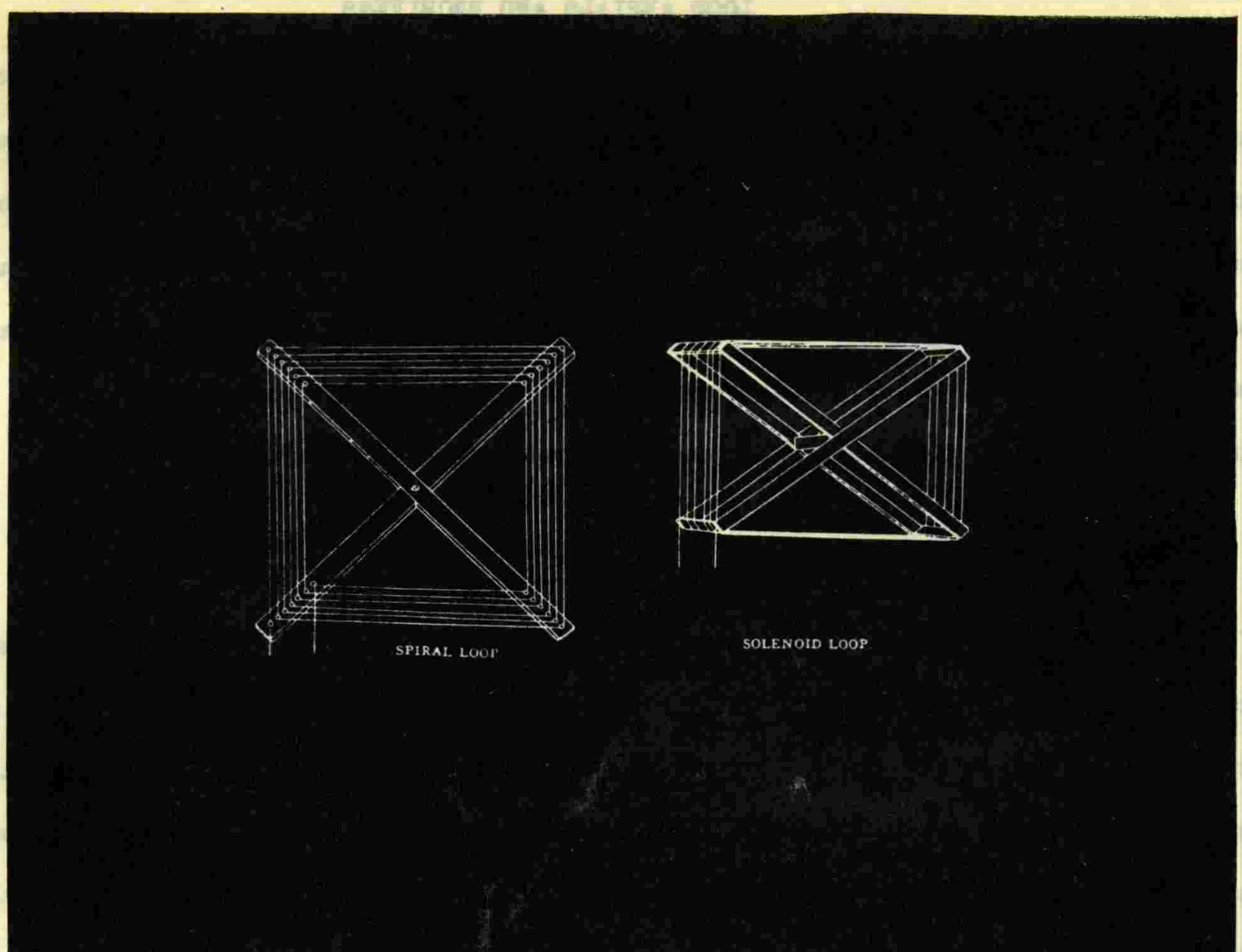


LESSON 27 R

LOOP AERIALS AND RECEIVERS

RADIO-TELEVISION TRAINING SCHOOL · ESTABLISHED 1922 · INC. · LOS ANGELES

RADIO-TELEVISION TRAINING SCHOOL, INC.

5100 SOUTH VERMONT AVENUE • LOS ANGELES 37, CALIFORNIA, U. S. A.

LOOP AERIALS AND RECEIVERS

The increased number of broadcasting stations and the greater electric power output that is being employed by these stations, have brought the loop receiving antenna into great favor due to the numerous advantages it possesses over the familiar outdoor antenna. However, on account of the relatively small amount of energy that is absorbed by the loop antenna, more powerful receivers are necessary to produce entirely satisfactory results. It is for this reason that loops are generally used only with superheterodyne or multitube tuned radio frequency receiving sets.

