across the input of the amplifier) is then adjusted so that the meter M gives a deflection that is easy to read. The switch is then thrown to the B position which connects the input of the amplifier to a source of known 60-cycle a.c. voltage the value of which is variable, as will be explained below. The 60-cycle voltage is so adjusted that the reading of the meter in the plate circuit of the output tube is the same as it was when the amplifier was connected to the power unit, and in which case this value of 60-cycle voltage is then equal to the hum voltage impressed upon the input of the amplifier.

Unit No.	Load in Milliamperes	Volts Output	Watts Input	Hum Voltage	Per cent. Hum
1	0	245	9	0.01	0.004
	10	216	11	0.03	0.014
	20	205	14	0.02	0.01
	30	193	16	0.02	0.01
	40	182	19	0.05	0.027
	50	170	22	0.05	0.03
2	0	215	34	0.075	0.035
	10	204	35	0.067	0.033
	20	195	37	0.067	0.034
	40	170	40	0.067	0.039
	50	164	44	0.067	0.041
3	0	270	88	0.27	0.1
	10	250	91	0.26	0.105
	20	210	92	0.25	0.12
	40	150	96	0.315	0.21
	50	120	98	0.165	0.14
4	0	240	17	0.14	0.058
	10	220	18	0.15	0.068
	20	195	20	0.17	0.087
	40	150	24	0.23	0.153
	50	135	26	0.28	0.210

TABLE 2

Using this method (of connecting to the input of the amplifier a known voltage equal in value to the unknown voltage) makes unnecessary the calibration of the amplifier. It is necessary, however, to have available a source of 60-cycle voltage from which voltages can be obtained comparable in value to the hum voltages ordinarily obtained from radio power units. These voltages, which are around 0.01 volt in the case of a poor unit, can be obtained using the circuit indicated in Fig. 2 as: "Source of known voltage."

The transformer T in this circuit is an ordinary one designed to supply voltages to a.c. tubes. The 1.5-volt winding is used and across its terminals is connected a 6-ohm rheostat with an additional connection soldered to the free end of the resistance wire so that the rheostat might be used as a potentiometer. The voltage across the voltmeter can be adjusted to any value, between 0 and 1.5 volts, by means of the sliding contact on the rheostat. Across the voltmeter are connected, in series, a 4-ohm and two 2-ohm resistances, these resistances constituting a voltage divider the effect of which is to extend the voltmeter range downwards. Connections from these resistances are brought out to four pin jacks marked 1, ½, ¼, and 0, indicating the portion of the voltage associated with the particular pin jack. Thus, if P is connected to the jack marked ½, the actual voltage impressed across X-Y is only one half of that indicated by the meter, etc. To the pin P is connected one end of a 400-ohm calibrated potentiometer, the purpose of which is to subdivide the voltmeter readings to even smaller fractions than is possible with the other resistances. By means of these adjustable units it is possible to impress across the input of the amplifier any voltage from 1.5 volts down to about 0.005 volts with an accuracy of not less than about 90 per cent., which is sufficiently accurate for measurements of this type.

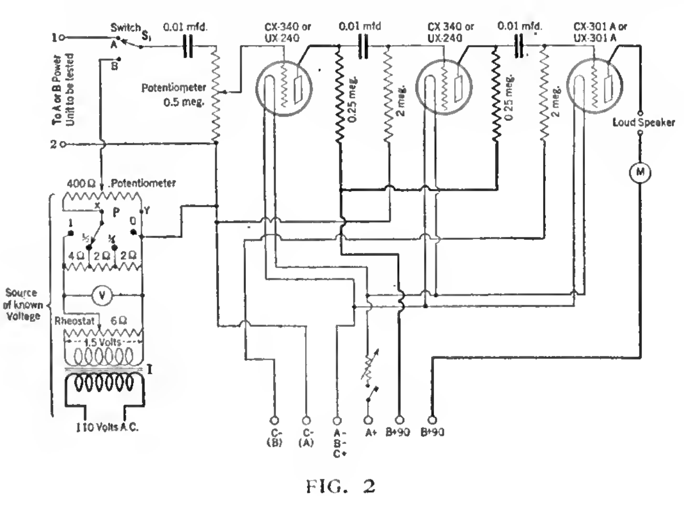


FIG. 2

Some examples of measurements of this sort are given in columns 5 and 6 of Tables 1 and 2. Column 5 gives the value of 60-cycle voltage that is equal to the hum voltage. Column 6 gives the percentage hum in terms of the d.c. voltage output of the device. Power unit No. 1 (Table 1) shows the smallest amount of hum in the output but it could not deliver more than one ampere at 6 volts. Unit No. 3 has more hum voltage than unit No. 1, but is capable of supplying up to 2.7 amperes at 6 volts.

