The ARMSTRONG Super-Regenerative Circuit

BY

GEORGE J. ELTZ, JR., E. E.
A. I. E. E.

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INTRODUCTION

IN writing a short non-technical book on the subject of Super-Regeneration, the author is confronted with a difficult problem. Not only are the principles involved fundamental, necessitating a complete review of the entire science of electricity if the subject is to be completely covered, but Super-Regeneration itself is highly technical.

This work is presented in as non-technical a manner as possible. It is directed particularly to that class of experimenters who are concerned not so much with the technical aspects of the circuit as they are with its practical working value.

The author wishes to express his thanks to Mr. E. H. Armstrong, the inventor of the circuit, for the valuable suggestions and assistance given.

GEORGE J. ELTZ, JR., E.E.

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CHAPTER I.

THE purpose of this book is to describe as clearly as possible the operation of the "Super-Regenerative Circuit." It contains diagrams of connections and a brief description of a set which has been found satisfactory in operation.

The Super-Regenerative Circuit is a direct outcome of the regenerative circuit. It is the latest contribution to the art, and is fittingly made by Mr. E. H. Armstrong, the inventor of the original regenerative circuit. The results obtained with the circuit far surpass those obtained with any other circuit using the same number of tubes. It is especially adapted to the reception of radio telephone signals and is undoubtedly the receiving set of the future.

Perhaps before considering the various circuits shown it will be well to discuss briefly the action of the receiver. It must be assumed that the reader is familiar with the straight regenerative circuit in common use, for with this as a basis, the explanation of the fundamental action is fairly easy.

Consider a regenerative circuit with the plate circuit tuned by means of a variometer and with the grid circuit also tuned by the same means, or by the use of a coil and condenser. In "tuning in" a signal with this arrangement the primary is first adjusted, then the secondary or grid circuit (both variations generally being made at the same time), and finally the plate circuit is adjusted to obtain the "regenerative" effect. An explanation of the action is almost unnecessary. The signal increases in loudness as the plate circuit is changed, the increase in intensity resulting in a loss in tone, until finally a loudest point is reached when further increase in regeneration causes the set to oscillate and the signal to disappear entirely.

This is the familiar regenerative action. How often has it occurred to the operator what the effect would be if, just as the signal is increasing in intensity, some means were available to stop the oscillations and permit the variometer to be turned twenty more degrees. Undreamed of amplification would be the result and in fact is the result with the "Super-Regenerative Circuit."

The Super-Regenerative Circuit, by a trick, makes it possible to turn the variometer the twenty extra degrees and the results obtained are remarkable.

Expressed in simple language, the Super-Regenerative Circuit consists of a regenerative circuit in which by the use of an extra oscillator the regenerative circuit is alternately permitted to oscillate and stopped from oscillating at a frequency determined by the extra oscillator. The effect is somewhat the same as that which it is imagined would be obtained were the plate circuit variometer revolved at a rapid rate.

A better, though more technical description of the action is obtained by considering the circuit purely from a resistance standpoint. The fundamental factor on which regeneration is based is the supplying of energy to a circuit by the circuit itself to reinforce an oscillation already existing in the circuit. This action is equivalent to introducing in the circuit a negative resistance which by neutralizing some or all of the positive resistance of the circuit reduces the effective resistance. Obviously three cases can occur.

1. The negative resistance can be less than the positive.
2. The negative resistance can be equal to the positive.
3. The negative resistance can be greater than the positive.

An example of the first case is the action taking place in the ordinary regenerative receiver up to the point of oscillation. The resistance of the circuit is always positive and the current always reaches a definite maximum value.

The second case is one not used in general practice at the present time.

The third case i. e., the negative resistance greater than the positive, is the case on which the action of the Super-Regenerative Receiver is based. It is the condition existing in the regenerative circuit when in oscillation.

If a circuit is arranged so that the negative resistance is greater than the positive the current in the circuit will go to infinity (i. e., the capacity of the tube), as soon as an e.m.f., no matter how small, is impressed. This is a desirable characteristic provided it can be controlled, which fortunately is the case. The control is effected by varying the negative and positive resistances of the circuit. Again three cases are possible.

1. The negative resistance may be varied with respect to the positive.
2. The positive resistance may be varied with respect to the negative.
3. The positive and negative resistances may be varied simultaneously.

The action of the Super-Regenerative Circuit consists in varying the negative resistance of the circuit with respect to the positive or the positive with respect to the negative so that the negative resistance is alternately greater and less than the positive but with the average resistance positive. Such a circuit will not of itself produce oscillations and during those periods where the negative resistance is the greater, the current in the circuit will go to exceedingly high values. The variation in resistance is accomplished at a frequency relatively low compared to the frequency of the signal to be amplified; the frequency being determined to a large degree by the use to which the circuit is to be put; i.e., telephone, C. W., or spark.

From the foregoing paragraphs a general idea of the action may be obtained. By considering the three ways in which the resistance may be varied and the circuits used in each case, a complete working knowledge of the action is readily secured.

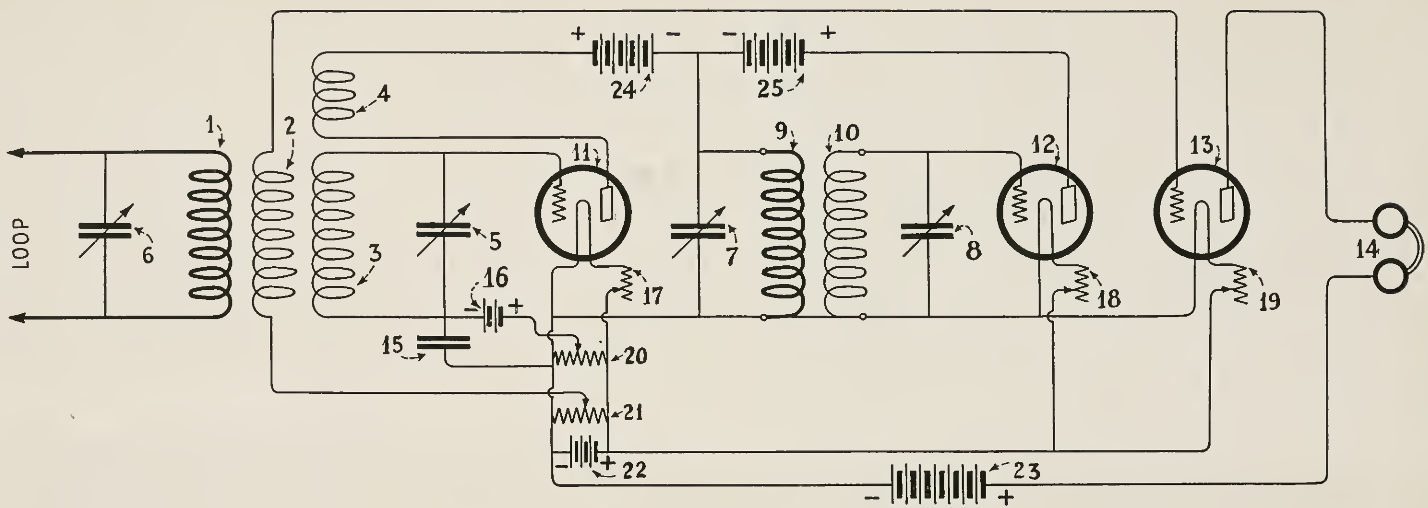


Figure 1

Variation of negative resistance with respect to positive. Best for CW and spark reception.

1. Loop coupling coil. Variocoupler ball with 25 to 40 turns 22 s.c.c.
2. Detector coupling coil—25 to 30 turns 22 s.c.c. on 4″ tube.
3. Grid tuning coil—25 to 30 turns 22 s.c.c. on 4″ tube.
4. Tickler coil—50 turns 22 s.c.c. on coupler ball.
5. Grid tuning condenser—.0005 mf.
6. Loop tuning condenser—.001 mf.
7. Oscillation plate condenser—.0015 variable with fixed units to give .005 mf.
8. Oscillation grid tuning condenser—.0015 variable with fixed units to give .005 mf.
9. Oscillation plate circuit coil—1500 turns, Honeycomb or Duo-Lateral coils.
10. Oscillation grid circuit coil—1500 turns, Honeycomb or Duo-Lateral coils.

11, 12 and 13. Hard vacuum tubes.
14. Telephone receivers.
15. Fixed condenser—.01 mf. or more.
16. Negative "C" battery.
17, 18 and 19. Filament rheostats.
20 and 21. "A" battery potentiometer.
22. 6 Volt storage battery.
23. "B" battery—22½ volts, depending on the tube used.
24. "B" battery—45 volts.
25. "B" battery—66 volts.

CHAPTER II.

IN chapter one it was stated that the operation of the Super-Regenerative Circuit could be brought about in three ways depending on

1—Whether the negative resistance was varied with respect to the positive.

2—Whether the positive resistance was varied with respect to the negative.

3—Whether both resistances were varied simultaneously.

This chapter will deal with the first case given above. Consider the circuit shown in Fig. 1. This circuit is so arranged that the negative resistance is varied with respect to the positive, the variation being brought about by means of the oscillator No. 12. A close inspection of the circuit will show that it consists of two oscillating circuits, the circuit composed of units 3, 4, 5 and 11, being the familiar oscillating or regenerative circuit, and the circuit composed of units 7, 8, 9, 10 and 12, a straight oscillating circuit.

The circuit composed of units 3, 4, 5 and 11 (called the regenerative amplifier circuit) is built up in much the same manner as the average regenerative circuit arranged with a tickler coil. The wavelength range covered may be any desired, the best results being obtained for the shorter wavelengths (below 1000 meters). The circuit 7, 8, 9, 10 and 12 (called the low frequency oscillator circuit) is arranged to oscillate at a relatively low frequency of the order of 15,000 or below, depending on what type of signal it is desired to receive.

When both circuits are in operation and a signal is received the action is as follows. The low frequency oscillator alternately takes energy from and supplies energy to the regenerative amplifier at a frequency dependent on the values of the capacities 7 and 8 and the inductance 9 and 10. This frequency is low compared to the frequency of the received signal but high compared to the rectified frequency represented by the spark frequency or speech frequency, if telephone is to be received. The change in the plate current of the regenerative amplifier tube results in a variation of the negative resistance and, as already explained, when the negative resistance exceeds the positive, high current values are obtained. The net result of the action is that though the average value of the resistance is positive and the regenerative amplifier circuit will not oscillate, still the currents flowing when the negative resistance is the greater are of such a magnitude that an average amplification of tremendous value is obtained. The effect is much the same as that which would be obtained if the "B" battery voltage were varied at a rapid rate, the variation being sufficient to stop or start the circuit oscillating.

In this type of circuit the actual detection of the received signal is accomplished by means of an additional tube. It is possible to insert the telephone receivers in the plate circuit of either of the tubes Nos. 11 and 12, but more satisfactory results are obtained by the use of an extra tube. This tube acts as a pure detector and is coupled with the grid circuit by means of a coil of the same general character as the grid coil. This coil is described later. It performs the function of applying the amplified signal voltage to the grid of the detector tube at the same time performing the added valuable function of filtering out of the telephone receivers any of the low frequency oscillation generated by the low frequency oscillator. The output from the detector tube, of course, can be amplified with any low frequency amplifier and caused to operate a loud speaker or other device.

The circuit shown in Fig. 1 is now considered in detail. Specific constructional details cannot be given but the same general rules followed in constructing a regenerative receiver apply. The apparatus need not be placed in any definite relation other than that dictated by good design, convenience, and accessibility.

The values given are for amateur and broadcasting wavelengths.

1. This is the loop coupling coil. It is conveniently composed of a variocoupler ball wound with No. 22 S. C. C. Wire. 25 to 40 turns should be used depending on the loop.
2. This coil consists of 25 or 30 turns of No. 22 wound on a tube 4″ in diameter; it is wound next to coil No. 3.
3. This consists of a coil of 25 or 30 turns of No. 22 wound on the same tube as coil No. 2 and immediately next to it.
4. This is a variometer or variocoupler ball wound with No. 22 S. C. C. and arranged to rotate in relation to coil No. 3. About 50 turns will be satisfactory. A variocoupler with the windings slightly changed may be successfully used to accommodate coils 1, 2, 3 and 4.
5. Variable condenser of .0005 M. F. or more.
6. Variable condenser of .001 M. F. or more.

