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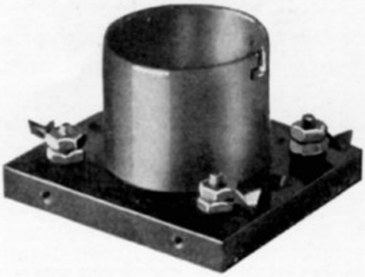
101 RECEIVING CIRCUITS
Fourth Installment



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A Super-Regenerative Receiver

A new receiving system which promises to revolutionize short wave radio reception.

By W. H. Bullock

While the instructions here given for the construction of a 3-tube super-regenerative receiver are considered so explicit in every detail that anyone who is mechanically inclined can construct the set, it is not an instrument to be built by the novice. It is recommended for the radio enthusiast whose interest in the radio art makes the scientific phase of apparatus construction and operation of greater moment than simply listening to signals on an outfit that requires no skill to adjust and maintain.

Theory of the Circuit

ON JUNE 7, 1922, Mr. Edwin H. Armstrong presented a paper before the Institute of Radio Engineers in which he described a method of amplification quite different from anything that had previously been used in radio reception. The theory upon which this system was based seemed so sound, and the results obtained in his demonstration were so unusual, that the circuit was generally accepted as a great advancement in the radio art.

In short, the circuit is an ingenious method of permitting regenerative amplification beyond the point at which a vacuum tube ordinarily falls into oscillation when the feed-back is increased. Heretofore we obtained maximum signal strength just before this point was reached, but as soon as it was passed the character of the signal was changed and increased feed-back coupling did not produce greater audibility. This was because the negative resistance of the circuit was so great that free oscillations persisted after the first impulse was received, while subsequent impulses did not materially change the state of oscillation which had been created. The signal strength, therefore, was not as great as when the relative value of the negative resistance was low enough to enable the telephone current to return to its normal value between received impulses. It is the point just before oscillation sets in that the difference in amplitudes is greatest and therefore the signal strength is strongest. The super-regenerative circuit provides for a periodic change of the relation between the positive and negative resistances of the circuit and makes use of free local oscillations for amplification rather than the forced or incoming oscillations. The received energy starts local oscillations which increase in amplitude while the negative resistance exceeds the positive resistance, but are damped out by a change in resistance relation, thereby bringing the circuit to a condition at which the next received impulse can act in a similar manner. It is the changing of the relative values of the positive and negative resistances which prevents continuous oscillation in the circuit.

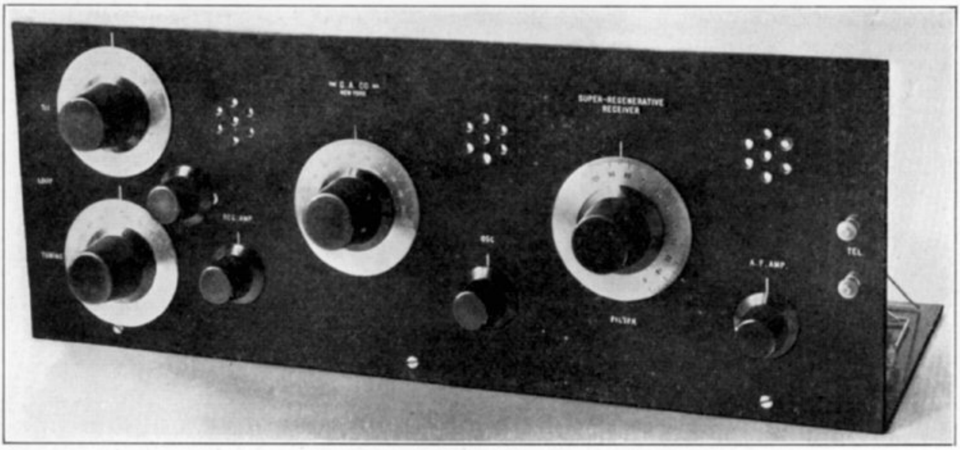

Fig. 1. A front view of the super-regenerative receiver

There are three general methods of varying the resistance relation. One means is to periodically change the negative resistance while the positive resistance remains at a definite value, another, to vary the positive resistance with the negative resistance fixed, and the third is to simultaneously change both resistances at a proper phase relation. In each case an oscillatory vacuum tube is used to make the periodic change. While it is possible to use a single tube for both regenerative amplification and oscillation, separate tubes are usually employed. The first, called a regenerative amplifier, is connected to the tuning system while the oscillator is wired so as to vary the resistance of either the plate or grid circuit of the first tube. The frequency of the local oscillator should be as low as can be attained without producing a tone which would be objectionable in the telephones. A frequency of 15,000 cycles is quite desirable for radio telephone reception, tho a lower period can be used for radio telegraphy.

A Super-regenerative Receiver The super-regenerative receiver constructed for this article includes three tubes. In addition to the two just mentioned, a stage of audio frequency amplification is used. After testing out several circuits this three-tube outfit was adopted as the most practical system for general use. In it, the positive resistance is varied with respect to the negative at a frequency of 12,500 cycles per second. Fig. 4 depicts the wiring diagram employed.

Referring to Fig. 1, the lower left hand knob controls a 0.00025 mfd. condenser for tuning to the wavelength of a desired signal. A means for enabling fine adjustment is provided in the form of a vernier condenser connected in parallel to the eleven plate variable. The inductance component of the circuit consists of a loop antenna and a series inductance of fixed value. The latter is located behind the upper left hand portion of the panel. An inductance rotor is mounted in the coil to act as a feed-back for the first tube with the coupling variable thru the agency of the knob and dial seen above the condenser.

The center dial controls a 0.001 mfd. variable coupling condenser whose function is to control the feed-back action of the oscillator tube. In the circuit, it is wired in series with a radio frequency impedance between the grid and plate to permit a variation in the coupling of the grid and plate circuits without materially affecting the tuning of the set. The right hand knob and dial serves as the adjusting member for a second 0.001 mfd. condenser. This variable capacity forms part of a filter system designed to take care of an annoying whistle produced by the circuit. It is employed in conjunction with a choke coil having an inductance of about 150 millhenries, and is shunted by a fixed condenser of 0.001 mfds. capacity. Separate rheostats are provided for each tube but they require very little adjustment since "hard" tubes are employed thruout. As seen from the engraving on the panel, the left hand tube is a regenerative amplifier, the center one the oscillator, and the one at the right an audio frequency amplifier. Only four binding posts are located on the front panel—two at the tuning end to accommodate the loop antenna, and two at the amplifier end to act as telephone terminals.