The hum voltage measurements given in Table 2 give some idea of the magnitude of hum voltage obtained from some present-day B power units. It is possible to make some interesting mathematical calculations regarding the hum in B power units to indicate the effect in the loud speaker of various values of hum voltage, and this subject will be discussed in an early issue of RADIO BROADCAST. There is room here only to point out briefly the salient points regarding the matter. It can be shown that with a given audio amplifier, capable of amplifying down to 60 cycles, the permissible amount of hum in the output of a B power unit decreases:

(a.) as the amount of audio amplification in the receiver is increased and (b.) as the voltages on the various tubes, especially the detector tube, is increased.

Just how much hum is permissible is, of course, a function of the amount of amplification the audio amplifier gives at the hum frequency and how well the loud speaker will respond to these frequencies and their harmonics.

COST OF OPERATION

THE cost of operation per hour of an A or B power unit is found by first determining the amount of power the device consumes in watts when supplying the receiver, multiplying this power by the cost of power per kilowatt hour, and dividing by 1000. The cost of operation per month can, of course, be found by multiplying the cost per hour by the number of hours the set is in use per month. An example will make the whole calculation clearer. Suppose that a receiver drawing 40 milliamperes of plate current is operated from B power unit No. 4, Table 2, and that the set is in operation on an average of three hours a day. What will be the cost of operation per month, if the cost of power is $0.10 per kilowatt hour? From Table 2 we know that this particular B power unit draws 24 watts of power when supplying 40 milliamperes. Following the information given at the beginning of this paragraph, we multiply 24 by 0.10 and then divide by 1000. This gives $0.0024 as the cost of operation per hour. Since the set is in use 90 hours per month, then the cost per month is $0.21½. Other examples can be worked out in the same manner.

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. In July, 1927, an index to all Sheets appearing up to that time was printed.

All of the 1926 issues of RADIO BROADCAST are out of print. A complete set of Sheets, Nos. 1 to 88, can be secured from the Circulation Department, Doubleday, Doran & Company, Inc., 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 serious errors do occur, a new Laboratory Sheet with the old number will appear.

—THE EDITOR.

No. 177 RADIO BROADCAST Laboratory Information Sheet April, 1928

Characteristics of Speech

ARTICULATION

CLEAR speech is only possible when the person speaking uses careful articulation. Articulation is especially important in radio for if we do not understand something, we cannot have it repeated. In analyzing speech sounds a clear understanding of how the various sounds are produced is essential.

The human voice consists of sustained and transient notes and noises. The sounds which are ordinarily difficult to recognize (and which therefore require careful articulation), are the transients such as are associated with the sounds "t" and "d" or "p" and "b." These sounds are hard to reproduce accurately for they contain many of the highest frequencies found in sounds of speech.

If we examine the manner in which the sounds "p" and "b," for example, are produced, they will be found to have much in common. They are both produced by first compressing the lips together and then rapidly opening them. To pronounce the word "pa," we first produce the "p" sound by suddenly opening the lips and permitting the air to rush through them and then the vocal chords are set in motion to produce the vowel sound "a." The syllable "ba," is produced with a very similar motion of the lips but the vocal chords are set into motion and the lips open at the same instant and also there is only a slight rush of air from between the lips. The "pa" sound is characterized by an initial sound of high intensity; the "ba" sound does not have this feature. If the radio loud speaker cannot reproduce accurately the strong portion of the former sound, "pa," it will sound very much like "ba."

Some of the sounds most difficult to reproduce accurately are noises such as the dropping of a book on a table, for these sounds contain frequency components extending throughout the entire range of audible sounds.

The study of how words are formed is very interesting and can best be done with the aid of an oscillograph, which is an instrument with which we can obtain photographic records of the wave form associated with any sound. An analysis of these records, which are sometimes termed "audiograms," is helpful in determining the range of frequencies which must be handled by a radio broadcasting system if the reproduction is to sound natural.