7. Variable condenser of .0015 or greater capacity.
As it is desired to increase the capacity to values sometimes as great as .005 small fixed condensers may be used in conjunction with condenser No. 7.
8. The same as No. 7.
9-10. These coils generally take the form of 1250 or 1500 turn Duo-Lateral or Honeycomb coils. They should be arranged to permit variation of the coupling between them.
11-12. Hard vacuum tubes such as are used for amplifying. Western Electric or UV 201 are best.
13. Hard or soft detector tube. For uniform results a hard tube is recommended.
14. Telephone receivers or input to audio frequency amplifier.
15. Fixed telephone condenser about .01 M. F. or more.
16. Negative "C" battery for grid of amplifier tube.
One or two small flashlight cells are satisfactory depending on the tube.
17-18-19. Filament rheostats.
20. "A" battery potentiometer. This regulates the grid voltage of the amplifier.
21. "A" battery potentiometer. This regulates the detector tube grid voltage. A small negative "C" battery may be substituted or a grid leak and condenser used.
22. Six volt storage battery.
23. Detector tube "B" battery generally 22½ volts depending on the tube.
24. Amplifier "B" battery about 45 volts depending on the tube.
25. Oscillator "B" battery about 66 volts or more depending on the tube used.

This circuit may be successfully used for the reception of all types of signals. It is best suited, however, to the reception of spark and C. W. signals. For the reception of spark signals no change is necessary. For the reception of C. W. an external hetrodyne very loosely coupled is best although the circuit operates satisfactorily as shown.

To receive signals with their natural tone such as spark or telephone, coils 9 and 10 may be either No. 1250 or 1500 turn Duo-Lateral or Honeycomb coils and the condensers 7 and 8 should be between .0015 M. F. and .005 M. F. Greatest amplification will be obtained with larger coils and condensers, but the tone of the signal is lost. As coils and condensers of the values given are easily obtainable, their use is recommended.

The circuit in Fig. 1 shows the loop coupled to the grid circuit by means of a variable coil. This method of coupling is not absolutely necessary. The loop coil may be wound on the same tube that holds the grid and detector coils. The coupling is then fixed. With the average loop consisting of 8 or 10 turns on a three or four foot frame, the loop coil should consist of about 25 turns for broadcasting and amateur wavelength reception. Still another modification is possible. The coil No. 1 and the condenser No. 6 may be eliminated entirely and the loop connected directly across the grid coil. The size of the grid coil No. 3 and the detector coil No. 2 should be increased if this is done as the effective inductance is lowered by putting the loop in parallel. An increase of 10 turns will be sufficient for the ordinary loop.

CHAPTER III.

THE next circuit to be considered is that in which the positive resistance of the circuit is varied with respect to the negative. For average use this circuit will prove the most satisfactory since the variation of one of the factors in the circuit will not change the others.

The complete circuit is shown in Fig. 2. The circuit composed of units 4, 5, 6 and 1 is the regenerative amplifier. The circuit composed of units 11, 12, 13, 14, 15 and 2 is the low frequency oscillator.

When both circuits are adjusted and a signal is received the action is as follows: The low frequency oscillator being directly connected to the grid circuit of the regenerative amplifier alternately changes the potential of the grid. The change taking place at the frequency of oscillation determined by the coil 11 and the condenser 12. As the potential of the grid is varied the resistance of the regenerative amplifier circuit is changed since when the grid is made positive the plate current is increased and when it is made negative, it is decreased. This is a familiar action and obviously is due to a change in the positive resistance of the circuit, the resistance being lowered with positive potential on the grid and being increased with negative potential on the grid. In operation the regenerative amplifier circuit is adjusted to a condition which would result in oscillation if the low frequency oscillator were not operating. This setting insures a high value of negative resistance and each time the positive resistance is decreased below the value of the negative resistance in the circuit a large current flows resulting in a strong amplification of the signal. As explained in Chapter I the average resistance of the circuit is positive and oscillation will not occur in the amplifier circuit but the large currents flowing at the time when the negative resistance is greatest, result in an amplification of great magnitude.

As this is probably the circuit which will find the greatest application in practice, the function of each part will be considered separately.

Refer to Fig. 2. The values given are for amateur and broadcasting wavelengths.

1, 2 and 3. Amplifier tubes.

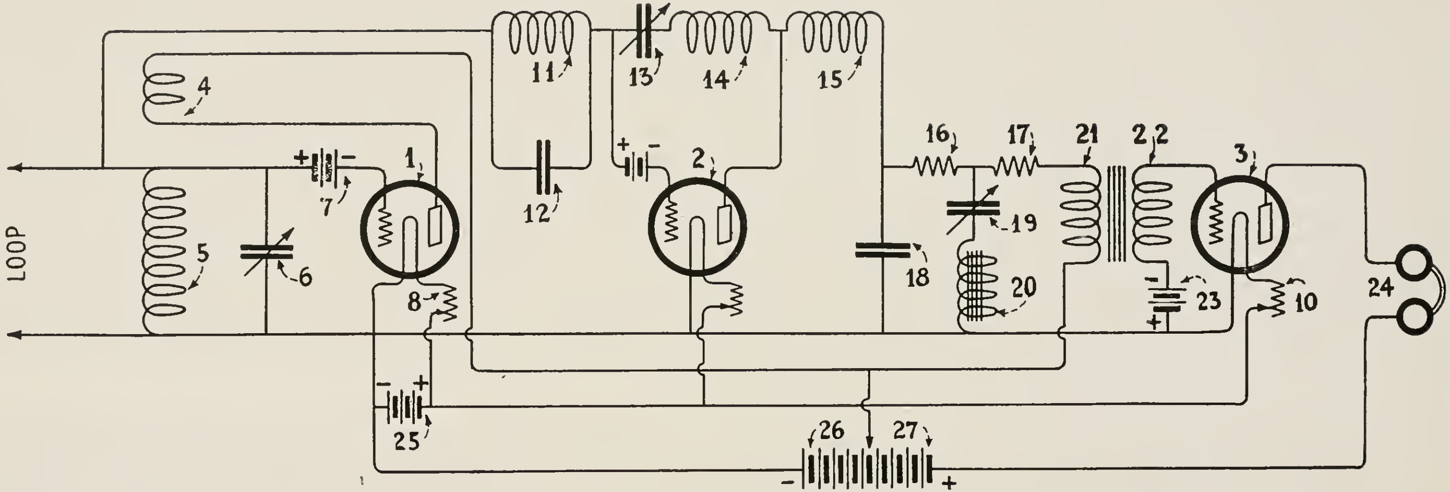


Figure 2

Variation of positive resistance with respect to negative. Best for telephone and spark at naturaltone.

1, 2 and 3. Hard vacuum tubes.
4. Tickler coil—variometer ball wound 50 turns 22 s.c.c.
5. Loop and grid tuning coil 25 or 30 turns 22 s.c.c. on 4″ tube.
6. Grid tuning condenser .0005 variable.
7. Negative "C" battery 2 flashlight cells.
8, 9 and 10. Filament rheostats.
11. Oscillation grid coil. 1250 turns Honeycomb or Duo-lateral.
12. Oscillation tuning condenser. .0015 variable with fixed units to give .003 mf.
13. Coupling condenser. .0015 mf. variable.
14. Choke coil 300 turns Honeycomb or Duo-lateral.
15. Oscillator plate coil 1500 turns Honeycomb or Duo-lateral.
16 and 17. Filter resistance 12000 ohms resistance.
18. Filter condenser .005 mf. fixed condenser.
19. Filter condenser .0015 mf. Variable and fixed units to give .005 mf.
20. Filter choke coil .1 or .25 Henry coil.
21. Primary of audio-frequency transformer.
22. Secondary of audio-frequency transformer.
23. Negative "C" battery.
24. Telephone receiver.
25. Storage battery.
26. "B" battery 45 to 88 volts.
27. "B" battery 88 to 200 volts.

4. Plate or tickler coil of the regenerative amplifier. This coil is similar to the one described in Chapter I. It consists of a variometer ball wound with No. 22 S. C. C. wire about 50 turns being satisfactory.
5. This is the grid coil. It is conveniently made. if used exactly as shown with the loop in parallel, by winding 25 or 30 turns of No. 22 on a four inch tube.
6. Variable condenser of .0005 or .001 M. F.
7. Negative "C" battery. This consists of one or two small flashlight cells, the number used being determined by the tube.

8, 9, and 10. Filament rheostats.

11. This is a 1250 turn Duo-Lateral or Honeycomb coil.
12. This may be either a fixed or variable condenser or a combination of both. The capacity should be about .003 M. F.
13. Variable condenser .0015 M. F.
14. This is a 300 turn Duo-Lateral or Honeycomb coil.
15. This is a 1500 turn Duo-Lateral or Honeycomb coil.

16-17. These are 12000 ohm resistances; their function will be explained later.

18. Fixed condenser .005 M. F.
19. Variable condenser and fixed condenser in combination, .0015 M. F. to .005 M. F.
20. Choke coil of .1 or .2 Henry.
21. Primary of audio-frequency amplifying transformer.
22. Secondary of transformer.
23. Negative "C" battery for audio-frequency amplifier.
24. Telephone headset.
25. Six volt storage battery.
26. "B" battery for regenerative amplifier and oscillator.
27. Added "B" battery for use on audio-frequency amplifier.

A great many of the items enumerated above and their use is perfectly obvious. A few of them, however, will bear further explanation.

The functions of the circuit consisting of units 4. 5, 6 and 1 (the regenerative amplifier) should be plain. It is in this circuit that the amplification takes place. The change in resistance brought about in the amplifier is similar to the change which would take place were a resistance coil alternately shunted and removed from across the coil No. 5.

The function of the circuit consisting of 11, 12, 13, 14, 15 and 2 (the low frequency oscillator) is to set up the frequency which will effect the change in the grid potential and consequently in the positive resistance of the regenerative amplifier. This circuit consists of several coils and condensers but only the coil No. 11 and the condenser 12 are instrumental in setting the frequency. The coil No. 15 is placed at right angles to the coil No. 11, thus precluding the possibility of oscillation. Coil No. 14 and condenser No. 13 are then used in the manner shown to effect coupling between the plate and grid coils No. 15 and No. 11. By means of this method the magnitude of the oscillation set up can be carefully determined. This is of value if the maximum results are to be obtained from the circuit. The coil No. 14 acts as a choke preventing the tuning of the regenerative amplifier from effecting the oscillator or vice versa.

The combination of units 16, 17, 18, 19 and 20 form a filter circuit. This circuit is absolutely necessary if audio-frequency amplification is to be used. The need for the circuit arises out of the fact that the oscillator No. 2 is generating currents of an audible frequency or slightly above. If the frequency is above audibility the telephone receivers may be substituted for the primary of the audio-frequency transformer No. 21 and operation will be satisfactory with the filter circuit excluded. If it is desired to use an additional stage of amplification, however, the filter must be used since the oscillations are so powerful they will paralyze the amplifier tube. The filter circuit shown is a simple one and operates fairly well, later on a typical telephone filter circuit of high efficiency is described. The resistance 16 and 17 may be of any type either inductive or non-inductive, the only requirement is that they have a rather low distributed capacity. The "Lavite" resistances of the Western Electric Company are ideal for this purpose. The coil No. 20 is described in a later chapter, the inductance should be about .1 to .25 Henry wound either with or without an iron core. If an air core coil is used care must be taken to see that the coil does not of itself pick up currents from the stray field of the oscillator. A trial will show the best position in which to place the coil or the possibility may be eliminated entirely by placing the coil in a metal box which is grounded to the filament. As already mentioned condenser No. 19 may be either variable or fixed. If condenser No. 18 is fixed the value of condenser No. 19 may be determined by use of a variable condenser and the proper fixed condenser substituted. This is permissible since the frequency is fixed.

The connections of the audio-frequency amplifier are obvious and need no explanation. The "C" battery No. 23 may be dispensed with if voltages of the order of 100 volts are used as "B" battery.

This circuit is best adapted for the reception of telephone signals and spark signal at their natural tone. There is no distortion if the set is properly adjusted and the amplification is remarkable. The big point in its favor is the fact that adjusting one part of the circuit does not effect the others. Once set there is no need to vary any of the units except the tuning condenser No. 6 and the regenerative coupling No. 4. The other units are adjusted only when new tubes are inserted in the set.

The circuit shown in Fig. 2 is a circuit which will give the maximum amplification possible. This is not always desirable especially when it can be accomplished only at the expense of added instruments and more or less complication. There is shown in Fig. 3 a modification of the circuit which while it will not give the maximum results will give results satisfactory enough for everyday use. The circuit is shown provided with filament control jacks, this refinement may be omitted, of course, if not desired.

This circuit has been built into a receiver, photographs of which are given. The numbers of the various pieces of apparatus on Fig. 3 and the numbers on the photographs correspond. It is thus possible to identify each piece of apparatus in the circuit diagram and in the assembly. This method of assembly and wiring is particularly satisfactory as all parts are accessible and the wiring easy to follow. Modification of the method of assembly and wiring are of course a question of personal taste and entirely up to the builder.

A list of the various items used and suggestions on each piece follow.

1. This condenser can be identified in the various photographs as a 43 plate variable condenser of .001 M. F. capacity. A smaller or larger condenser will be equally satisfactory, the only change being in the wavelength range covered.