All of the apparatus is mounted upon $\frac{3}{16}$ in. L. P. F. A base panel measuring 7½ by 20 ins. and a front panel of the same size are joined by three brackets made of ⅜ in. angle brass. This type of construction is found extremely simple, economical and neat, and permits convenient access to the various parts for inspection, adjustment, or experimental purposes. The battery leads are cared for by binding posts located on the base. With reference to Figs. 2 and 3, the pair at the rear are filament battery terminals and the cluster of three are for the plate battery. Counting

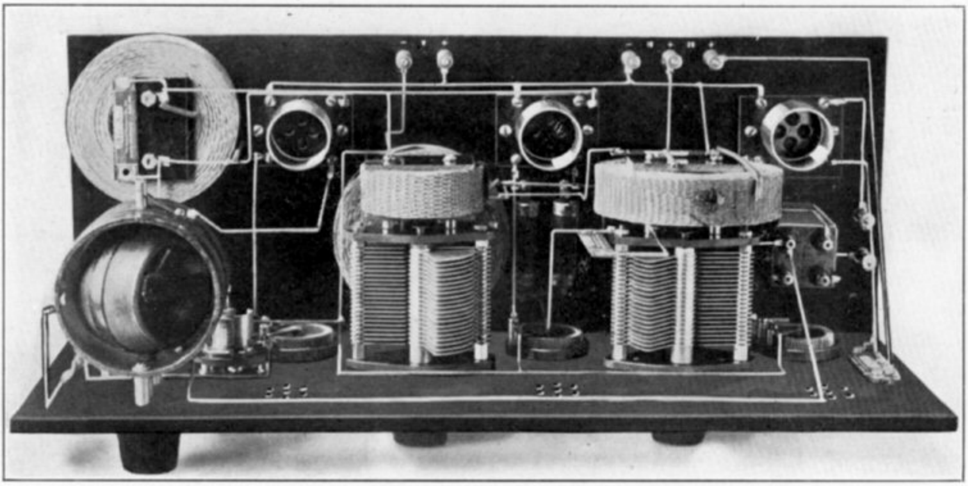

Fig. 2. Top view showing details of assembly

from the left, the first is the negative, the second 90 volts positive, and the third 225 volts positive. At the output end of the base, two grid battery terminals are provided for a tapped 22½ volt B battery. With the exception of the variocoupler, the inductances are of a concentrated form, held in place by two screws which clamp small L. P. F. panels against them. The position they occupy is quite important, as their external fields are so great that coupling between different portions of the system is liable to result, with troublesome effects if the arrangement is poor. With this general description of the super-regenerative receiver, and a careful study of Figs. 1, 2, 3, and 4, the instrument should be understood clearly enough to take up the construction of the set.

Work on the Panels

Laying out and drilling the panels is the first step to be taken in building the receiver. L. P. F. panels measuring 7½ by 20 ins. may be purchased already cut and squared since this is a standard size. Unless the builder has a well equipped shop it is advisable to obtain the panels with finished edges, for squaring up a 7½ x 20 in. piece of this insulating material is not as simple a matter as it might sound. Assuming that we have the two panels the proper size with straight edges and square corners, they should be laid out for drilling in accordance with the scale drawing, Fig. 5.

This illustration shows the panels at one fourth actual size, so the location of all holes may be obtained by measurements made upon the drawing and multiplied by four. The diameter of each hole is indicated by numbers appearing beside them. In most cases the number of the drill to be used is given, but for the larger holes the diameter in inches is specified. Concentric circles are shown where holes are to be countersunk to take flat head screws. It should be noted that the drawing of the base panel shows the under side, since the countersink circles are given in full lines. Locate all holes on the back of the front panel and the bottom of the base panel by fine intersecting lines and start the operation with a center-punch before attempting to drill. This insures the correct location of each hole, which is a requisite for a well made piece of apparatus. Care should be taken to see that the drill is sharp and that the work of drilling is not rushed to an extent which might cause the panel to break out as the drill is about to come thru. As a precaution, it is a good idea to place the panel on a smooth flat surface and do the drilling with comparatively high speed and little pressure. This, of course, refers to hand and not machine drilling.

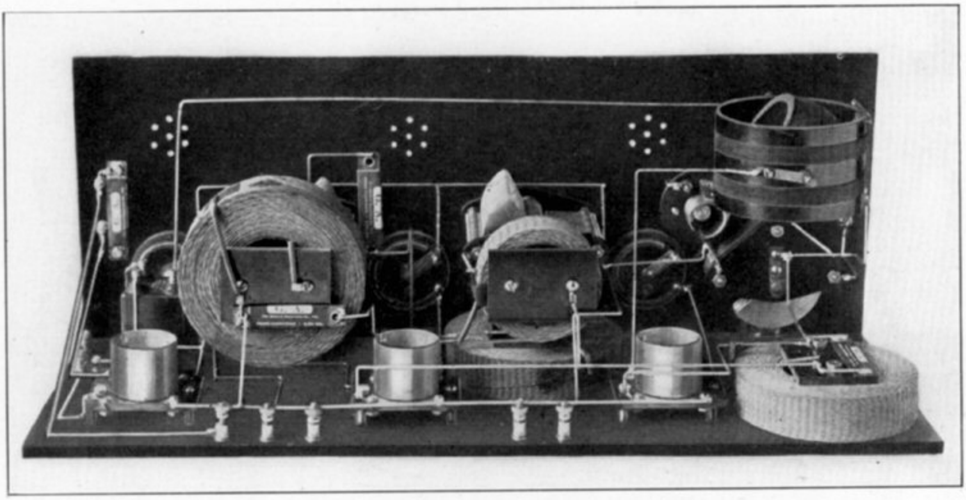

Fig. 3. Rear view which should assist in the wiring of the set

Construction of the Variocoupler

The tuning inductance and tickler coil are mounted together in the form of a variocoupler of fixed inductance values. The grid circuit coil is wound upon an L. P. F. tube, 2½ ins. long and 3½ ins. in diameter. Before the winding is started, drill the cylinder with two ¼ in. shaft holes midway between the ends. A No. 27 hole is then placed $1\frac{3}{16}$ in. from each to take machine screws which hold shaft contact springs. On a line drawn thru one shaft hole parallel to the axis drill two more No. 27 holes—one ⅜ in. in from each end of the tube .These serve $\frac{5}{16}$ by ⅝ in. brass support pillars which hold the unit to the panel. To provide terminals for the winding place two ¼ in. 6-32 screws and nuts 90 degrees from the shaft holes. Each screw should be fitted with two copper soldering lugs and located ⅜ in. in from each end of the tube. One lug of each pair takes care of the end of the winding while the other is left for the conductor which connects the inductance to its proper place in the circuit. Using No. 24 S. S. C. wire, start the winding by securing the end of the wire to a lug and place the first