No. 178 RADIO BROADCAST Laboratory Information Sheet April, 1928

The Exponential Horn

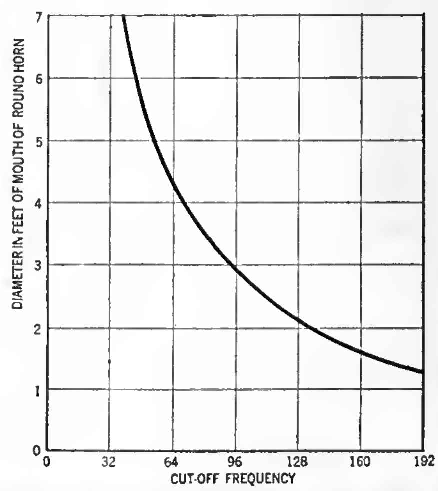
THE CUT-OFF FREQUENCY

THE LOWEST frequency transmitted by a horn of the exponential type is determined by the rate of expansion of the cross sectional area of the horn, and to eliminate reflection the diameter of the mouth of the horn (if it is round) must be made equal to one-quarter of the wavelength corresponding to the lowest frequency to be transmitted.

The velocity of sound in air is 1120 feet per second and, therefore, the wavelength (in feet) corresponding to any particular frequency may be found by dividing 1120 by the frequency. The diameter of the mouth of the horn in feet must then be equal to this wavelength divided by 4.

The accompanying curve shows graphically the relation between the diameter of the mouth of a round horn and the cut-off frequency. It should be realized that the diameter of the mouth is not the only factor determining the lowest frequency that the horn will satisfactorily transmit and that the size of the mouth is an indicator of this frequency only if the remainder of the horn has been correctly designed. As shown by the curve, to transmit frequencies down to 64 cycles, for example, it is necessary that the horn's mouth have a diameter of about 4.5 feet.

If the horn is square rather than round, it will be satisfactory to make the area of the mouth equal to that of the equivalent round horn.



No. 179 RADIO BROADCAST Laboratory Information Sheet April, 1928

A Problem in Audio Amplification

THE EFFECT OF TRANSFORMER RATIO

PROBLEM:—The audio amplifier in a receiver comprises a 3:1 transformer in the detector circuit, followed by a 201-A type tube in the first audio stage, a 4:1 audio transformer for the second stage, and a power output tube. What will be the effect on the amount of signal voltage supplied to the grid of the power tube of substituting a 6:1 transformer for the 4:1 transformer?

ANSWER:—Let us first calculate the gain of the original amplifier. The total amplification to the grid of the power tube will be equal to the turns ratio of the first transformer multiplied by the effective amplification of the tube times the turns ratio of the second transformer. The effective amplification of a tube in a properly designed transformer-coupled audio amplifier can be taken as about 80 per cent. of the amplification constant of the tube; for a 201-A type tube, therefore, we take 80 per cent. of 8, which is 6.4. The total gain of the amplifier is, therefore:

$$3 \times 6.4 \times 4 = 76.8$$

Similarly the amplification with the 6:1 transformer substituted for the 4:1 will be:

$$3 \times 6.4 \times 6 = 115.2$$

The substitution of the 6:1 transformer, therefore, has increased the voltage gain by 50 per cent.; this represents a gain of 3.6 TU.

Now, the power into the loud speaker is proportional to the square of the signal voltage on the grid of the power tube feeding the loud speaker. When the voltage gain is increased 50 per cent., therefore, the power into the loud speaker is increased 125 per cent. This corresponds to a power gain of 3.5 TU which, while not very great, is appreciable. (The minimum gain audible to the ear is 1 TU.)

If the power tube is a 171 type with 40 volts on the grid, then using the original amplifier, approximately 0.5 volts (40 divided by 76.8) are required out of the detector tube in order to place 40 volts signal voltage on the grid of the 171. When the 6:1 transformer is used, only 0.3 volts (40 divided by 115.2) are required from the detector in order to "load up" the power tube.

No. 180 RADIO BROADCAST Laboratory Information Sheet April, 1928

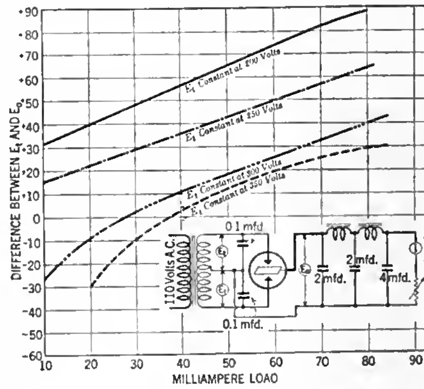
B Power Unit Characteristics

EFFECT OF TRANSFORMER VOLTAGE

THE CURVES published herewith were made by the Raytheon Manufacturing Company using one of their BH type tubes with an ordinary filter, as indicated in the accompanying circuit diagram. The curves show the relation between the voltage, E_t, across the secondary of the transformer and the input voltage, E_o. The output load in milliamperes as measured by the meter 1 is plotted along the horizontal axis and along the vertical axis has been plotted the difference between the effective value of the transformer voltage E_t and the average value of the voltage E_o into the filter system. The line marked +20, for example, indicates the voltage E_t to be 20 volts greater than E_o; the line marked +20 indicates the converse.