2. This is the loop coupling coil. By referring to the drawing it will be observed that this coil is wound in three sections. Thirty turns in all are used spaced as shown in Fig. 11. In the actual set No. 20-38 Litz was used but No. 22 d.c.c. may be used with practically the same results. It is not absolutely necessary to space the turns as shown but a proper value of coupling was obtained by this means.

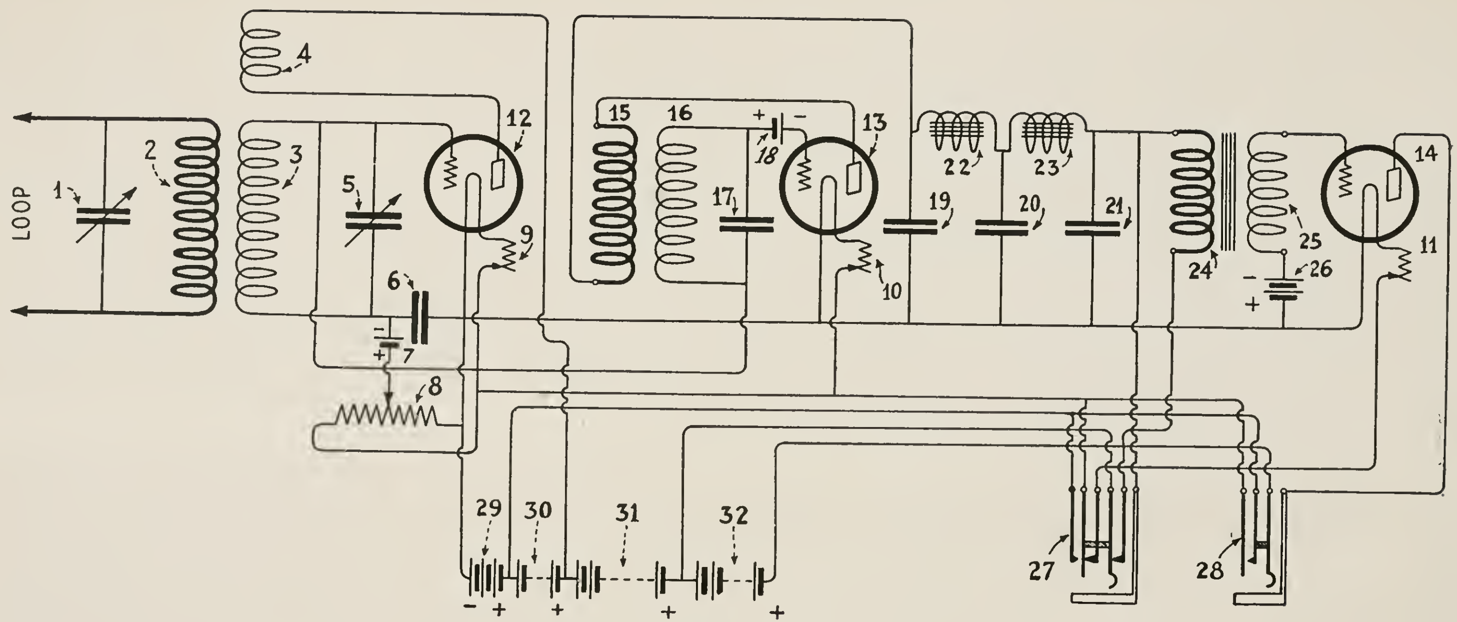


Figure 3

Adaptation of the circuit in Fig. 2 to eliminate several adjustments. Variation of positive resistance with respect to negative. Best for telephone and spark at natural tone.

1. Loop tuning condenser .001 mf. variable.
2. Loop tuning coil 30 turns 22 d.c.c. 4¾″ tube.
3. Grid tuning coil 25 turns 22 d.c.c. on 4¾″ tube.
4. Tickler coil—rotor of variometer.
5. Grid tuning condenser .0005 mf. variable.
6. Fixed condenser .01 mf. or larger.
7. Negative "C" battery 2 or 4 small flashlight cells.
8. "A" battery potentiometer.
9, 10 and 11. Filament rheostats.
12, 13 and 14. Hard vacuum tubes.
15. Oscillation plate coil 1250 turns Honeycomb or Duo-lateral coil.
16. Oscillation grid coil 1500 turns Honeycomb or Duo-lateral coil.
17. Oscillation grid condenser .003 mf. fixed condenser.
18. Negative "C" battery 1 or 2 flashlight cells.
19 and 21. Filter condensers .00181 mf. fixed condenser.
20. Filter condenser .00362 mf. fixed condenser.
22 and 23. Filter choke coils 2.28 Henry choke coils.
24. Primary of audio-frequency transformer.
25. Secondary of audio-frequency transformer.
26. Negative "C" battery 3 or 4 small flashlight cells.
27. First stage automatic filament control jack.
28. Last stage automatic filament control jack
29. Storage battery.
30. "B" battery 45 to 88 volts.
31. "B" battery 45 to 88 volts.
32. "B" battery 100 volts or over.

3. This coil is the grid tuning coil, 25 turns of 20-38 Litz were used spaced as shown in Fig. 11. Here again No. 22 d.c.c. may be used with good results.

4. This is the plate or tickler coil. It consists of the rotor of a variometer. The fixed winding of the variometer is removed from the frame and the outside part merely forms a support for the two tubes. These tubes which may be of laminated wood, bakelite or cardboard are fastened to the variometer housing with small pieces of brass suitably bent and drilled. See Figs. 10 and 11.

5. The value of this condenser need not exceed .0005 M. F. With this capacity as maximum the set will cover a wavelength range of 190-500 meters.

6. This condenser is a fixed paper condenser, the value may be anything above .01 M. F.

7. This is the negative "C" battery used to regulate the potential of the grids of both tubes. The value of the battery voltage must be changed to suit the particular tubes used, and the "B" battery voltage. Two to four small flashlight cells are suitable.

8. This is an "A" battery potentiometer to permit fine regulation of the value of the grid potentials. If desired this may be eliminated and the regulation effected entirely by the battery No. 7.

9-10-11. Filament rheostats of any type.

12-13-14. Hard vacuum tubes such as Western Electric or UV-201.

15. This is a 1250 turn Duo-Lateral coil mounted, as shown in the photograph, within the tube. See Fig. 9.

16. This is a 1500 turn Duo-Lateral coil also mounted within the tube with rather close coupling to coil No. 15. The coils should be so placed that the outside of the winding connects to the plate and grid when they are arranged for oscillation.

17. This is a .003 M. F. fixed mica condenser and with coil No. 16 gives a frequency of the order of 7000 to 8000 cycles. This frequency is sufficiently high to be readily filtered out and at the same time low enough to give good amplification results.

18. This is a separate "C" battery for regulation of the negative potential of the oscillator tube. It is not necessary in some

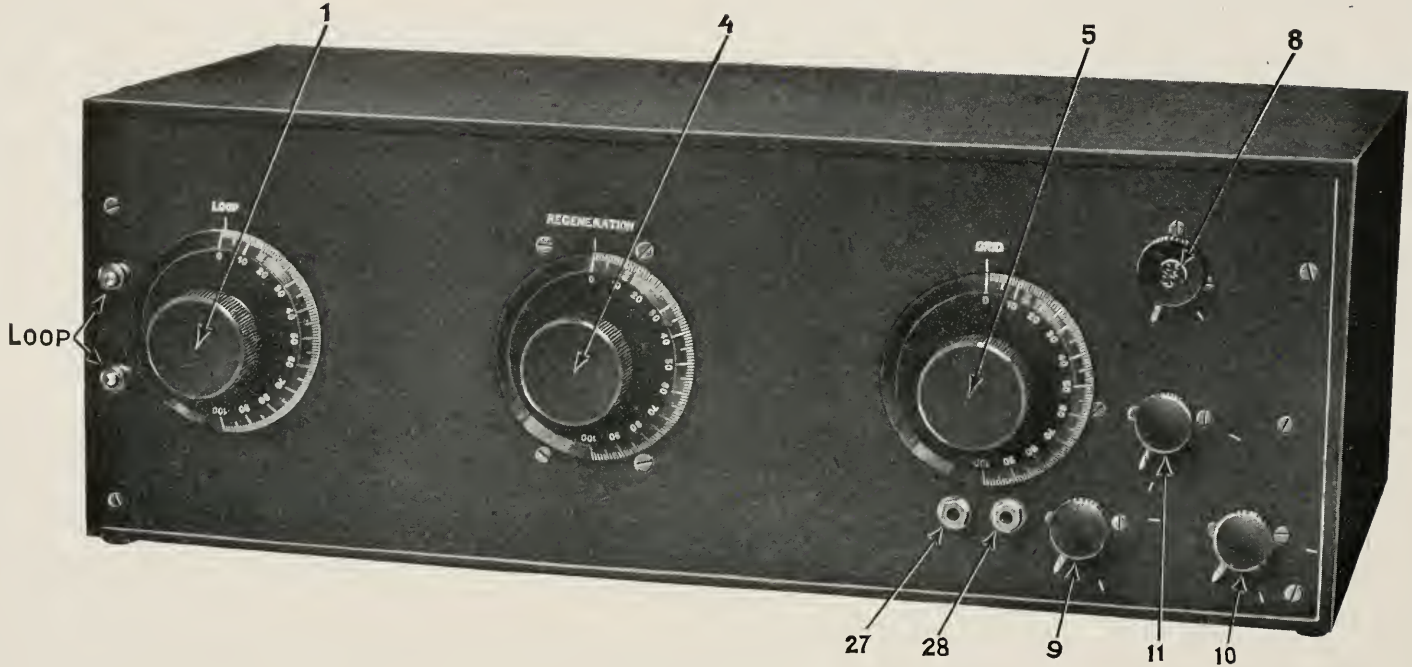


Figure 4

Outside view of complete receiver.

1. Loop tuning condenser.
4. Regeneration.
5. Grid tuning condenser.
8. "A" battery potentiometer.
9, 10 and 11. Filament rheostats.
27 and 28. Filament control jacks.

cases though frequently with certain tubes, both negative "C" batteries must be varied to obtain results. One or two small flashlight cells are suitable.

19-20-21-22-23. These units comprise the filter system; they are considered separately in a chapter on filters.

24. Primary of audio-frequency transformer.
25. Secondary of audio-frequency transformer.
26. Negative "C" battery for use with audio-frequency transformer when the plate voltage is above 100 volts. This battery should have a voltage of 3-4½ volts.
27. Filament control jack first stage type.
28. Filament control jack last stage type. Both these jacks may be dispensed with if it is desired to do so.
29. Six volt storage battery.
30. 45-88 volt "B" battery.
31. 45-88 volt "B" battery depending on the tubes used and the value of battery No. 30. In other words both batteries No. 30 and No. 31 must be varied to give best results.
32. Battery for plate of amplifier tube. This may be as great as 300 volts or more depending on the amount of power required and what the tube will stand.

The foregoing description together with a study of the photographs should give the reader a fair idea of the method of constructing the receiver. No rigid iron bound rules must be followed, the descriptions and the photographs are given more with an idea of guiding his line of thought, and not to dictate the method he should follow.

In Fig. 12 there is given the panel layout of the particular set under discussion. As the parts procurable in radio supply stores are far from standard, it is not possible to strictly follow the dimensions given. The drawing is shown with an idea of giving the size of panel necessary. The panel used was ¼″ thick but $\frac{3}{16}$″ would be just as satisfactory.

As already stated the results obtained with this receiver are not the maximum than can be obtained. They are satisfactory enough for ordinary use, however, and several troublesome adjustments are eliminated. The operation of the receiver is simpler than the common regenerative set once the major adjustment such as "B" battery voltage and "C" battery voltage are made. The use of filament control jacks and the simplicity of adjustment places the set from a convenience standpoint on a par with the best receivers on the market, from an operating standpoint it is far superior.