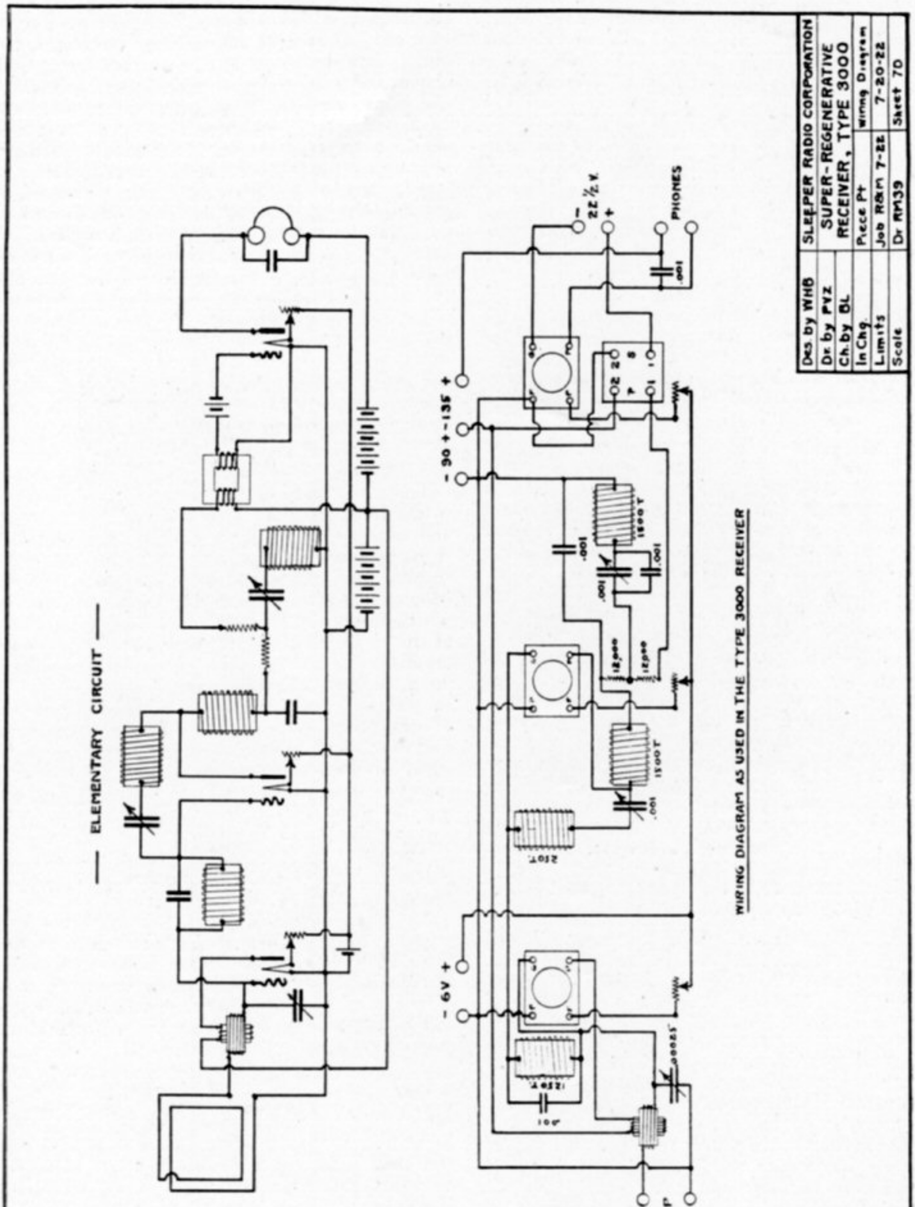

Fig. 4. Wiring diagram of the super-regenerative receiver

turn 3/4 in. in from the end of the tubes. Wind on 18 turns, skip a space of 1/2 in. to clear the shaft and wind on 18 more. Both ends should then be soldered into the terminals provided for the purpose.

The plate coil is wound upon a 3 in. mahogany rotor ball, using the same size wire as that employed for the grid inductance. First drill a small hole near each outside flange of the rotor for fastening the ends of the winding and since the coil cannot be wound in two sections, two more holes are drilled at the center rib so that the top ends of each half may be joined on the inside of the ball. Wind one half full, then change the form end for end and wind the other side in the same direction. Insert the two center ends in the holes drilled for them, twist the two together and solder the joint.

The shaft is made in two sections which serve to lead the rotor circuit thru the tube. To make contact with the shafts, 1/4 by 1 13/16 by 1/64 in. phosphor bronze strips are now fastened to the cylinder by 1/4 in. 6-32 machine screws and nuts which pass thru holes previously drilled in such a position that the end of each spring will bear upon the shaft. A copper soldering lug must be fitted to each to provide a terminal for the wiring of the set. Next cut a 2 in. and 3 1/4 in. piece of 1/4 in. round brass rod from a stock 12 in. lengths. Remove all burrs from thin ends and insert the longer one into the shaft hole placed between the support pillars. Extend it about 1/8 in. into the tube and place two fibre washers over the end for spacing purposes. Put the rotor ball in place and drive the shaft into it. In a similar way force the rear or 2 in. shaft section into the wood form. Solder an end of the tickler winding to each end of the shaft and put the variocoupler aside for the general assembly operation.

Assembling the Parts

The front panel is fastened to the base by three angle brackets 1 in. in length. Each is drilled with a No. 27 hole on each side to take 6-32 flat head machine screws which clamp them to the L. P. F. These angle brackets may be cut from a stock 12-in. length of 3/8 in. angle brass or may be purchased already cut, drilled, and nickeled. Before any apparatus is mounted on either panel test the angle made by the two and see if it is perfectly square. If not the difficulty should be remedied at this point in the construction of the instrument. Now mount the four binding posts on the front panel and the seven on the base. The former are fitted with round head machine screws while the latter have flat heads so that they will be flush with the underside of the base. Each one carries a copper soldering lug for connection to other parts of the circuit. The three sockets are next put in place and turned so that their filament terminals are toward the left hand end of the instrument. This may seem like a small matter but such an arrangement greatly simplifies the wiring. Two honeycomb coils are fastened to the base by means of 1 1/2 in. 8-32 F. H. machine screws and nuts which clamp 1 3/4 by 2 1/2 in. L. P. F. panel against them. Reference to Figs. 2 and 3 clearly show how this is to be done. The coil at the left hand end of the base has 1250 turns and the one located near the center contains 1500 turns of wire. The smaller one is connected in the grid circuit and the larger one in the plate circuit of the oscillator tube. Between the center socket and the front panel the filter resistance is mounted. In Fig. 2, two 12,000 ohm lavite resistances are shown but these have been replaced by a 24,000 ohm resistance unit designed especially for this work. This unit has three brass eyelets thru which machine screws are passed for terminals. Two 3/4 in. 6-32 machine screws are passed thru the base and then thru the two end eyelets of the resistance. Lugs are held at the top by brass nuts to provide the necessary means for connection. Thru the center hole in the resistance a 1/2 in. 6-32 screw is passed for securing a third soldering lug. When the wiring is done these lugs should be removed from the instrument for the soldering operation as too much heat may injure the resistance. An audio frequency amplifying transformer is next mounted ahead of the right hand audion socket making the last instrument to be added to the base.

The three filament rheostats are now fastened to the front panel by a 1/2 in. 6-32 F. H. screws and nuts. One screw is sufficient to hold each rheostat since the shaft prevents the base from turning, but two screws may be used if desired. Mount two 43-plate variable condensers in the position shown in Fig. 2, and one 11-plate variable at the extreme left of the instrument. The photographs show a new type of vernier condenser mounted near the small tuning condenser. In the early experiments with the outfit this addition was of considerable value, but after the set was working well it was found that the 11-plate condenser gave close enough tuning for all needs. Its use may therefore be eliminated without materially impairing the operating qualities of the receiver. The variocoupler is held in the upper left hand corner of the panel by two nickel plated coil support pillars. These are tapped with a 6-32 thread, being held to the L. P. F. by 1/2 in. F. H. screws and to the inductance tube by 1/4 in. R. H. machine screws. The assembly should be stopped at this point until some of the wiring is done for if the Honeycomb coils are now mounted on the rear of the variable condensers considerable trouble will be experienced in making the soldered joints in their vicinity.