These curves show that (to take an example) with a transformer voltage of 300 volts per anode, the average value of the voltage into the filter is 27 volts higher than the transformer voltage when the load is 10 milliamperes. At a load of 28 milliamperes the voltages are equal and at a load of 60 milliamperes the input voltage to the filter has dropped to a value 25 volts below the transformer voltage. During these tests the transformer voltage, E_t, was held constant.

Other data showing the effect of various transformer voltages, obtained with the same circuit used here, were given on Laboratory Sheet No. 146, published in the December, 1927, RADIO BROADCAST.



No. 181 RADIO BROADCAST Laboratory Information Sheet April, 1928

R. F. vs. A. F. Amplification

A COMPARISON

THE SIGNAL output from a radio receiver may be increased by augmenting either the audio-frequency or radio-frequency amplification or by boosting the detecting efficiency. On this Laboratory Sheet we give briefly the comparative merits of audio-frequency and radio-frequency amplification. In the accompanying table is shown the effect on the power into the loud speaker of increasing the a.f. or r.f. amplification. The first column gives the increase in amplification and the second column the increase in power into the loud speaker if this extra amplification is introduced in the audio amplifier. The third column shows the increase in power into the loud speaker if the extra amplification is placed in the r.f. amplifier.

This table is based on the fact, first, that the power into the loud speaker is proportional to the square of the voltage on the grid of the power tube and, secondly, that the output of the detector is proportional to the square of the voltage on its grid. When the audio-frequency amplification is multiplied by 10, for example, the power into the loud speaker is 100 times greater. When the radio-frequency amplification is multiplied by 10, however, the output of the detector is 100 times greater and the power into the loud speaker is 10,000 times greater. It is evident from these figures, therefore, that increases in r.f. gain are much more effective in producing greater signal than increases in audio-frequency gain.

Added Amplification	*Increase in Power into Loud Speaker* A. F.	R. F.
2	4	16
5	25	625
10	100	10,000
20	400	160,000
50	2500	6,250,000

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To Convert Your Hammarlund Hi-Q Set To A C Operation

The Karas A-C-Former] will] deliver the correct voltage for the new AC tubes, types X-226 or CX 326, and Y-227 and CX 327. It does not permit the excessive voltage fluctuations which are ruinous to AC tubes—thus protecting them and insuring their long life. The A-C-Former needs no separate device for centertap. It has a convenient extra loop of wire for connection to the panel switch, and plug-in connection for "B" Eliminator.

Type 12 — **$8.75** List Price

Supplies filament potential for 12 tubes as follows: 8-1½ volt, type 226 or 326 tubes, 2-2½ volt, type 227 or 327 tubes, and 2-5 volt type 171 tubes.

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The General Radio type 277 Coils are interchangeable thus making them adaptable to both short and long wave reception. They are so shaped in ratio of diameter to length and the construction is such that they have very low losses. Priced from $1.25 to $1.50 according to range. Type 274-B Coil mounting base as illustrated $1.00. Described in bulletin 929.

GENERAL RADIO CO.

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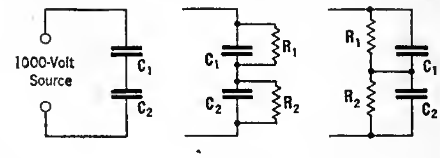
No. 182 RADIO BROADCAST Laboratory Information Sheet April, 1928

Filter Condensers

HOW TO CONNECT THEM IN SERIES

IF WE desire to place a filter condenser across, for example, a 1000-volt source of direct current and we have available two large-capacity 500-volt condensers, it is ordinarily not possible to connect them in series across the 1000-volt leads with safety. Why this is so will be explained on this Laboratory Sheet.