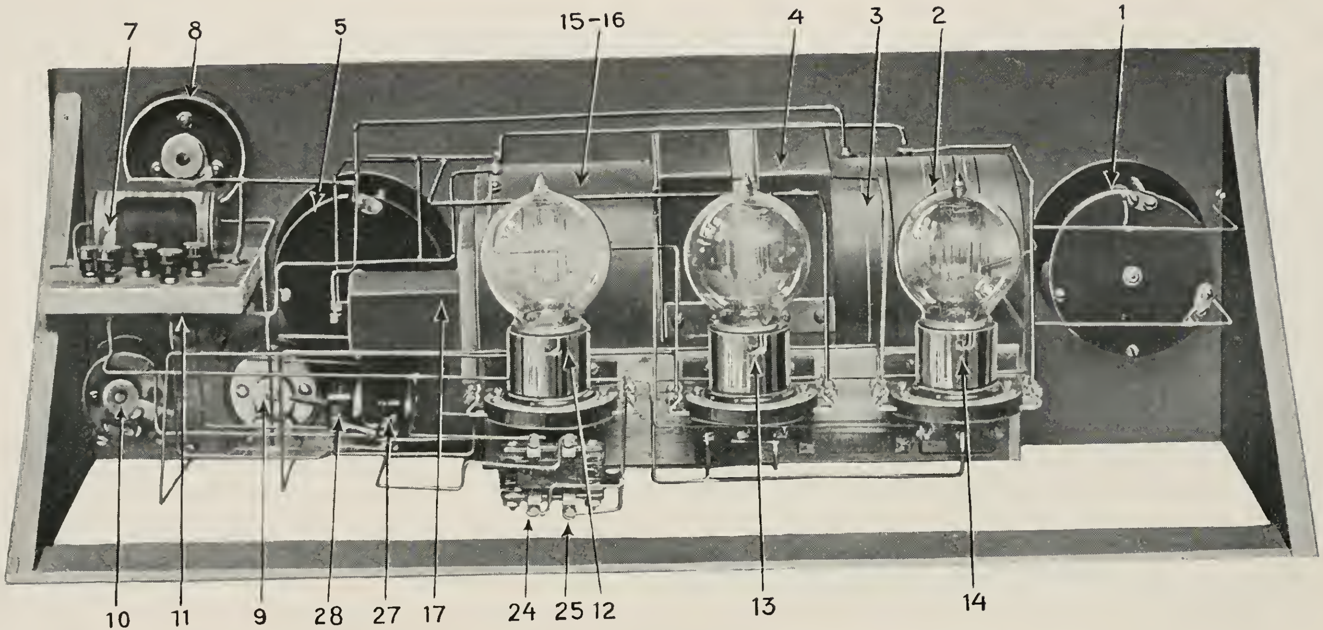


Figure 5

Back view of completed receiver showing general method of assembly and mounting of panel on side supports.

1. Loop tuning condenser.
2. Loop tuning or coupling coil.
3. Grid tuning coil.
4. Variometer.
5. Grid tuning condenser.
7. Negative "C" battery.
8. "A" battery potentiometer.
9. 10 and 11. Filament rheostats.
12, 13 and 14. Vacuum tubes.
15 and 16. Oscillation coils contained in tube.
17. Oscillation grid tuning condenser.
27 and 28. Filament control jacks.

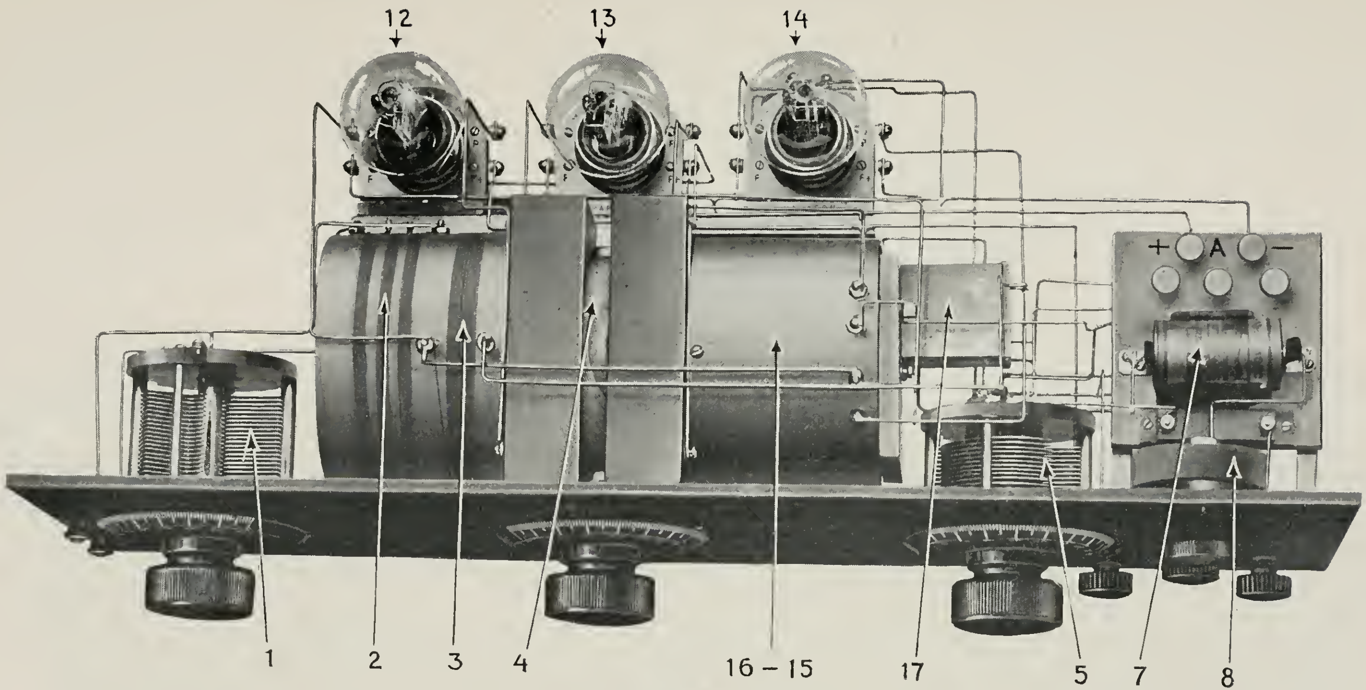


Figure 6

Top view of complete set showing method of attachment to panel. Note the method used in mounting the vacuum tubes on the variometer housing.

1. Loop tuning condenser.
2. Loop coupling coil.
3. Grid tuning coil.
4. Rotor of variometer.
5. Grid tuning condenser.
7. Negative "C" battery.
8. "A" battery potentiometer.

12, 13 and 14. Vacuum tubes.

15 and 16. Oscillation coils mounted inside of wooden tube.

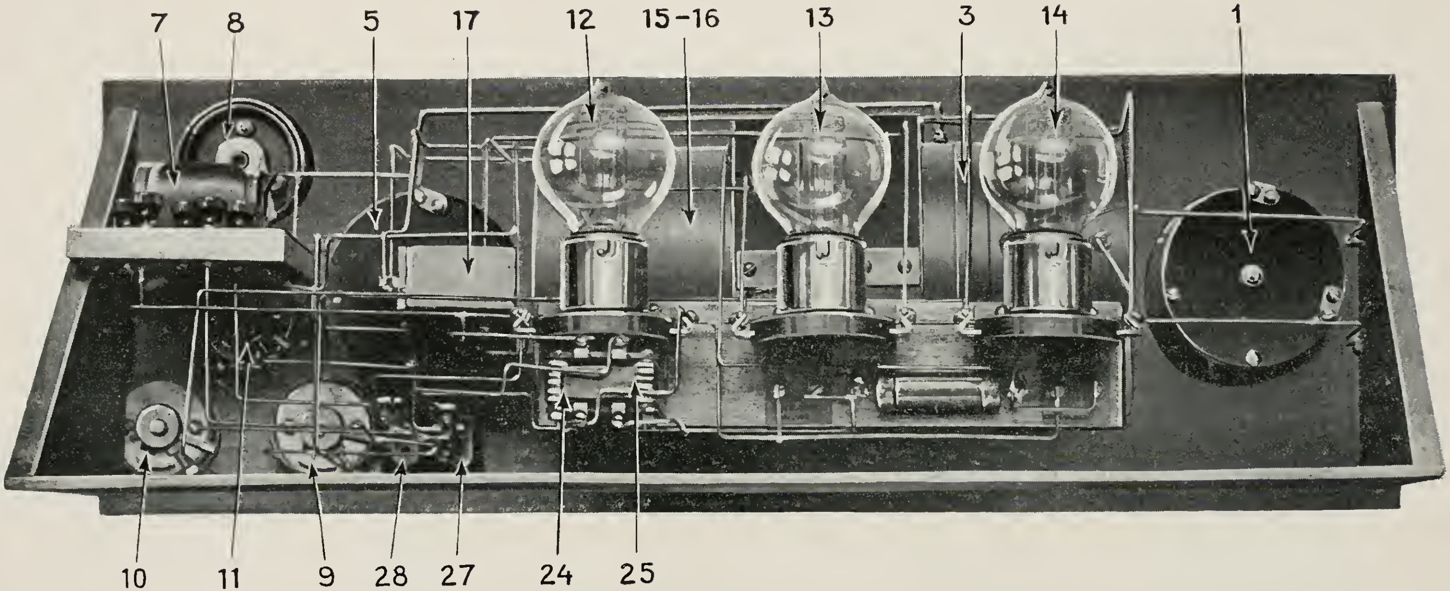


Figure 7

Rear view of completed set looking from below, tilted a trifle backward.

1. Loop tuning coil.
3. Grid tuning coil.
5. Grid tuning condenser.
7. Negative "C" battery.
8. "A" battery potentiometer.
9, 10 and 11. Filament rheostats.
12, 13 and 14. Vacuum tubes.
15 and 16. Oscillation coils contained in wooden tube.
24 and 25. Primary and secondary of transformer.
27 and 28. Filament control **jacks.**

1. Loop tuning condenser
2. Loop coupling coil.
3. Grid tuning coil.
4. Variometer.

9 and 10. Filament rheostats.
12, 13 and 14. Vacuum tubes.
15 and 16. Oscillation coils in tubes.
24 and 25. Amplifying transformer.
27 and 28. Filament control jacks.

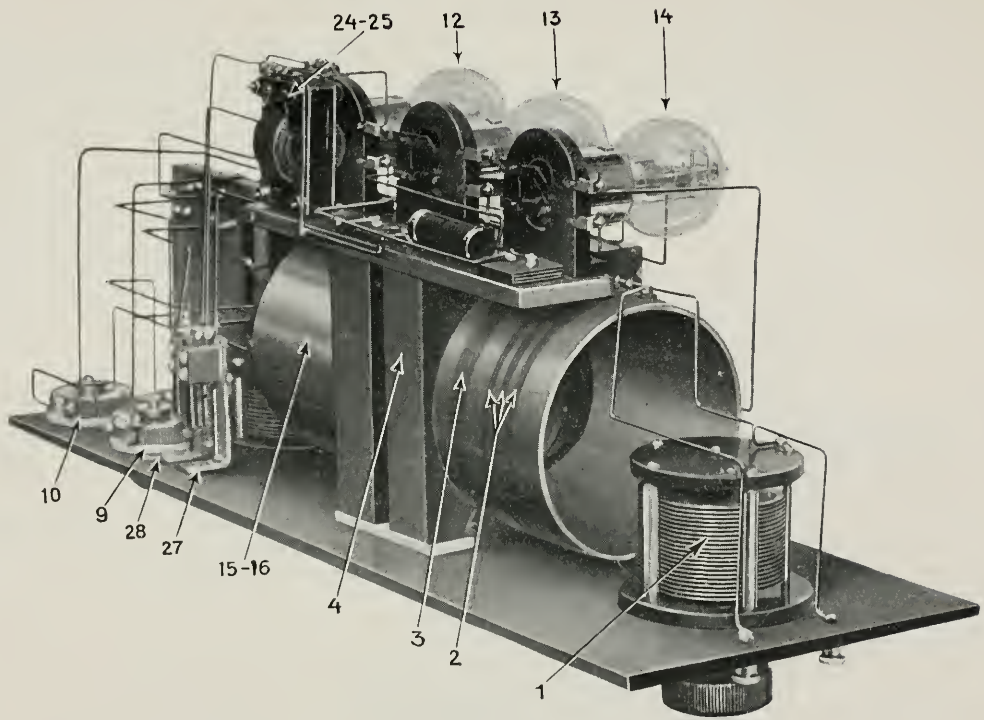


Figure 8

Bottom view of completed receiver from lower left hand corner.

1. Loop tuning condenser.
2. Loop coupling coil.
3. Grid tuning coil.
4. Variometer.
5. Grid tuning condenser.
8. "A" battery potentiometer.
9, 10 and 11. Filament rheostats.
12, 13 and 14. Vacuum tubes.
15 and 16. Oscillation coils in tube.
27 and 28. Filament control jacks.