Wiring the Set

The filament circuit of the system is now wired to the A battery binding posts. Square tinned copper bus bar is used for the purpose and small soldering lugs should be fitted to the rheostats and other terminals where the square wire is to be connected. First connect all of the rear filament terminals of the socket bases together and solder the conductor to the negative A battery terminal and to the negative B battery binding post. The other terminal of each socket is wired to its respective rheostat while the remaining rheostat posts are connected together and led to the positive A battery terminal. The upper loop binding post is wired to the upper end of the grid circuit inductance, the other end of which is soldered to the rotary plates of the .00025 mfd.

(Continued on Page 74)

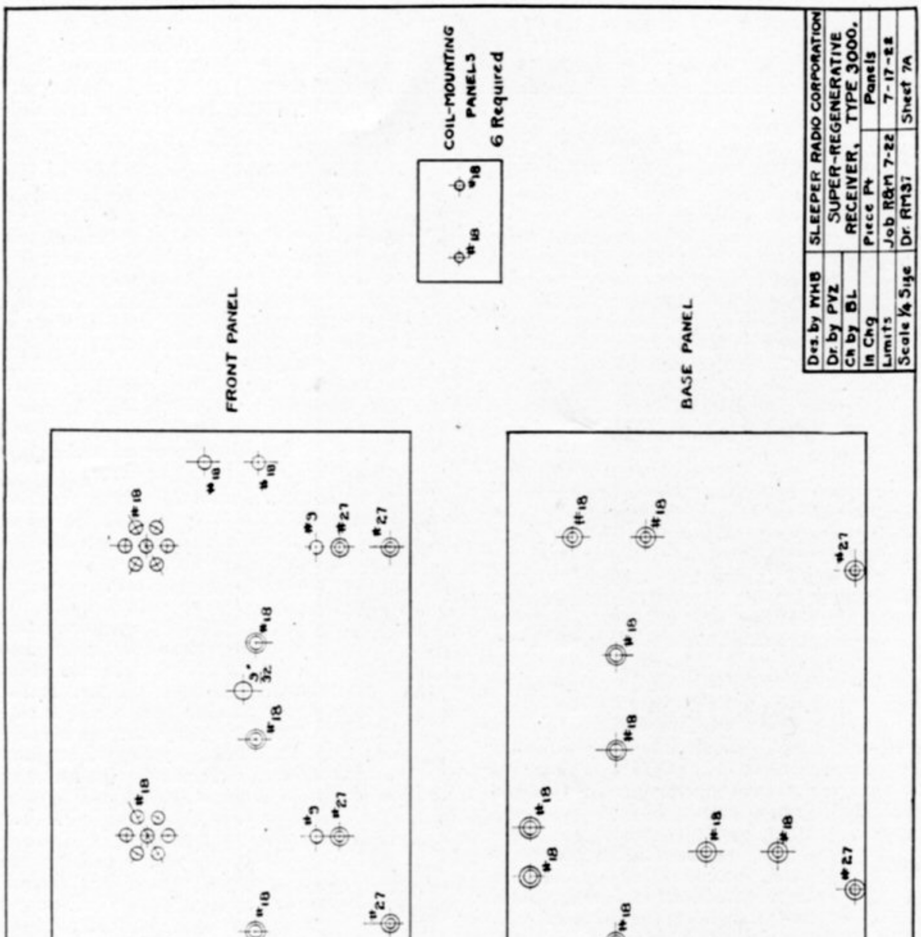

Fig. 5. Scale drawings showing the location of all holes in the panels

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Editor
M. B. SLEEPER
Associate Editor
W. H. BULLOCK
Circulation Director
F. A. SKELTON

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EDITORIAL

RADIO Experimenters, and by that I mean the regular old stand-bys, cannot be blamed too much for having failed to hold themselves responsible for unfortunate developments against which they might have exerted and can exert tremendous influence, but I would like to use a little space to point out several ends toward the accomplishment of which every Experimenter should strive during the winter season.

That radio activities will pick up with a rush after the first of September everyone is certain. In fact, the results this winter will far surpass the last season. Whether conditions in general will be improved is largely up to you and every other individual Experimenter.

Let me explain by quoting from a letter just received from Mr. Porter T. Bennett, which is another way of saying "The Southwest Radio Supply Company," of Dallas, Texas.

" . . . the number of radio stores here is now close to 35 or 40, both exclusive and otherwise.

"They have even gone to the point where one candy manufacturer has put in radio, and a drug store moved medicine from one of its windows and filled it with tubes, sockets, rheostats, and such things. The men in charge of these concerns are self-appointed specialists and experts who can tell more wild, vivid tales regarding the work of their own special receivers than can be found in half a dozen volumes of Poe's works.

"They have gone so far as to sell loud speakers for use with crystal sets, guaranteeing them to fill a room with music. They have sold telephone receivers guaranteed to cut out static. . . . We are preaching to the radio public that the only way to continue real radio work is to get back to radio fraternal."

Men like Mr. Bennett can do just so much to bring radio back to normalcy, but the final cleanup will only be brought about thru the most rigid censorship by the old-time Experimenters themselves. You must see to it that newspaper and magazine articles do not carry misleading statements. You must see that your friends buy standard equipment, and that they get it in "service" radio stores. A man came into the Sleeper Radio Service Station, a short time ago, with a Clapp-Eastham tuner. He bought it at the Blank Radio Shop, but when he took it back for some information, the salesman said, "Oh, we aren't carrying those sets any more. I don't know anything about them." Watch out for such stores and warn your friends. It might seem better to help those dealers, but remember that there are established dealers really worth while helping where your effort and interest will be far more effective. This is your problem and you must take it upon yourself to solve it.

Both dealers and Experimenters will be interested in visiting the new Sleeper Radio Service Station at 86 Park Place, New York City. The purpose this addition is to show dealers how to display and of handle radio equipment. One wall is lined with shallow cases in which different instruments and sets of parts are arranged. They can be examined closely for no counter is used to keep back the visitor. In the center of the floor ar• flat, shallow displays under glass for small parts. This plan was adopted because we know that an Experimenter likes to have a close view of apparatus. No shelves of stock are visible. A salesman takes the Experimenter to the different displays in which he is interested, writes down his order, and passes it on to a clerk in a separate stock room, where the order is made up and wrapped. The entire space is taken up with things of interest to radio men, rather than rows of boxes on shelves.

Whether you are in need of supplies, just interested to see what we have there, or if you need information in connection with your work, stop in at the Service Station. If you live out of town, don't fail to see the things there. Perhaps you can take back some ideas to your local store. Dealers are particularly urged to visit the Service Station and talk to Mr. Klingenschmitt who is in charge. Park Place, on the north side of the Woolworth Building, runs west from Broadway. Number 86 is at the corner of West Broadway. Going downtown get off, on the Lexington Avenue Subway, at Brooklyn Bridge, or at Chambers Street on the Seventh Avenue line.