At A in the diagram is shown the connection of two condensers, C_1 and C_2, in series across the 1000-volt source. Now, a condenser has a definite d.c. resistance, which is generally very high but nevertheless finite, and this resistance is represented as R_1 and R_2 in B as external resistances across each condenser. A small amount of current will flow through these resistances and the voltage drop across the two resistances will be in direct proportion to the resistances. The resistances of condensers vary widely and therefore it is extremely unlikely that we would have two condensers with the same d.c. resistance. For example, condenser C_1 might have a d.c. resistance of 100 megohms while the d.c. resistance of condenser C_2 might be 900 megohms. The d.c. voltage drops across the two condensers being proportional to the resistances there would then be 100 volts across C_1 and 900 volts across C_2. If the two condensers were both rated at 500 volts, the obvious result would be that condenser C_2 would have a very short life because of the overload being placed on it. The solution for this difficulty is to connect external resistances R_1 and R_2 across each condenser as indicated at C with a sufficiently low value in comparison with the internal resistance of the condenser (which is always very high) so that the voltage drops will be determined by the external resistances rather than by the internal resistances



A B C

of the condensers. If we have two 500-volt condensers connected to a 1000-volt source, we might equalize the voltage across them by connecting two 100,000-ohm resistances in series across the source, as indicated at C. There would be 500 volts drop across each resistance and, therefore, 500 volts across each condenser, and the latter would then be satisfactory in operation and have normal life.

No. 183 RADIO BROADCAST Laboratory Information Sheet April, 1928

The Type 280 and 281 Tubes

THEIR CHARACTERISTICS

THE characteristics of the type 280 and 281 rectifier tubes are given below. These tubes are for use as rectifiers in B power units, the 280 in circuits designed for full-wave rectification and the 281 in half-wave circuits. Two 281 tubes may be used, if desired, to give full-wave rectification:

TYPE 280 FULL-WAVE RECTIFIER

Filament Voltage	*5 Volts*
Filament Current	*2 Amperes*
A.C. Plate Voltage (Max. Per Plate)	*300 Volts*
Max. D.C. Output Current	*125 Milliamperes*
Max. D.C. Output Voltage	*260 Volts*
Height of Tube	*5⅝ Inches*
Diameter of Tube	*2$\frac{3}{16}$ Inches*

TYPE 281 HALF-WAVE RECTIFIER

Filament Voltage	*7.5 Volts*
Filament Current	*1.25 Amperes*
A.C. Plate Voltage (Max.)	*750 Volts*
A.C. Plate Voltage (Recommended)	*650 Volts*
D.C. Output current (Recommended)	*65 Milliamperes*
D.C. Output Current (Max.)	*110 Milliamperes*
D.C. Output Voltage (Max.)	*620 Volts*
D.C. Output Voltage (Recommended)	*620 Volts*

The type 280 tube may be used in circuits designed especially for it or may be used in circuits designed for the type 213 tube. The characteristics of these two tubes are similar with the exception that the former tube is capable of somewhat greater output than the 213. If a 280 tube is used in place of a 213, the 280 will be operating at less than full load and will consequently have a very long life. These facts are also true with regard to the 281, which may be used satisfactorily in place of a 216-B type tube.

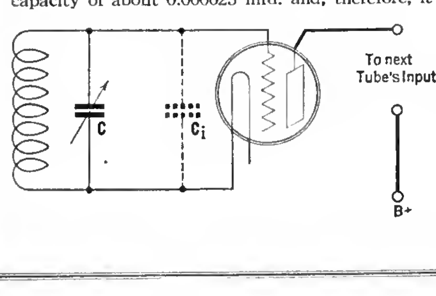
If more than about 65 milliamperes at 600 volts is necessary to operate a radio installation, it will be a good idea to use two type 281 tubes in a full-wave circuit with about 650 or 700 volts a.c. on the plate of each tube. With this arrangement an output in excess of 100 milliamperes at 600 volts will be available.

No. 184 RADIO BROADCAST Laboratory Information Sheet April, 1928

Tuning

THE EFFECT OF DISTRIBUTED CAPACITY

A RADIO receiver to cover the broadcasting band must be able to tune-in signals from 550 kc. to 1500 kc., a ratio of 2.73 to 1 in frequency. It can be shown mathematically that, in order to obtain this range, the ratio of the maximum to minimum of the capacity across a tuning coil must be 8.6 to 1 approximately. If we use a tuning condenser with a maximum capacity of 0.0005 mfd. then the minimum capacity across the coil must theoretically be (if the desired tuning range is to be obtained) 0.0005 divided by 8.6, or 0.000058 mfd. An ordinary condenser might have a minimum capacity of about 0.000025 mfd. and, therefore, it



appears that we should be able to cover the broadcasting band very easily. In the circuit, however, there is another capacity across the coil which has an important effect. This additional capacity is the effective input (grid-to-filament) capacity of the tube, indicated as C_i in the diagram, and this capacity varies with the amount of amplification the tube is producing in the circuit. This capacity, C_i, is in parallel with C, the tuning condenser, and its effect must therefore be added to that of C. The result is that the actual minimum capacity of the circuit is greater than that of the minimum capacity of C, and this will tend to restrict the tuning range of the receiver unless the precaution is taken that a variable condenser with a low minimum capacity is used to tune the circuit, that the coil itself does not have much distributed capacity, and that long leads in the circuit do not introduce objectional capacity.