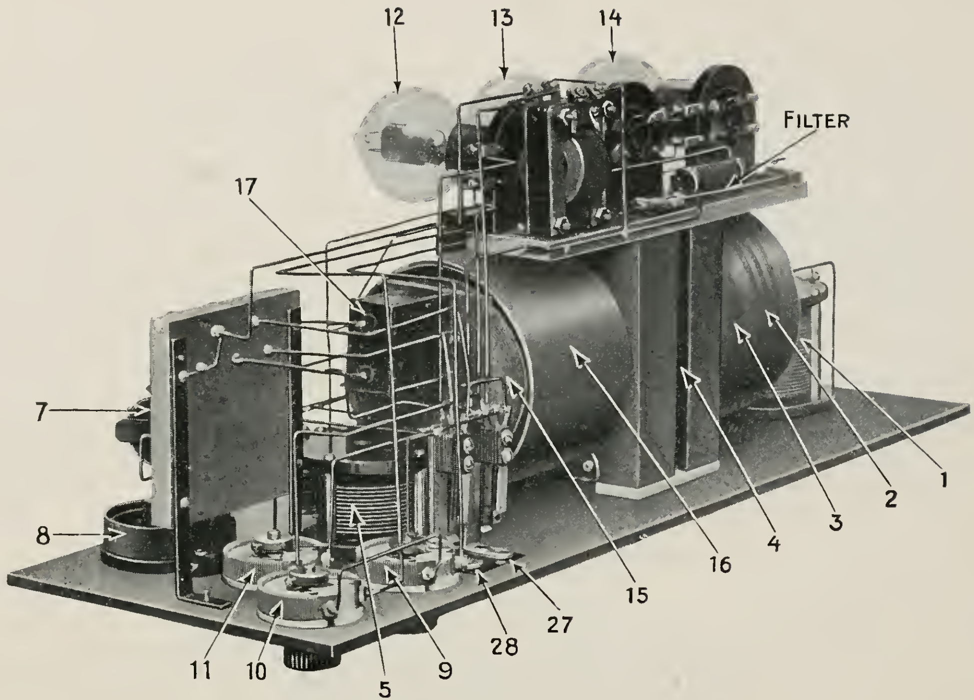


Figure 9

Bottom view of completed receiver from lower right hand corner.

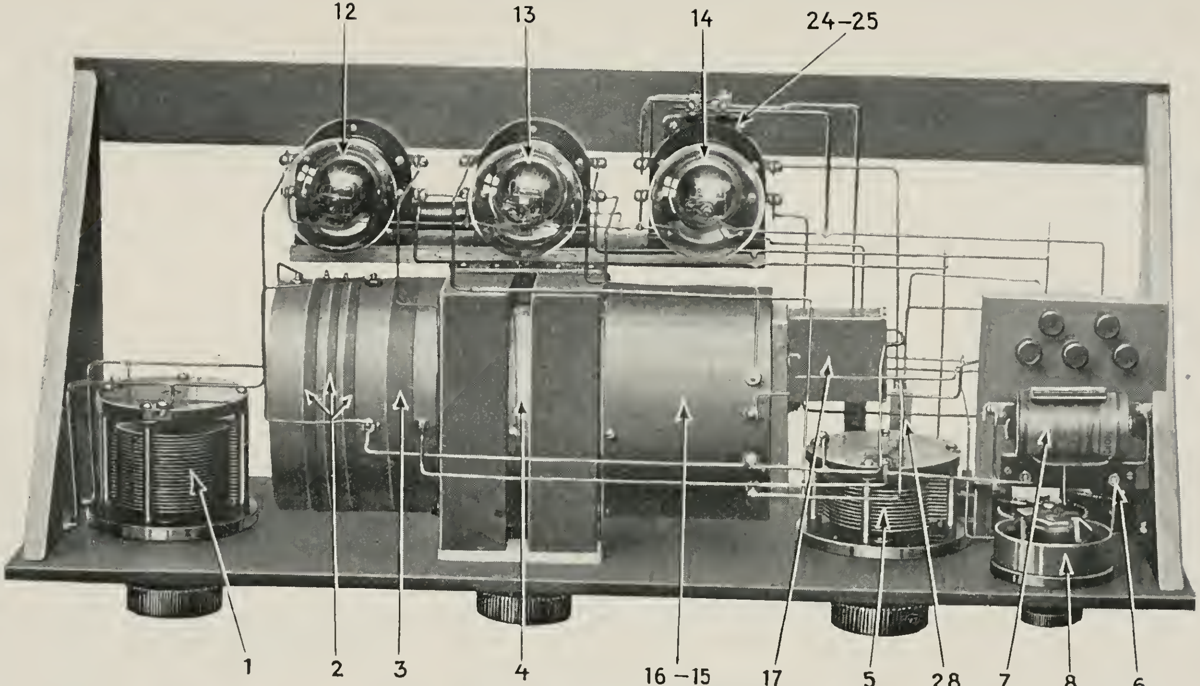


Figure 10

Top view of completed set tilted forward.

1. Loop tuning condenser.
2. Loop coupling coil.
3. Grid tuning coil.
4. Tickler coil.
5. Grid tuning condenser.
6. Fixed condenser.
7. Negative "C" battery.
8. "A" battery potentiometer.

12, 13 and 14. Vacuum tubes.

15 and 16. Oscillation coils mounted in tube.

17. Grid tuning condenser.

24 and 25. Audio-frequency transformer.

28. Filament control jack.

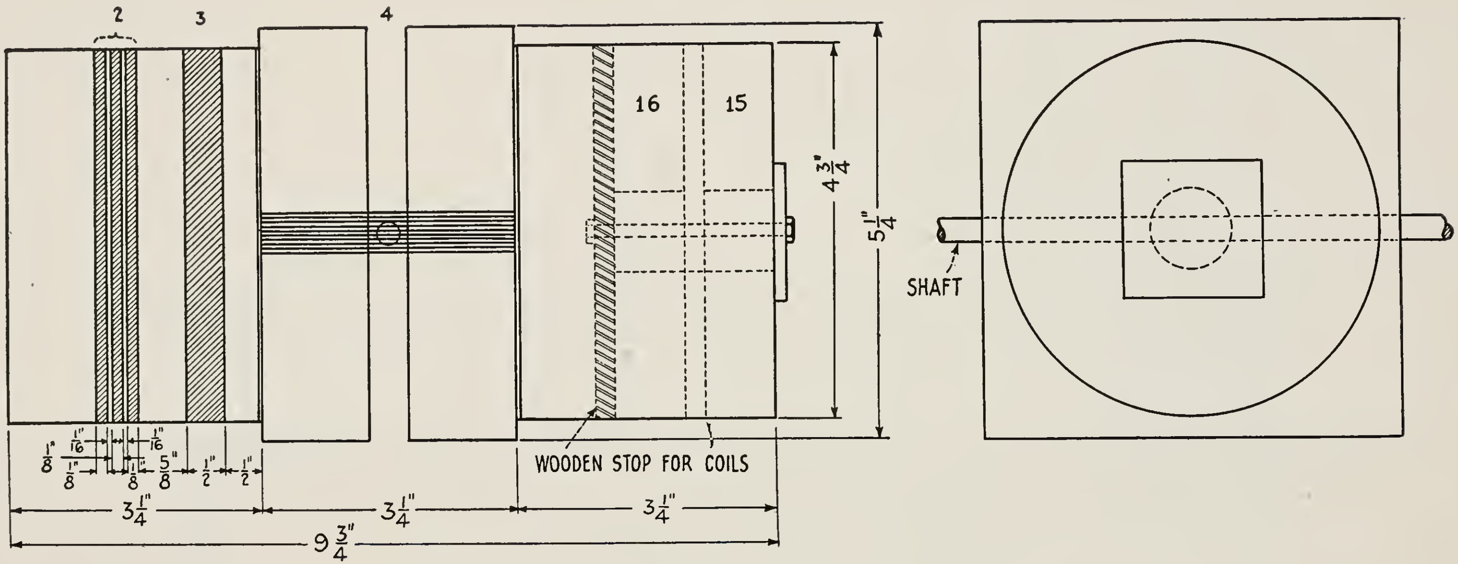


Figure 11

Outline of the method of assembly of the coils on the variometer. The stationary winding of the variometer is removed and the outside housing forms a support for the coils. The oscillator Honeycomb or Duo-lateral coils are mounted inside the tube attached to the variometer housing. The grid and loop coupling coils are wound on the tube mounted on the opposite side of the variometer.

Separate the oscillator coils about 1/4 inch.

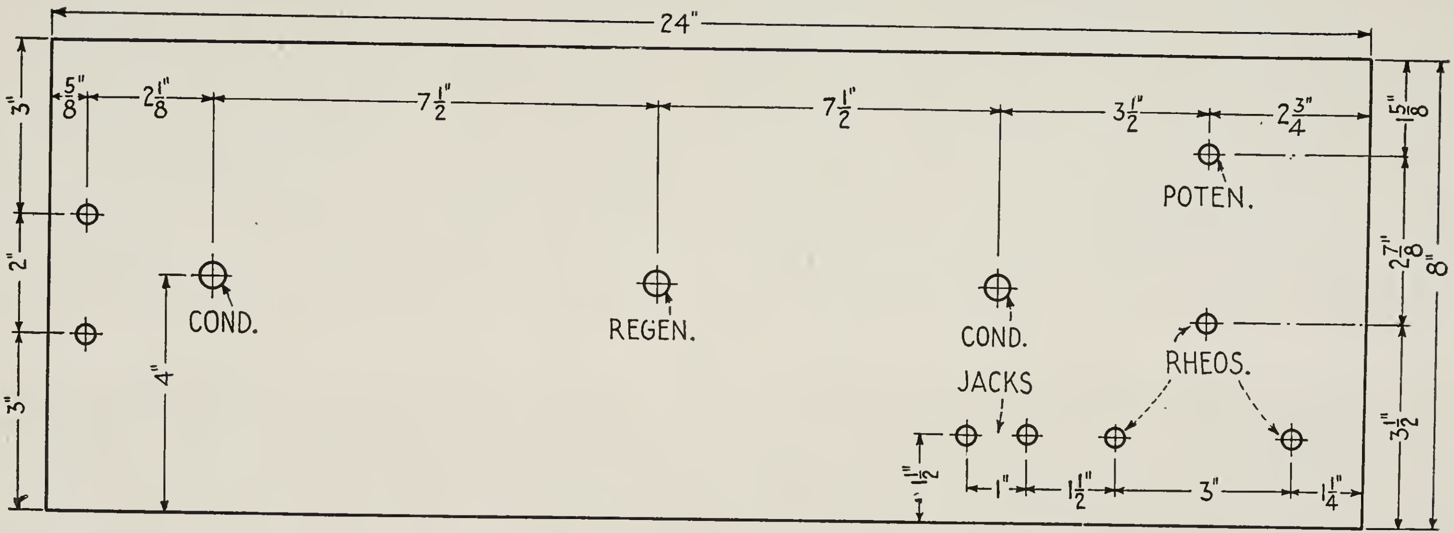


Figure 12

Layout of panel for completed set. Bakelite, formica hard rubber or any other good insulating material should be used. The shielding for the back of the panel may be attached by means of rubber cement. The shield need not be over 2 or 3 thousandth of an inch thick. Copper or brass is best. The inside of the cabinet need not be shielded unless desired.

By this time the thought must have occurred to the reader that the Super-Regenerative Circuit described in this chapter can be adapted to the ordinary regenerative receiver in common use. This is the case and in Fig. 13 there is shown the circuit diagram of a Super-Regenerative receiver adapted to a CR-5 Grebe receiving set.

A study of this circuit will show it to be identical with that shown in Fig. 3 with the exception of the coils 11 and 12 which in this case are made variable one with the other. To one side of the center line is the regenerative receiver as placed on the market by the manufacturers, to the other side is the apparatus necessary for the change. The dotted lines shown in the drawing are the changes in the wiring of the set which are necessary for the alteration.

The interesting items shown in Fig. 13 are enumerated below.

1. A variable condenser of .001 M. F. cap. This condenser tunes the loop circuit of the set.
2. This condenser is furnished with the receiver. It may be used as supplied in the manner shown or it may be short-circuited and connected in to take the place of condenser No. 1. Best results will be obtained with the extra condenser.
3. Switch for wavelength change.
4. Grid tuning coil.
5. Tickler coil.

6-7. Grid leak and condenser. The grid leak should be removed and the small battery shown inserted. The condensers need not be disturbed.

8. Hard vacuum tube such as Western Electric or UV-201.
9. By-pass condenser already in the set.
10. Negative "C" battery 3-4½ volts.
11. Duo-Lateral or Honeycomb coil of 1250 turns.
12. Duo-Lateral or Honeycomb of 1500 turns. These coils are mounted in a regulation mounting and are variable one with the other.
13. Variable condenser .003 M. F. This condenser may be either variable or fixed as desired. A combination of both fixed and variable is most economical.
14. Hard vacuum tube.

15-16-17-18-19. Filter circuit described later.

20-21. Filament rheostats.

22. Output of Super-Regenerative receiver. Connect the telephones here or run to audio-frequency amplifier.
23. Negative "C" battery 3-4½ volts.