M. B. SLEEPER,
Editor.

REGARDING RENEWALS

All subscriptions are discontinued as they expire, and if you find a renewal blank in your copy of the magazine it indicates that your subscription expires with that number. Subscribers will please be prompt in sending in renewal remittance so that the next copy of the magazine will not be missed. Please sign your name exactly as it appears on your present address. If you have changed your address, give the old address as well as the new one so there will be no delay in locating your name and making the necessary change.

variable condenser. The fixed condenser plates are joined to the lower loop terminal and to the negative of the filament battery. The rear contact spring of the inductance unit is next connected to the plate of the first tube, while the front shaft contact is led to P2 of the audio frequency amplifying transformer and to the center B battery terminal. P1 of the transformer is wired to one end of the resistance unit. S1 is led to one of the two binding posts on the end of the base and the other binding post goes to the grid of the audio frequency amplifier tube. Connect S2 to the negative side of the tube filament. Now wire the third B battery binding post to the upper telephone terminal, and the plate of the amplifier tube to the lower one. A .001 mfd. telephone condenser is placed across both in the manner shown in Fig. 3. One end of the 1500 turn Honeycomb coil is connected to the free end of the resistance unit and the other end is wired to the plate of the oscillator tube. The center terminal of the resistance is led to the stationary plates of the right hand 43-plate variable condenser.

Drill and tap two 8-32 holes, 1½ ins. apart in the rear end plate of this condenser. Place a 1¾ by 2½ in. panel on each side of a 1500 turn Honeycomb coil and pass two 1½ in. 8-32 screws thru them to the rear of the condenser. Brass spacers 5/16 in. high should hold the unit from the condenser so that connection may be easily made to the rotary plate terminal. This construction may be better understood by referring to Figs. 2 and 3. The variable plates are next connected to one end of this inductance and the other end is carried to the negative side of the filaments. A .001 mfd. phone condenser is shunted across the variable and the second one is connected between the negative side of the filament and the end of the resistance unit which is wired to the Honeycomb coil. Now mount a 250 turn Honeycomb coil to the rear of the second 43-plate variable condenser in the same manner. One end of this inductance must go to the plate of the oscillator tube and the other to the fixed plates of the condenser which supports it. The variable plates are connected to the grid of the same tube. Another phone condenser of the capacity previously used is shunted across the 1250 turn inductance, one end of which is wired to the grid of the oscillator tube and the other end to the grid of the regenerative amplifier tube. From this latter point a final piece of square bus bar is led to the place where the tuning condenser joins the tuning inductance. The wiring should be carefully checked over from the two diagrams given in Fig. 4. This illustration gives the circuit in two forms which may assist the builder in following out the wiring of his set.

Up to this point in the construction of the regenerative receiver we have left off the knobs and dials to prevent them from being scratched while the rough work was in progress. They may now be added to make the instrument complete. Dials graduated through 180 degrees are used for the three condensers while a 90 degree indicating disc is employed on the regenerative amplifier feedback shaft. The appearance of a set very often depends upon the way the various knobs match up so for this reason it is well worth while to use both rheostat and condenser knobs of a symmetrical design. With the instrument itself completed we may next give our attention to the construction of the loop antenna with which it is employed.

The Loop Antenna

The use of a loop antenna for general reception has heretofore been discouraged by the most reliable advisers in the radio field, for the reason that the energy picked up by such an aerial was extremely small compared to the more familiar type of out-door antenna, and resultant signals were so poor as to discourage the users who often cast reflections upon the manufacturers of the equipment they employed. Now it is a different matter. Where a super-regenerative receiver is employed, the use of a loop is not only very practical but is quite desirable as well. An antenna of the open type is liable to pick up enough energy to paralyze the system and destroy the super-regenerative state of the circuit, so for this reason the operation of the set is found less troublesome with the use of a loop. Owing to the fact that the amplification obtained from an outfit of this type is theoretically infinite, the strength of signals received on a loop may be as great as if a large open-circuit type of antenna were used.

That settles the most important point. While practically equal to the regular aerial as far as the strength of received signals is concerned, it surpasses it where interference is considered. The bi-lateral directional characteristic of the coil antenna eliminates signals coming from points lying in a line with the axis of the loop, thereby removing all interference from two directions. Maximum response is obtained when the plane of the loop passes thru a transmitter and the strength of signals varies from this to zero, thru a 90 degree rotation of the loop. This means that efficient reception is accomplished in but one general direction at a time and thus the intensity of interfering signals from all other directions is materially reduced. However, the selectivity of a loop used with a super-regenerative receiver does not seem to be as great as when employed with a regenerative receiver. Its so called maxima is broader and its minima much sharper than is usually found, due to the great amplification of the super-regenerative set. This increases the value of the loop for direction finding work since more accurate bearings of a transmitter is permitted by the sharper characteristic curve at the point of minimum signal strength.

Where receiving stations equipped with oscillating vacuum tubes are located near together, considerable interference often results from the emission of continuous waves from the receiving aerials. For a receiving antenna it is therefore desirable to employ a type which is a poor radiator. The loop fills this requirement exceedingly well and for that reason its use is advised with a super-regenerative receiver. It is not only for consideration due to ones neighbors but is of direct value to the operator in making available some energy which would be re-radiated by an antenna of the open type.

It is quite the unusual case in radio to have a choice between two devices and find that the one which is preferable from an electrical point of view is also attractive from the viewpoint of economy. Fortunately we now have such a condition. The material required for the construction of a loop antenna costs less than the wire which is used in the average aerial, while the time necessary for erecting the two bear even a great difference. The space factor is another important advantage. No unsightly wires need to be run to a window for an aerial connection, or to a grounded object for the earth terminal, and the loop itself is so small that it occupies less table space than the receiving apparatus. This is of particular value in apartment house installations or places where the erection

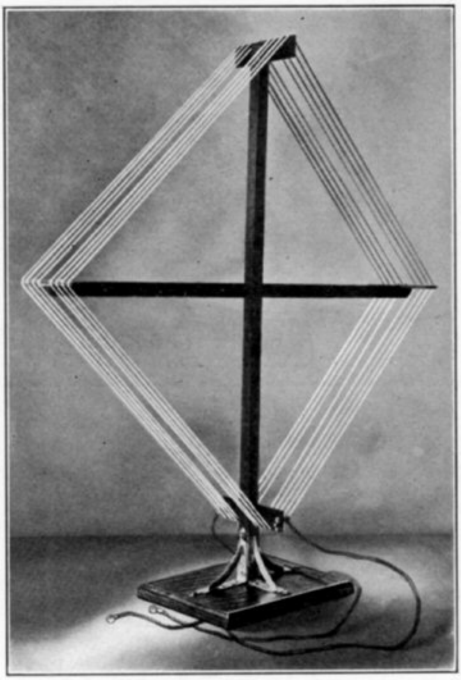


Fig. 6. The loop Antenna

of an aerial of the old type is prohibited. Moreover, no lightning arrester or other protective devices are required and the upkeep is nil.