If a station transmitting on the lowest frequency (longest wavelength) used in the broadcasting band tunes-in on the set with the condenser plates all in (as they should be) but it is found impossible to tune-in a station operating on the highest frequency (shortest wavelength), it is possible that the cause may be due to a tuning condenser with a large minimum capacity or excessively long leads connecting the coil with the condenser.

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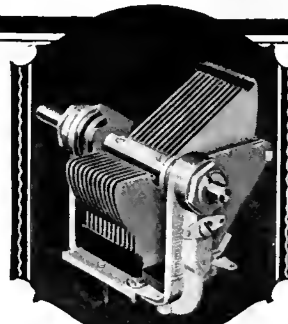

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Soldered brass plates with tie-bars; warpless aluminum alloy frame; ball bearings; bronze clock-spring pigtail; full-floating, removable rotor shaft permits direct tandem coupling to other condensers. Made in all standard capacities and accurately matched.

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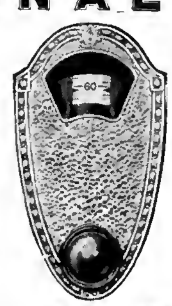

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The Jewell Lightning Arrester is the best protection available for radio sets against Lightning. As an indication of its reliability, it is listed as Standard by Underwriters' Laboratories, who give it regular periodic tests for performance. It consists essentially of an accurately calibrated air gap enclosed and sealed within a glazed brown porcelain case suitable equally for indoor or outdoor installation.

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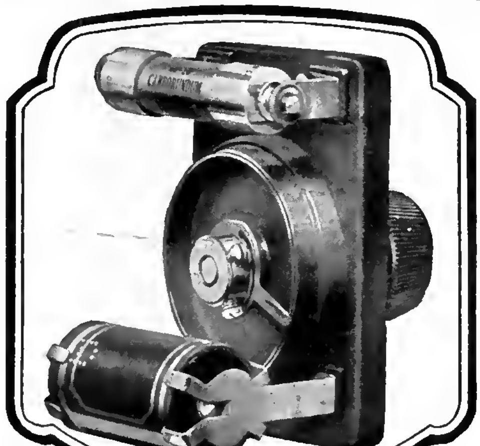

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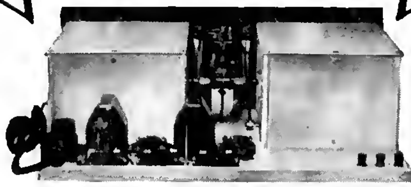

The Hammarlund "Hi-Q" Receiving Set which uses box shields of Alcoa Aluminum Sheet and special corner post moulding.

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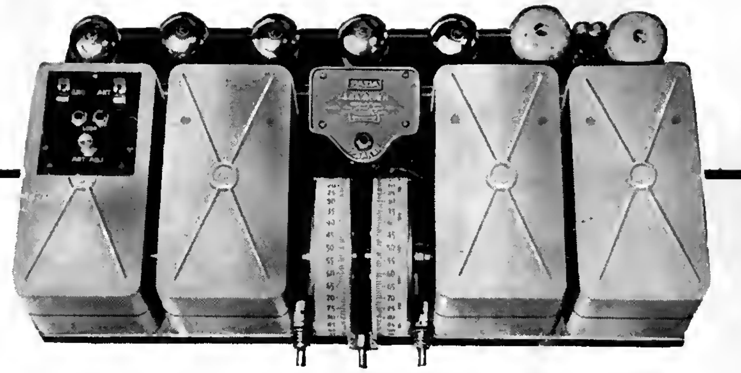

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> MR. L. M. CLEMENT *Chief Engineer* of F. A. D. Andrea, Inc., commenting on shielding says, "In a radio receiver aluminum, because of its electrical conductivity, makes a more efficient shield than any other of equal weight. The material can be easily drawn into the desired shape and its finish is permanent and pleasing to the eye."

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