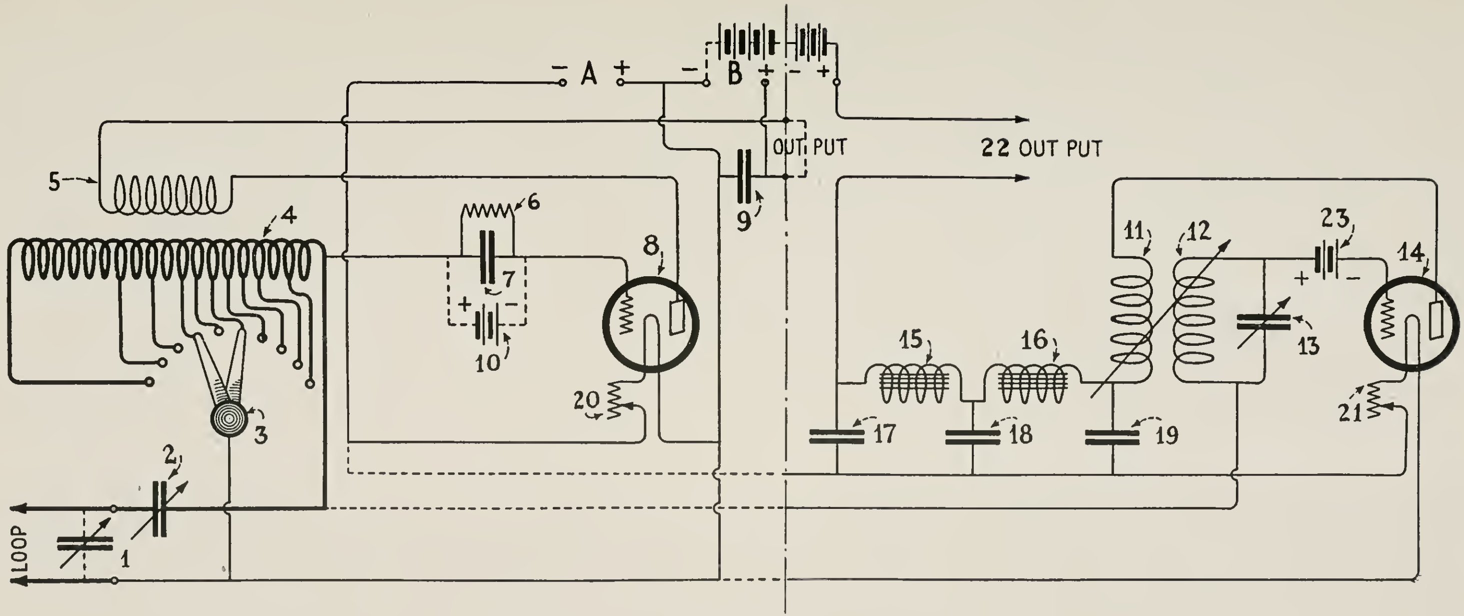


Figure 13

Super-Regenerative circuit adapted to a Grebe "CR-5" receiver.

1. Loop tuning condenser—.001 mf. variable.
2. Loop and grid tuning condenser provided in set.
3. Wave length change switch.
4. Grid tuning coil.
5. Tickler coil.
6. Grid leak.
7. Grid condenser.
8. Vacuum tube.
9. By-pass condenser.
10. Negative "C" battery—2 or 3 flash-light cells.
11. Oscillator plate coil—1250 turn Honeycomb or Duo-lateral coils.
12. Oscillator grid coil—1500 turn Honeycomb or Duo-lateral coils.
13. Oscillator grid tuning condenser, .0015 mf. Variable condenser with fixed units to give maximum of .003 mf.
14. Vacuum tubes.
15 and 16. Filter choke coils—2.28 Henry coils.
17 and 19. Filter condensers—.00181 mf. fixed.
18. Filter condenser—.00362 mf. fixed.
20 and 21. Filament rheostats.
22. Output.
23. Negative "C" battery 3-4½ volts.

The circuit shown in Fig. 13 is simple to set up and will operate as efficiently in conjunction with a regenerative receiver as a completely constructed set. Of course, the circuit may be adapted to any of the other regenerative receivers on the market, the main requirement being that the receiver can be readily made to oscillate. If this is the case the addition may be made with positive assurance of success. The changes in the set which are necessary are very slight and can be made without destroying the effectiveness of the receiver when used as a straight regenerative set. By a little ingenuity the amateur can construct a switching arrangement which will permit the change from regenerative to Super-Regenerative reception with little trouble.

CHAPTER IV.

IN Chapter 3 mention was made of the filter circuit necessary for proper operation and it is proposed to describe in this chapter several filter circuits which will prove satisfactory.

As it is desired to surpress or filter out only one frequency at a time the filter problem presented is not very difficult of solution. Before describing the methods to be used it will perhaps be well to refresh the mind of the reader on the need for the filter.

The Super-Regenerative Circuit it will be remembered depends for its operation on the variation of the resistance of the regenerative circuit. This variation is accomplished by the use of another frequency which thus far has been generated by an added tube called the low frequency oscillator. (Later a circuit will be shown in which one tube performs all functions.)

The introduction of this extra frequency in the circuit results in an audible sustained note in the telephone receivers (if the frequency is within the audible range) which is extremely annoying. By raising the frequency the note may be passed out of the audible range and fair results obtained if the circuit is used without audio-frequency amplification. If additional amplification is used the sustained oscillation will overload the amplifier tube and render it ineffective.

In general the lower the frequency possible with the low frequency oscillator the greater the amplification obtained with the regenerative amplifier. Obviously for the reception of speech the frequency cannot be below the speech frequency or of the speech harmonics.

For the reception of spark signals the frequency can be lowered since it is not necessary to keep the spark tone for good reception.

For signal recording work a sub-audible frequency is permissible.

In all cases the use of some type of filter is necessary if audio-frequency amplification is to be used.

In Fig. 1 the filter circuit consists of a coil of wire wound next to the grid coil of the Super-Regenerative amplifier. This coil due to its small inductance and the rather loose coupling cannot transfer enough of the low frequency oscillating current to the grid to cause trouble. The coupling is sufficient for the high frequency currents amplified however, and enough voltage is induced in the coil to operate the detector tube. In this circuit, therefore, the use of a filter is not necessary.

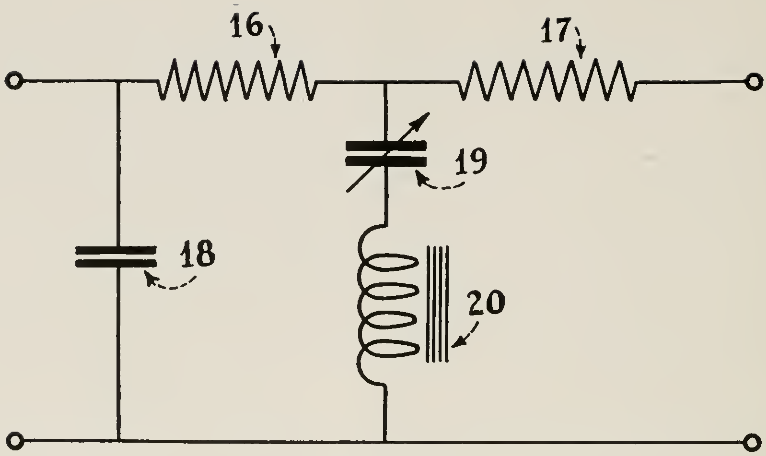


Figure 14

Combination resistance and resonance type filter.

16 and 17. 12000 ohm resistance.
18. Fixed condenser—.005 mf.
19. Variable condenser—.005 mf. maximum.
20. Choke coil about .1 to .25 Henries.

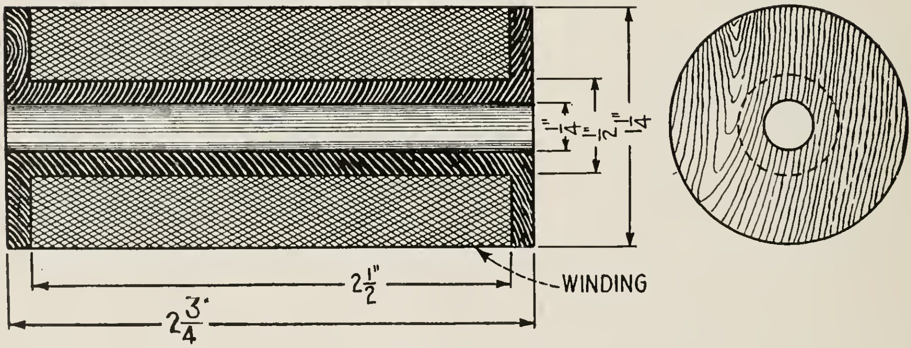


Figure 15

Constructional details of coil No. 20 in Fig. 14. The core consists of No. 22 iron wire tightly forced in the hole provided.

In Fig. 2 the scheme of connections is considerably different and a filter is necessary. Here the plate current of the oscillator flows through the telephone receivers. The filter circuit consisting of units 16, 17, 18, 19 and 20 in Fig. 2 is shown in detail in Fig. 14.

The resistances shown are each of 12000 ohms either inductive or non-inductive. They should be capable of carrying the few milliamperes flowing in the plate circuit of the tube without trouble. The condenser No. 18 is a fixed condenser of .005 M. F. The condenser No. 19 and the coil No. 20 are tuned to resonance with the low frequency oscillator. The capacity of the condenser may vary between .002 and .005 maximum, depending on the frequency of the oscillator. The inductance of the coil should be from .1 to .25 Henry. In Fig. 15 is shown a small coil having an inductance of .23 Henry. This coil is suitable for the purpose in mind and has been used successfully. The winding space should be filled with No. 32 S. C. C. wire, 3900 turns being required. Use an .003 variable condenser with this coil for frequencies about 12,000 cycles.

In Fig. 16 is shown another form of filter which is more or less satisfactory. Condenser No. 1 is of .0025 M. F.; variable in combination with fixed units. Condenser No. 2 is fixed at .0025 M. F. Coil No. 3 is the primary of an audio-frequency amplifying transformer, coil No. 4 the secondary. The condenser No. 5 shunted across coil No. 4 should have a maximum capacity of .001 M. F. By suitably adjusting these condensers it will be possible to filter out the frequency and operate the amplifier.

Both the filters described are of the resonant type. They surpress only one frequency and an alteration in one of the factors governing the frequency of the low frequency oscillator necessitates a readjustment of the filter to eliminate the new frequency.

In Fig. 17 is shown a low pass filter which can be readily calculated to pass all frequencies up to a pre-determined value, offering exceedingly high resistance to all frequencies above.

In calculating a filter of this character two facts must be given.

1. The resistance (or impedence) of the circuit the filter works into.
2. The cut-off frequency.

Fortunately the value of the first factor need not be exact a variation of 25% is permissible consequently assuming the telephone impedence or the impedence of the primary of the transformer to be 25000 ohms gives correct results with sufficient flexibility to take care of variations in apparatus.

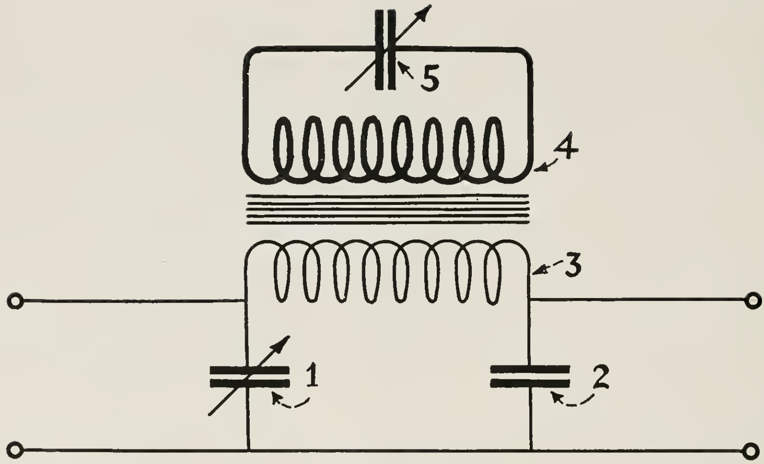


Figure 16

Resonance type filter.

1. Variable condenser—.0025 mf.
2. Fixed condenser—.0025 mf.
3. Primary or audio-frequency transformer.
4. Secondary of audio-frequency transformer.
5. Variable condenser—.001 mf.

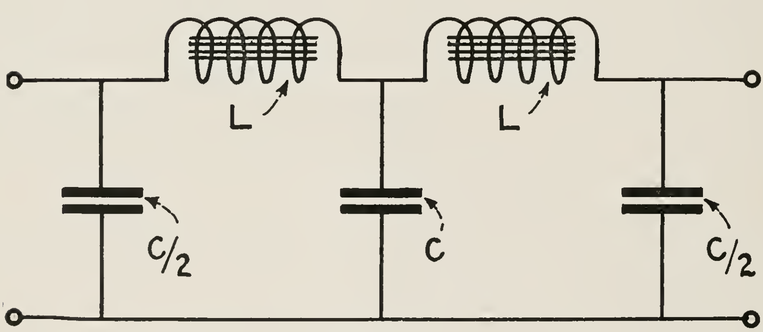


Figure 17

Low pass filter calculated to pass all frequencies up to 3500 cycles.