Various sizes of loops have been tried out, but with the super-regenerative receiver it appears that one size is practically as good as another. In fact there was so little difference noted in the results obtained from a square loop measuring 3 ft. on a side and one of 12 by 15 ins. that the builder will make no serious error by constructing his coil antenna of a size that will best suit his conditions or individual taste. The loop used with the set here described is seen from Fig. 6 to be of very simple construction. Eight turns of No. 20 D. C. C. wire were wound upon a frame having a diagonal of 28 ins.—four turns ½ in. apart on each side. The arms are notched to accommodate strips of $\frac{3}{16}$ in. L. P. F. which measure $1\frac{3}{16}$ by 5 ins. These are sawed from standard 2½ by 5 by $\frac{3}{16}$ in. panels of this material to provide non-moisture absorbing supports for the conductors. The lower piece carries two nickel plated binding posts to which the ends of the loop are soldered. Mahogany was used for the woodwork, altho any stock that the builder may have at hand will serve the purpose. In Fig. 7 a scale drawing, one-eighth actual size, is given to assist in the construction. The upright piece is ¾ in. square and 32 ins. long, and the horizontal stick of the same cross section is 28 ins. in length. The two are secured together with a half-lap joint 14 ins. down from the top, while the cross thus formed is made fast to the base by means of small brackets. Each L. P. F. cross-piece is notched where the wire is to pass and fastened to the arms by two ½ in. 6-32 R. H. wood screws. If an elaborate instrnment is desired, the wood should be well sanded, stained and varnished. Several coats of a good grade of varnish, will bring out a highly polished surface if each is allowed to dry and rubbed down before the next is applied.

This construction may be altered to suit the builder, the directions here given being more in the nature of a suggestion for a loop of convenient size and simple form.

Operation of the Receiver

The various units may now be wired together and the receiver given its initial test. Connect the loop to the binding post provided on the left hand end of the instrument panel and attach the telephones to the two on the right. A 6-volt storage battery is wired to its terminals on the rear of the base, two 45-volt B batteries in series between the first two plate battery posts and three 45-volt batteries to the second and third. This places 90 volts on the plates of the regenerative amplifier and oscillator, and 225 volts on the plate of the audio frequency amplifier. It is possible to use only 90 volts on the three tubes but considerable improvement in signal strength is obtained by increasing the plate potential of the last. To take care of the higher voltages a radiotron UV 202 should be used for the audio amplifier while radiotron UV 201 tubes are employed in the other sockets. As a matter of fact most of our work was done using UV 201 tubes throughout, but it is not a good practice since 225 volts is far in excess of the plate voltage which they are rated to carry. Connect a tapped 22½-volt B battery unit to the two binding posts on the right hand end of the base to maintain the grid of the audio frequency amplifier tube at a proper negative potential. The adjustment of this battery does not seem to be critical since very little difference was noted between the 16 and the 22½-volt tap, altho 22½ volts gave slightly better results.

With both 43-plate variable condensers set at the maximum adjustment, light up the filaments of the three tubes by turning the rheostats almost to their limit. Then adjust the feed-back coupling of the regenerative amplifier tube to a point where the regeneration is indicated by a hissing sound in

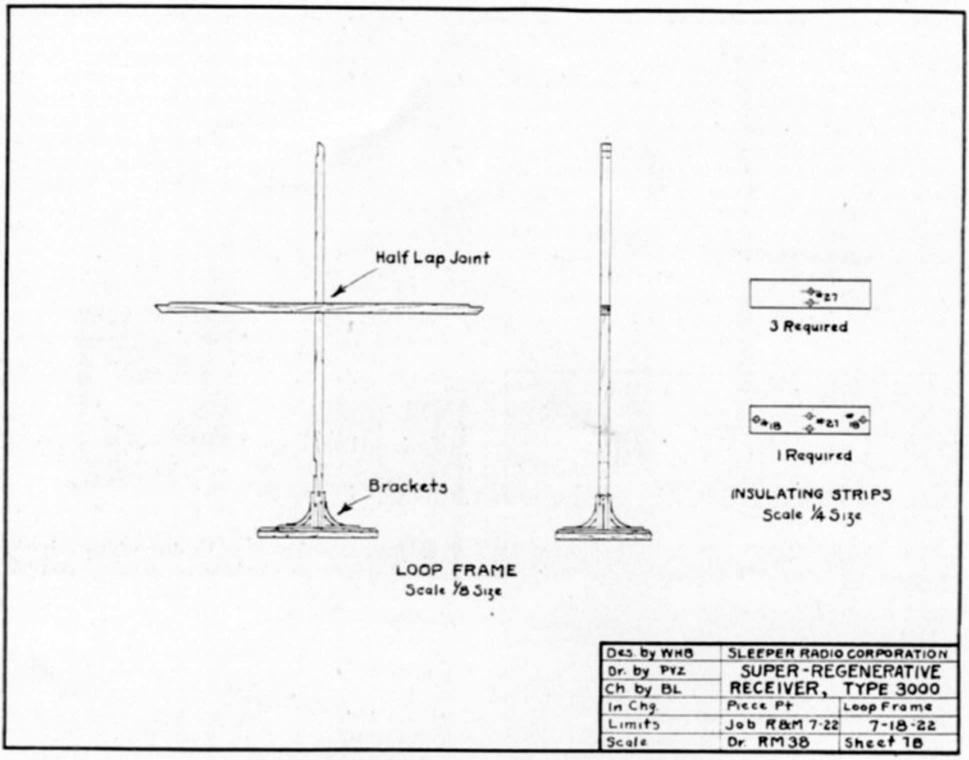


Fig. 7. A scale drawing of the loop frame and L. P. F. strips

the telephones. Next vary the center knob and dial to adjust the coupling between the grid and plate circuits of the oscillator tube. This adjustment will be accompanied by various qualities of hisses and whistles in the headset which change with the rotation of the coupling condenser. When circuits of the first two tubes are properly adjusted a note of very high frequency will be heard in the telephones. This is easily distinguished from the familiar whistle produced by the heterodyning of an undamped wave. When first heard it will probably be somewhat annoying but its intensity may be greatly reduced, if not eliminated, by the adjustment of the right hand condenser which controls the period of the filter system. It may be impossible to remove this tone produced by the local oscillator tube, but by proper adjustment of the filter and coupling condensers it may be brought to an audibility so low that it will not be noticed. Assuming that the circuit has now been adjusted to the super-regenerative state tuning for a transmitting station is next in order. This is accomplished by varying the 11-plate variable condenser and the feed-back coil located above it. With the outfit described it was found that 360 meter signals were received at the 30th division of the 100 division condenser dial and best amplification was obtained with a 50-degree coupling dial at 40. This adjustment of course will not be the same on all sets since slight variations in construction will alter it. However, it may give the operator some idea as to where he should look for signals.

In operating the super-regenerative receiver don't be discouraged if it fails to give expected results immediately. The circuit is considerably more complicated than those which we have been in the habit of using and until the characteristics of the set are learned it will be found that many of the adjustments are quite critical. Since this system of receiving was made public thousands of radio experimenters have undertaken to construct a regenerative receiver, but judging from the results obtained by men we know, it appears that over ninety per cent experience considerable trouble before they get their outfits to operate properly. Like the rest we had some difficulty in obtaining good results from the outfit here described. The system worked perfectly when all of the apparatus was spread out upon a laboratory table, but when it was collected and confined to the limits here shown the trouble began. The cause of the trouble was found to be of a minor nature, and when eliminated, the receiver gave wonderful results. Using the small loop, radio telephone signals from broadcasting stations within about 20 miles were heard on a loud talker with an intensity that should satisfy anyone. When head telephones were employed the signals were strong enough to be uncomfortable to the ears.