L=2.28 Henries. C= .00362 mf.

The cut-off frequency may be safely assumed as 3500 cycles, this being about 1000 cycles above the highest voice notes.

With these two factors determined the following equations are solved, giving the values below as correct for the filter.

Z=Impedence worked into
L=Inductance of the coil
C=Capacity of the condenser
F=Cut-off frequency
L C=4 (LC for cut-off frequency)

$$Z=\sqrt{\frac{L}{C}}$$

$$L\,C \text{ for cut-off frequency} = \frac{1}{(2\pi F)^2}$$

from which after solution with Z = 25000 ohms F = 3500 cycles, the values of L & C obtained are

L=2.28 Henry
C= .00362 M. F.

In solving equations of this kind the answer is obtained in Henries and Farads, to obtain working values point off the correct number of places.

Considerable space has been devoted to this form of filter as it is probably the best form for use in the Super-Regenerative receiver. The reader by use of a little algebra can solve the two equations given and design a filter to suit his own particular needs. The amount of energy at a frequency above the cut-off frequency passed by a filter of this type is extremely small. The efficiency of the filter may be improved by the addition of more sections. Adding sections does not effect the calculation in any way provided the end condensers are always made, as shown, equal to one-half of the value of the center condensers. The values of L and C just given apply to a filter designed for radio telephone work. A photograph of a filter constructed with these values is given in Fig. 18.

The coils used consist of one section of the secondary of an ignition coil. The winding has been reduced to 2800 turns of wire wound 140 turns to the layer, there being 20 layers. The length of winding is 1¼ inches. The core consists of iron wire 3 inches long and ¾ of an inch in diameter packed tightly in place. By counting the number of layers and the turns per layer similar coils can be made from any ignition coil.

The condensers consist of small copper plates ¾ x 1 inch separated by varnished paper .0015 inches thick. To obtain the value of C calculated seven plates are required (four and three), in other

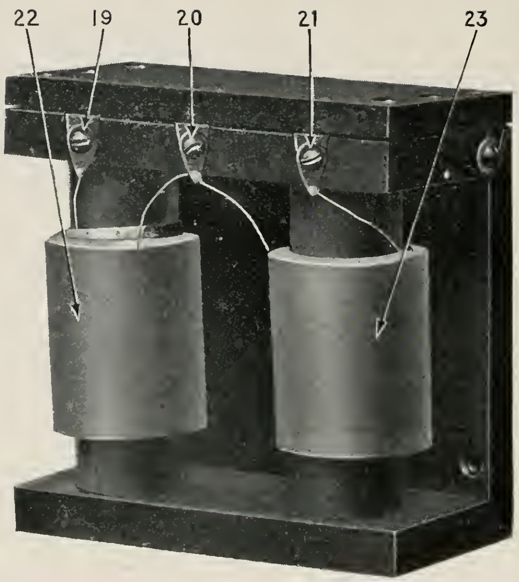


Figure 18

Completed filter as shown in Fig. 17. The lower cut shows the type of coil used.

19 and 21. Fixed condensers of .00181 mf. = (c/2).

20. Fixed condenser of .00362 mf. = (c)
22 and 23. Inductance coils of 2.28 Henries = (L).

This is a secondary of an ignition coil as used in the filter.

words, six complete surfaces are exposed. To obtain the value of C/2 three complete surfaces must be exposed or four plates are necessary.

The condensers are mounted directly on the side of the wooden frame supporting the coils. A piece of wood serves to clamp them in place and at the same time to compress the plates together giving the capacity desired.

The efficiency of a filter of this type is so high that frequently if placed in the circuit directly as shown in Fig. 3 and Fig. 13 the low frequency oscillator will not operate. To overcome this difficulty an additional condenser of .001 to .002 M. F. may be shunted across the input terminals of the filter or a resistance of the order of 12000 ohms used in the same way. Either one of these expedients permits the passage of the oscillation, at the same time not effecting the filter action.

This filter is especially adapted to this type of work since the frequency of the low frequency oscillator may be varied without changing the action of the filter. As already mentioned care must be taken to see that the filter itself and the wires connecting the filter and the low frequency oscillator do not pick up currents from the fields of the oscillator coils. By careful placing of the wires and the filter this trouble can be eliminated or the use of shielding resorted to.

CHAPTER V.

THERE remains to be considered the last circuit possible with the Super-Regenerative connection, the circuit in which the values of the positive resistance and the negative resistance are varied at the same time.

This circuit is shown in Fig. 19. A brief examination will show the similarity between parts of this circuit and the circuit shown in Fig. 1; likewise between other parts and the circuit shown in Fig. 2. Instead of two tubes one tube is caused to perform the function of amplifier and oscillator and if required the added function of detector.

The coil No. 10 and condenser No. 8 combined with the coil No. 11 and condenser No. 9 set the low frequency used in the circuit. The coil No. 3 and condenser No. 6 set the high frequency resonance condition and combined with coil No. 4, effect the regenerative action of the circuit.

Coil No. 8 is in series with coil No. 3 the grid coil for regenerative action. This is similar to the circuit shown in Fig. 2 and effects a variation of the positive resistance with respect to the negative. Coil No. 11 is in series with coil No. 4, the regenerative feed back coil. This is similar to the circuit shown in Fig. 1 and effects a variation of the negative resistance with respect to the positive.

In operation both these variations take place at once and it is easy to imagine a condition where the variation would take place in such a manner that the net change of resistance would be zero. This is a condition to be avoided. In like manner a variation of one resistance with respect to the other is possible which will give the greatest difference. This is the desirable condition. To bring about such a condition requires careful adjustment of the condensers No. 8 and No. 9, and the coupling between the coils 10 and 11. At the same time the adjustment of condenser No. 6 is important together with the feed back coil No. 4. The necessity for all these adjustments and the fact that each adjustment effects the others makes this particular adaptation of the circuit difficult to handle.

In Fig. 14 the telephone receivers No. 16 are shown in series with the plate circuit and B battery. When the telephones are placed in this position, the tube No. 15 and coil No. 2 may be dispensed with as the single tube No. 14 acts as oscillator, amplifier and detector. The telephone receivers will work satisfactorily in this position as

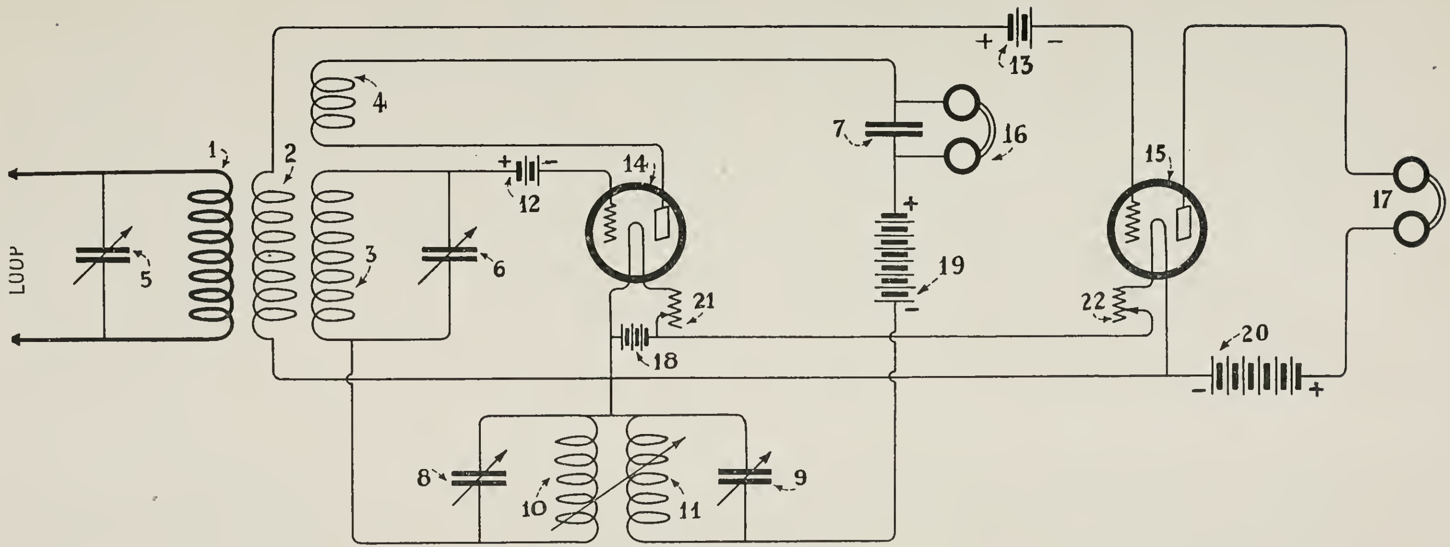


Figure 19

Single tube Super-Regenerative receiver. Variation of both positive and negative resistances simultaneously.

1. Loop coupling coil—variocoupler ball with 25 to 40 turns of 22 s.c.c. wire.
2. Detector grid coil—25 to 30 turns 22 s.c.c. on 4″ tube.
3. Grid tuning coil—25 to 30 turns 22 s.c.c. on 4″ tube.
4. Tickler coil—50 turns 22 s.c.c. on coupler ball.
5. Loop tuning condenser—.001 mf. variable.
6. Grid tuning condenser.
7. Telephone shunt condenser—.002 or .004 mf.
8 and 9. Low frequency tuning condenser—.0015 mf. Variable with fixed units to give maximum of .005 mf.
10 and 11. Low frequency tuning coil—1250 or 1500 Honeycomb or Duo-lateral coils.
12. Negative "C" battery—2 or 3 flash-light cells.
13. Negative "C" battery—2 or 3 flash-light cells.
14 and 15. Hard vacuum tubes.
16 and 17. Telephone receivers.
18. Storage battery.
19. "B" battery—45 to 88 volts.
20. "B" battery—22½ to 45 volts.
21 and 22. Filament rheostats.

long as the frequency determined by coils 10 and 11 and the condensers 8 and 9 is above audibility. When the frequency is lowered the audible note will be present in the receivers and cause trouble. If an audio-frequency amplifier is used it will be necessary to insert one of the filters described in the previous chapter in place of the telephone receivers to eliminate the oscillation and an overload on the amplifier tube. As the frequency of the circuit is being continually altered by variation of the condensers 8 and 9, the only practical filter to use is the low pass filter described. The use of this filter eliminates the necessity for constant adjustment of the filter which would be the case were a resonant type employed.

Where it is not objectionable to use an additional tube the telephones may be shorted out of position No. 16 and the detector tube used in conjunction with the coil No. 2. This method of detecting has already been described. The coupling between coil No. 2 and coil No. 3 is not sufficient to pass any of the low frequency oscillation but it is sufficiently high to impress enough high frequency voltage on the detector tube grid for operation.

The important items used in the circuit are as follows:

1-2-3-4-5 and 6. This entire circuit is similar to that used in the circuit shown in Fig. 1. The same size coils, condensers, etc., may be used.

7. Telephone shunt condenser about .002 or .004 M. F.

8 and 9. Variable condenser or combination of variable and fixed condensers to give a maximum capacity of .005 M. F.

10 and 11. Duo-Lateral or Honeycomb coil of 1250 or 1500 turns each.

12 and 13. Negative "C" battery 3-4½ volts. (Small flashlight cells.)

14 and 15. Hard vacuum tubes such as Western Electric or UV-201.

16 and 17. Telephone headset.

18. 6 volt storage battery.

19. "B" battery 45-88 volts.

20. "B" battery 22½-45 volts.

21 and 22. Filament rheostats.

While the same degree of amplification will be obtained with the circuit as with the others, the complication of adjustment recommends the others except where the use of more than one tube is objectionable. Of course if once set for a wavelength such as a broadcasting station the set will operate satisfactorily without adjustment.

CHAPTER VI.

IT will be interesting now to consider the various circuits given and discuss the characteristics of each with a view toward pointing out the best circuit for the purpose in mind.

Perhaps the most interesting point to consider is that the degree of amplification obtained with either one of the circuits is the same. The reason for this is evident after a little thought. All three circuits depend for their operation on the relative values of the negative and positive resistances. Where the negative resistance exceeds the positive the currents in the circuit increase to infinity, which in this case is the current carrying capacity of the tube. As the method by means of which the negative resistance is made to exceed the positive has no bearing on the value of the current once the condition is brought about naturally the results are the same for all the circuits.

The circuit shown in Fig. 1 is best adapted for the reception of C. W. and spark telegraphy. Where there is no particular objection to the reception of spark or C. W. at a tone different from the characteristic tone of the transmitter the low frequency oscillator may be set at about 500 cycles. This will give remarkable amplification results but as stated with the loss of the characteristic tone. The note due to the oscillator should not be present in the telephone receiver when a signal is not being detected.