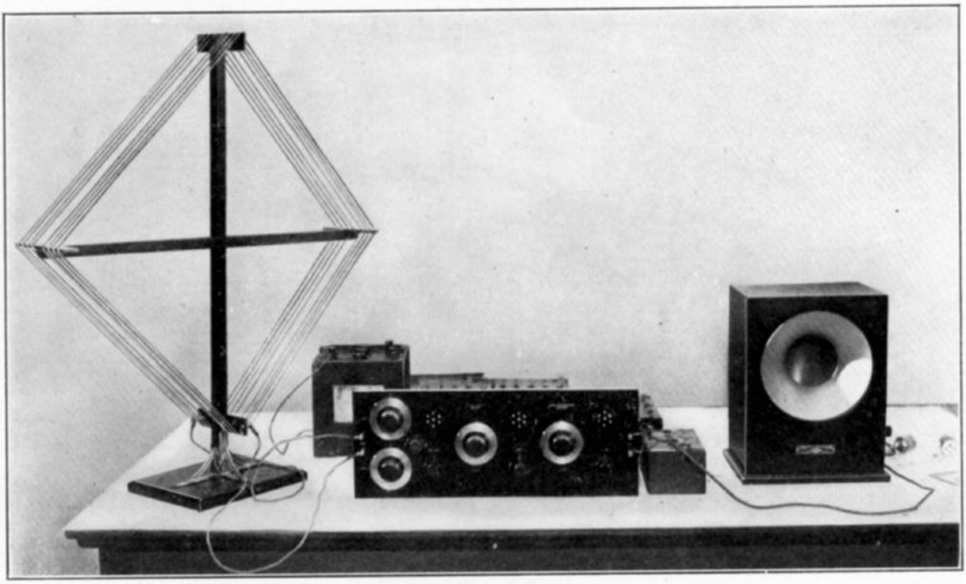


Fig. 8. Complete super-regenerative receiving equipment

Limitations of the Receiver

Of the many questions that have been asked regarding the super-regenerative receiver, the greater number refer to the distance over which reception may be expected. Unfortunately the new system has been in the hands of experimenters for so short a time that very little data concerning this point may be obtained. The circuit seems to have its chief advantage in the reception of relatively short distance concert signals, but it is by no means limited to this. It may be that difficulty will be experienced in long distance reception since the difference between the intensity of distant and local signals is so great that when the former may be heard, the latter will be strong enough to paralyze the system. The super-regenerative receiver will not replace the systems we have been using for general reception. The principal reason for this is that super-regenerative amplification varies inversely as the square of the wavelength so that when 1000 meters is exceeded, there is no improvement over the familiar detector and amplifier sets. While this places a limit on the maximum wavelength great possibilities are presented for short wave work, since the shorter the wavelength used, the greater will be the degree of amplification. The field for experimental work on short waves has thus been greatly increased, and the advanced or more optimistic experimenter may see a possibility of incorporating Armstrong's new receiving system with Marconi's directional transmitter which makes use of wavelengths as low as 1 meter.

101 Receiving Circuits

Fourth Installment

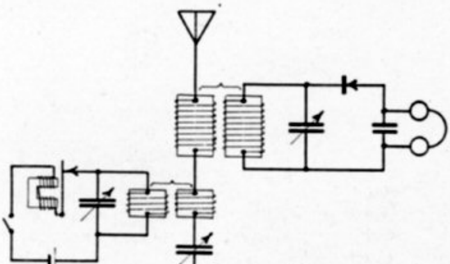
32. It frequently becomes desirable to have a buzzer circuit which will radiate most of its energy on a definite wavelength. Such a hook-up is shown in diagram 32. A tuned oscillating circuit, consisting of a condenser shunted by an inductance, is placed in series with a battery, buzzer and switch. When the switch is closed the buzzer contacts periodically open and close the circuit, setting up oscillations in the tuned circuit at an audio frequency equal to the tone of the buzzer, and on a wavelength determined by the capacity and inductance of the high frequency circuit. The inductance is electromagnetically coupled to the receiving circuit which must be tuned to the wavelength of the buzzer system before any response in the telephones can be expected. The advantage of this circuit over the preceding one is that actual radio frequency energy is supplied for testing the receiver. The best point on the crystal can be more reliably located and any defect in the tuning system will be checked up as well.

33. The Fleming valve detector from which the audion wave developed is shown connected

to a loosely coupled tuner in this diagram. The action of the detector is based upon the theory that in a vacuum negative charges will flow from a heated to a cold electrode and not in the reverse direction. The current flow is opposite in direction to the electronic stream. The cold electrode is termed the anode or plate, while the heated member is called the filament. To produce the required temperature, a battery is connected to the cathode, or filament, thru a variable resistance. Telephones shunted by a condenser are wired in series with a tuning inductance between the filament and plate to form the external circuit of the valve. Connection to the filament is made thru a potentiometer which may be regulated to place the proper charge on the plate.

In operation the potentiometer is adjusted to a point where a feeble current will continually flow thru the circuit. When a signal is tuned in, a radio frequency alternating current is induced in the closed circuit, tending to reverse the plate potential at a rapid rate. The alternation which assists the local potential increases the current flowing thru the telephones while the opposite alternation decreases it slightly. In this way a pulsating direct current rather than an alternating current is applied to the telephones. Owing to the fact that the effect of the positive side of the received current is greater than the negative, each group of oscillations, instead of single oscillations affects the telephone diaphragms, thereby producing audible sounds.

The Fleming valve is no more sensitive than the crystal detector but is considerably more reliable.



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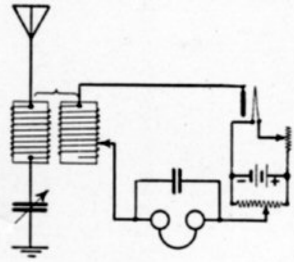

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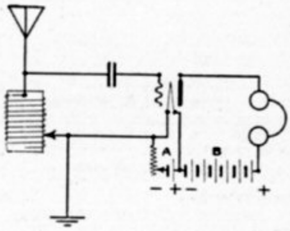

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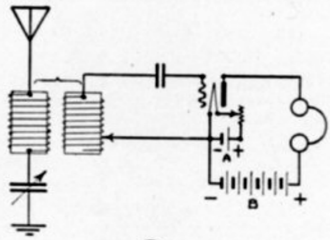

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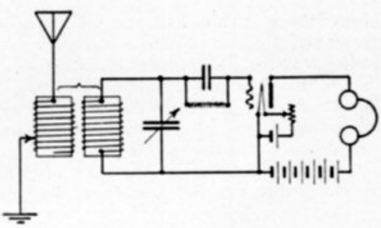
34. This is the simplest of audion detector receivers. A variable inductance is connected between the antenna and ground for tuning the outfit and the detector is wired to the same terminals. The grounded side of the tuner is connected to the filament while the antenna leads thru a fixed condenser to the grid. An A battery supplies the filament of the tube and a B battery in series with telephones maintains a positive charge on the plate.

The basic theory of operation is that of the Fleming valve, altho it is slightly more complicated due to the addition of the third element or grid. In the mechanical construction of the tube, the grid is located in the electronic path between the filament and plate. Normally the plate battery maintains a constant flow of current thru the telephones and tube, its magnitude being appreciably varied by minute changes in charge on the grid. When the grid is negative, it repels the like charges being emitted from the filament and prevents a large number from reaching the plate. This reduces the current flowing thru the telephones. A positive charge on the grid has the opposite effect.