For C. W. the circuit may be either used as shown or in conjunction with an oscillator. When the hetrodyne method is used the coupling between the hetrodyne oscillator and the set should be very loose.

When the circuit is to be used for telephone reception the frequency of the oscillator should be set at about 8-15000 cycles. This will give clear speech and will permit of good filter action by the grid coil of the detector tube.

The circuit shown in Fig. 2 is best adapted for spark reception at the natural tone and above all for telephone reception. The circuit has already been described in detail but a few general remarks may be valuable.

The frequency of the oscillator should be above 8 or 15000 cycles for telephone reception. Where spark reception with loss of spark tone is not objectionable the frequency may be set at 500 cycles as in circuit No. 1. The reception of C. W. with this circuit is best accomplished with an external oscillator loosely coupled. Results will be the same as with circuit No. 1.

The circuit shown in Fig. 19 is one which in spite of its complicated adjustments is bound to be popular since with one tube it is possible to duplicate the results of either of the other circuits. The circuit may be used for the reception of all types of signals, best results for C. W. being obtained with an outside hetrodyne. The second tube may be dispensed with when the low frequency oscillation is above audibility or a filter circuit used as already explained. This is a real amateur circuit, it contains all manner of variables and requires a real amateur to manipulate it.

The results obtained with any of the circuits are the equal of those obtained with a six tube super-hetrodyne circuit. The new circuit will not replace the super-hetroydne as the receiver par excellence. It will give, however, the same results with fewer tubes and slightly more complicated adjustments.

Two or more Super-Regenerative Circuits may be used in cascade securing tremendous amplification. These circuits are almost too complicated however, for practical use and will not be given.

Super-Regenerative Circuits should always be used with a loop. If connected with the aerial and ground the circuit will send out a modulated wave which will cause great interference with other receivers. The wave sent out occurs at that point in the cycle where the negative resistance exceeds the positive. In other words for a fraction of a second (determined by the frequency of the low frequency oscillator) the set is strongly oscillating, and acts as a miniature transmitter. As best results are obtained with a rather high "B" battery voltage the disturbance is greater than the ordinary regenerative receiver using a detector tube operating on 22½ volts or less. Moreover, connection to an antenna will not improve reception to any extent since the circuit depends for operation on the fact that the amplification will be the same regardless of the voltage received from the transmitter.

Another interesting point to be observed in the operation of the receiver is the fact that the degree of amplification increases with increasing frequency. Actual measurements indicate that the increase in amplification is inversely proportional to the square of the frequency. In plain language this means that if the amplification is 10 at 400 meters the amplification at 200 meters will be 40, at 100 meters the amplification will be 160 and so on. This interesting characteristic is not possessed by any other circuit at present in use. Needless to say this characteristic alone has untold value and will be of great aid in the operation of short wave signalling.

The Super-Regenerative Circuit depending for operation as it does upon the free oscillation made possible by the decrease in the positive resistance of the circuit posseses another characteristic which may prove of great value. Each time a variation in the positive or negative resistance occurs and at that time when the positive resistance is the greatest, all oscillations in the circuit whether of the free or induced type are wiped out. This is a valuable property since the interference set up by oscillations in the circuit due to stations other than the one desired are not permitted to oscillate freely in the circuit until damped out by the natural resistance of the circuit, as is the case with receivers in common use, but are wiped out immediately by the change in the circuit resistance brought about by the oscillator. This action applies not only to signals but to static as well and combined with the fact that a loop is used gives a greater freedom from static with this receiver than with others.

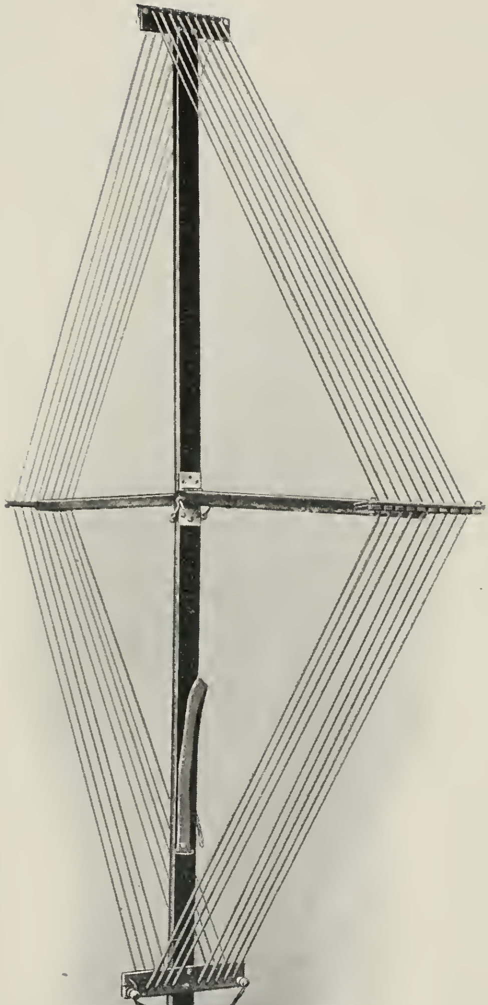
Of course, in constructing a finished receiver employing this circuit the same precautions in regard to shielding followed in constructing a regenerative receiver must be observed. Although not quite as sensitive to body capacity effects as the regenerative receiver still trouble will be caused if precautions are not taken. Another good point to bear in mind is that though iron core coils may be used in the low frequency oscillator circuit at a considerable saving in cost and in space (especially for 500 cycle work) the introduction of iron produces harmonies which will cause trouble in the operation. Air core coils are best and should be used in preference to the iron core even for extremely low frequencies.

After having the complete circuit set up and in operating condition the amateur will probably experience some slight difficulty in getting results. The number of mistakes it is possible to make are numerous. If, however, the following points are observed the amateur will aid himself greatly.

1. Be sure all connections are in accordance with the circuit diagram and that good contact is made all over. All connections should be soldered.
2. Be sure the regenerative circuit will oscillate properly when the low frequency oscillator tube is removed. A "click" will be heard in the telephone receivers if they are placed in the plate circuit and the plate coupling varied or the grid of the tube touched with the finger.

3. Be sure the low frequency oscillator is operating. If an audio-frequency is used this may be checked up by connecting the telephone receivers in series with the plate. If the frequency is above audibility a milliammeter in the plate circuit will indicate the oscillating condition by changing its reading when the grid is touched with the finger.
4. Be sure that the regenerative part of the circuit does **not** oscillate when the low frequency oscillator is turned on and is operating as shown in the circuit diagram. This can be checked by touching the grid with the finger. The familiar "click" present when the circuit is oscillating will not be heard.
5. If the regenerative circuit and oscillator are operating properly as the plate coupling of the regenerative circuit is changed, the familiar and characteristic noises of a regenerative receiver will be heard. These noises will be much greater in volume and slightly different from those of the straight regenerative set. The similarity will be enough, however, to indicate whether the operation is as it should be.
6. If the regenerative action is as indicated above the set is probably operating correctly. It should now be tuned to a signal of more or less steady character such as a broadcasting station, or a wavemeter excited by a buzzer and the adjustment of "B" battery and negative "C" battery made to give loudest signals.
7. If there is not a great increase in signal strength between the detector and the first stage of audio-frequency amplifier the filter is not working properly. This should be checked over and the proper adjustments made.

Before concluding it would be a mistake not to caution the amateur to be patient in his efforts to get the circuits operating. The degree of amplification obtained for the number of tubes used is beyond anything yet developed. Naturally the problem which must be solved is more difficult. Minor details that could be safely neglected in the straight regenerative receiver are of major importance in the new circuit. A few hours of perserverance will be rewarded a hundred times over once the circuit is in operation.



CHAPTER VII.

FOR the convenience of the amateur in purchasing the material necessary for the different circuits described there is listed below the apparatus which will be required, for the circuit showing in Figure No. 1.

1 Varicoupler
1 Varicoupler ball
1 Variable condenser .0005 mf.
1 Variable condenser .001 mf.
2 Variable condensers .0015 mf.
6 Fixed condensers .001 mf.
1 Fixed condenser .01 mf. or larger
2 1500 Honeycomb or Duo-lateral coils
3 Vacuum tube sockets
3 Filament rheostats
3 Hard vacuum tubes
2 "A" battery potentiometer
1 6 Volt Storage Battery
6 22½ Volt "B" Battery
3 Small flashlight cells
1 Pair telephone receivers

Additional material such as filament control jacks, telephone plugs, coil mountings, etc., may of course be added at the reader's option.

Circuit showing in Fig. No. 2 the following parts are required:—

1 Varicoupler
1 Variable condenser .0005 mf.
3 Variable condensers .0015 mf.
6 Fixed condensers .001 mf.
1 Fixed condenser .005 mf.
1 300 turn Honeycomb or Duo-lateral coil
1 1500 turn Honeycomb or Duo-lateral coil
1 1250 turn Honeycomb or Duo-lateral coil
2 12000 ohm resistances
1 .1 Henry choke coil
1 Audio-frequency amplifying transformer
3 Vacuum tube sockets
3 Filament rheostats
3 Hard vacuum tubes

4 Small flashlight cells
1 Pair telephone receivers
1 6 Volt Storage Battery
6 22½ Volt "B" Battery

For the circuit showing in Fig. No. 3 the following parts are needed:—

1 Variable condenser .0005 mf.
1 Variable condenser .001 mf.
1 Variometer
2 Tubes for coils
1 "A" Battery potentiometer
1 Fixed condenser .01 mf. or larger
1 Fixed condenser .003 mf.
1 Fixed condenser .00362 mf. (.0035) as supplied from stock
2 Fixed condensers .00181 mf. (.002) as supplied from stock
2 Iron core coils 2.28 Henries each
3 Vacuum tube sockets
3 Hard vacuum tubes
3 Filament rheostats
1 Audio-frequency transformer
1 Filament control jack for first stage
1 Filament control jack for last stage
1 Storage Battery
6 22½ Volt "B" Battery
4 Small flashlight cells

The following additional material will be necessary to convert the Grebe CR-5 or similar type regenerative receiver to a Super-Regenerative set as shown in Fig. No. 13:—

1 1500 Honeycomb or Duo-lateral coil
1 1250 Honeycomb or Duo-lateral coil
1 Variable condenser .001 mf.
1 Variable condenser .0015 mf.
3 Fixed condensers .001 mf.
1 Fixed condenser .00362 mf. (.0035) as supplied from stock
2 Fixed condensers .00181 mf. (.002) as supplied from stock
2 Iron core choke coils 2.28 Henries each
1 Vacuum tube socket
1 Hard vacuum tube
1 Filament rheostat
4 Flashlight cells
5 22½ Volt "B" Battery to give a total of 110 volts or more

In the single tube circuit shown in Fig. No. 19 the following will be required:—

1 Variocoupler
1 Variocoupler ball
1 Variable condenser .0005 mf.
1 Variable condenser .001 mf.
2 Variable condensers .0015 mf.
7 Fixed condensers .001 mf.
1 Vacuum tube socket
1 Hard vacuum tube
1 Filament rheostat
1 Storage Battery
5 22½ Volt "B" Battery
4 Small flashlight cells
1 Pair telephone receivers

If 2 tubes are to be used there will be required in addition:—

2 Small flashlight cells
1 Filament control rheostat
1 Hard vacuum tube
1 22½ Volt "B" Battery

If one tube is to be used and audio-frequency amplification in addition, the list of parts immediately above can be omitted and the low pass filter described in Chapter IV., substituted for the telephone receivers. If two tubes are to be used the audio-frequency amplifier can be added instead of the telephone receivers shown as No. 17 in Fig. No. 19.

In addition to the parts specifically mentioned of course there will be required the necessary wire for winding the small grid and loop coupling coils. About ¼ of a pound of No. 22 s.c.c. wire will be ample. Wire for connecting the various parts will also be required. A pound of No. 14 soft or hard drawn bare copper wire will be found suitable for the purpose.

The loop used in connection with either of the circuits is the same. There are so many forms of loop aerials and the method used in constructing is so varied that it is unnecessary to describe this part of the set in detail. In Fig. No. 20 is shown a typical form of loop aerial supplied by the Radio Corporation of America. The loop is shown with a small condenser mounted on the base. It may be purchased either with or without the condenser at a fairly reasonable price. If it is desired to construct a loop, this type of construction may be followed or any other which will provide from 6 to 10 wires on a frame about 2½ feet square with the wire spaced about ¾ of an inch apart.

The Super-Regenerative receiver used in conjunction with a CW or telephone transmitting set makes an ideal station for the amateur. Mr. J. O. Smith in his latest publication,

"MODERN RADIO OPERATION,"

fully describes his well known station 2ZL.

His book can be bought at your dealer or from "The Wireless Press," 326 Broadway, New York City.