The grid condenser stores up energy from the current which is rectified by grid and filament, and since the current can flow in but one direction, the grid side of the condenser always has a negative charge. Therefore, as a signal is received, the charge on the grid becomes more and more negative during the life of each wave train, causing a corresponding decrease in the plate circuit which is made audible by the telephones.

35. In diagram 34 the negative of the B battery is shown connected to the positive terminal of the A battery, but that does not mean that the two should always be so wired. Diagram 35 illustrates a common circuit where the negative of the plate battery is connected to the negative of the



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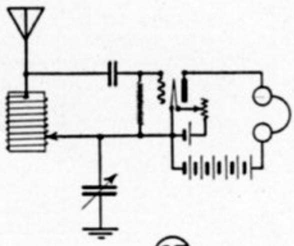

(37)

filament battery.

There is very little difference in the merits of the two systems. It should be noted that the tuner is never connected to the positive side of the filament. In addition to the change in battery connections, this diagram shows the wiring of a loose coupler to a an audion detector making a simple but selective outfit.

36. An inductively coupled tuner is here used with an audion detector equipped with a grid leak resistance. The value of the resistance is usually about one megohm and its function is to permit the negative charges to leak off of the grid so that the plate current will return to its normal value between successive groups of oscillation. The leak is most frequently connected in shunt with the grid condenser which makes it possible to effectively incorporate the two in one unit. The combination is known as the grid leak condenser.

37. A grid leak resistance may be directly connected from the grid to the filament of a vacuum tube. The principle of its operation is the same as if it shunted the grid condenser and its effectiveness in one position is equal to that in the other.

STANDARDIZED PARTS FOR THE SUPER-REGENERATIVE RECEIVER. TYPE 3000

2—L. P. F. panels 7½ by 20 by 3/16 ins.	1½ lbs.	$3.90
6—L. P. F. panels 1¾ by 2½ by 3/16 ins.	9 oz.	.60
2—Variable condensers, 0.001 mfds. capacity	2 lbs.	8.60
1—Variable condenser, 0.00025 mfds. capacity	1 lb.	3.25
3—Rheostats	15 oz.	3.45
3—Audion sockets	12 oz.	2.40
1—Mahogany rotor ball	6 oz.	.70
1—L. P. F. tube 3½ ins. diam., 2½ ins. long	3 oz.	.75
1—¼ lb. spool of No. 24 S. S. C. wire	8 oz.	.70
3—100 division dials and knobs	8 oz.	3.75
1—50 division dial and knob	3 oz.	1.25
1—Audio frequency amplifying transformer	6 oz.	5.00
1—Special resistance unit	3 oz.	1.00
2—1500-turn concentrated inductances	1 lb.	4.80
1—1250-turn concentrated inductance	1 lb.	1.80
1—250-turn concentrated inductance	6 oz.	.70
4—Fixed condensers, 0.001 mfd. capacity	3 oz.	1.40
7—Nickel plated binding posts, with F. H. screws	4 oz.	.70
4—Nickel plated binding posts with R. H. screws	2 oz.	.40
3—1-in. angle brackets	2 oz.	.30
1—1-ft. length ¼ in. round brass rod	8 oz.	.15
2—Shaft contact springs	1 oz.	.08
4—Fibre spacing washers	1 oz.	.20
2—Pkgs. of 20 small soldering lugs	2 oz.	.50
1—2-ft. length Empire tubing	2 oz.	.40
6—2-ft. lengths square tinned copper bus bar	6 oz.	.36
2—Coil support Pillars	3 oz.	.16
1—Pkg. of 10 1½-in. 8-32 F. H. nickeled machine screws	2 oz.	$ .17
1—Pkg. of 10 1½ in. 8-32 R. H. nickeled machine screws	2 oz.	.17
1—Pkg. of 10 8-32 nickeled nuts	2 oz.	.09
1—Pkg. of 10 ¾ in. 6-32 F. H. nickeled machine screws	2 oz.	.12
2—Pkgs. of 10 ½ in. 6-32 F. H. nickeled machine screws	3 oz.	.24
2—Pkgs. of 10 6-32 nickeled nuts	2 oz.	.16
1—Pkg. of 10 ¼ in. 6-32 R. H. nickeled machine screws	2 oz.	.11
4—3/16 in. nickeled plated spacers, 8-32 thread	2 oz.	.16
1—Pkg. of 10 No. 8 washers	1 oz.	.05
Complete set of unfinished parts as listed above for the super-regenerative receiver	13 lbs.	47.19

SEMI-FINISHED PARTS

The variocoupler complete	1 lb.	3.45
Complete set of parts with panels drilled and engraved, and the variocoupler completely assembled, packed in a neat display box	13 lbs.	57.90

AUXILIARY SUPPLIES

Eveready 45-volt B batteries	6 lbs.	5.50
Eveready 22½-volt B battery, tapped	3 lbs.	3.00
6-volt 40-ampere hour Witherbee storage battery completely charged and ready to use	15 lbs.	14.00
Radiotron UV-201 amplifier tubes	8 oz.	6.50
Radiotron UV-202 power tube	8 oz.	4.00
Deveau Gold Seal telephones, 2,200 ohms	1½ lbs.	8.00
Deveau Silvertone loud speaker	5 lbs.	35.00

MATERIAL FOR THE LOOP

2—L. P. F. panels 2½ by 5 by 3/16 in.	4 oz.	.66

STANDARDIZED PARTS FOR THE SUPER-REGENERATIVE RECEIVER—Cont'd. TYPE 3000

1—¼ lb. spool No. 20 D. C. C. wire	8 oz.	$0.40
1—Pkg. ½ in. No. 6, R. H. nickeled wood screws	1 oz.	.12

Owing to the difficulty in shipping we will not undertake to supply the wood for the loop frame.

Vernier Condenser

ONE of the most important of recent additions to our line of radio supplies is the Vernier Condenser. This is a small instrument requiring only slightly over a square inch of panel space for mounting. It may be used with any variable condenser to obtain the fine tuning that is so essential where reception from vacuum tube transmitters is desired. The Vernier is mounted on an instrument panel by means of two 6-32 machine screws which are turned into the insulating end piece. Ruggedness is displayed in every detail of its construction, from the heavy brass plates to the ¼ in. shaft which turns in a brass bearing ½ in. long. Such construction insures long life and permits a separation of only .005 in. between plates. All conducting surfaces are silver plated to provide a condenser where losses are of a negligible variety and an appearance which is unexcelled. The Vernier Condenser is a rare specimen of fine workmanship and for that reason should appeal to the most exacting of mechanical and radio critics.

Vernier Condenser, Type A95.................................$1.75

Postage 10c.

Resistance Unit

WHEN the Armstrong super-regenerative circuit made its appearance there was an immediate and large demand for 12,000 ohm resistances, two of which were required for each receiver. This demand is now met by our special resistance unit which replaces the two formerly required. Built in a form as simple as our fixed condenser, the resistance carries three brass eyelet terminals to take screws for mounting and connecting. The unit is essentially a 24,000 ohm resistance with a center tap, which solves the most difficult problem of the filter system in an ideal way.

Resistance Unit, Type A96.................................$1.00

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