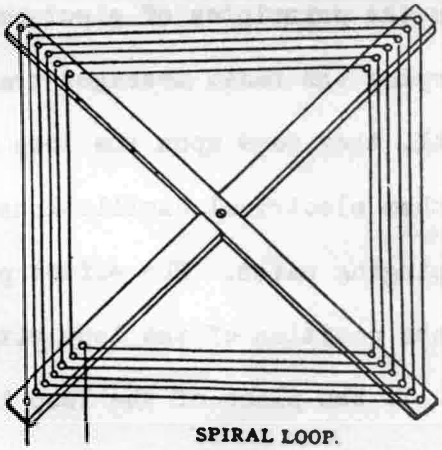
USES OF LOOP AERIALS

The loop aerial is a convenient form of aerial to use for receiving radio messages when it is difficult or impossible to erect a suitable outdoor antenna, or when an antenna is desired that can readily be carried from place to place without involving extensive erection or construction work. The loop is also the best type of antenna to use when it is desired to reduce to a minimum the interference resulting from other stations operating at nearly the same wave length. The greatest value of the loop, however, lies in its extreme directional qualities; that is if a properly designed loop is directed toward a distant transmitting station, the signals are received with very little interference from other nearby stations.

Other advantages of the loop aerial are that it is entirely immune from any danger due to lightning, and that it is not affected appreciably by atmospheric (static) or other weather conditions. In spite of these desirable features, however, the loop aerial is by no means a perfect aerial, for the amount of energy it can absorb is very small, and radio frequency amplification is necessary before the received oscillations are strong enough to be impressed upon the input or grid circuit of the detector.

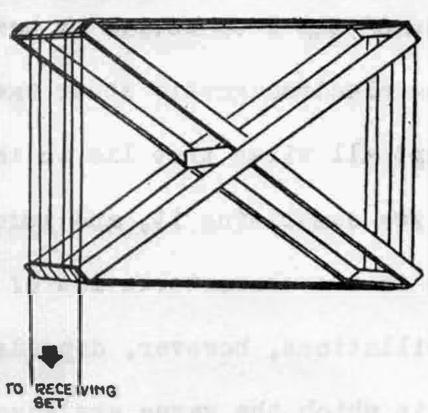
TYPES OF LOOP AERIALS

As the name suggests, the loop aerial consists of a long wire wound in the form of a loop or coil and held rigid on some convenient and sturdy support. The loop can be wound into numerous different forms, such as a square, rectangle, octagon, etc.; but trials and tests have shown that the most satisfactory form, both as to receiving efficiency and directional qualities, is the square loop. The square loop, in turn, can be wound in two ways, one of which is the spiral loop as is illustrated in Fig. 1. Here the wire is wound on a convenient support with one turn inside of the other and each turn becoming smaller as the center of the loop is approached. The winding is started at one corner, and after one complete turn is made, the second turn is started inside of the first, etc., the successive turns being spaced about one-fourth inch apart. The spiral loop thus resembles a large pancake coil, with all the wires lying in the same plane and each successive turn being smaller than the preceding one.



SPIRAL LOOP.

Fig. 1



SOLENOID LOOP.

Fig. 2

Another form of square loop is known as the solenoid loop, and is illustrated in Fig. 2. Here the loop is wound in the form of a large square coil, or solenoid, with a very large diagonal compared to its length. One important feature about this loop is that it lends itself readily to being wound on the interior of the containing cabinet enclosing the receiving set itself. Such an arrangement forms a very compact and self-contained unit, and if used in conjunction with suitable radio frequency amplifying apparatus, it gives very satisfactory and efficient service.

The spiral loop is highly directional and can be wound to be very compact. It is used extensively for radio compass stations and direction finders. Its disadvantage, however, is that its operation is restricted to the shorter wave lengths, in that it cannot easily be wound for the longer wave lengths on account of the smaller space allotted to each successive turn. The solenoid loop, however, is not hampered by such restrictions, because for a given size loop more turns can be arranged and each turn is of the same length. It is somewhat less directive than the spiral loop and also permits broader tuning. It is thus somewhat better adapted for the reception of broadcast messages and musical entertainments.

HOW A LOOP AERIAL WORKS

The operation of the loop aerial is based upon the principles of electromagnetic induction. As the electromagnetic ether waves carrying the radio messages travel through space and intercept all wires that lie in their path, they come upon the loop aerial, cut across the wires comprising it, and induce in them electrical oscillations corresponding in nature to the characteristics of the impinging waves. The effect produced by these induced oscillations, however, depends upon the position of the loop with respect to the direction in which the waves are advancing. If the plane of the loop is parallel with the front of the wave, that is, if one face of the loop is in the direction the waves are moving, then the oscillations induced in opposite sides of the coil will oppose each other and thus be neutralized. However, if the plane of the loop points in the direction of the advancing waves, the nearer side of the coil will be intercepted before the other side is; and although the difference may appear to be so minute if the speed of propagation of the wave is considered, the out-of-phase conditions of the oscillations in opposite sides of the loop are sufficient to enable the detection of the resulting induced currents, if sufficiently sensitive apparatus is employed. It is thus evident why the loop aerial is so directional in its operation, for the nearer the plane of the loop points in the direction of travel of the waves, the greater will be the phase difference and the more marked will be the resulting oscillations flowing in the loop. Therefore, when a loop aerial is used for receiving, the plane of the loop should always point in the direction of the station from which the desired signals are coming. By turning the loop slightly in one direction or the other, the position of maximum signal intensity can readily be found.

DESIGN AND CONSTRUCTION OF LOOPS

As to the size of a loop and number of turns of wire to use in its construction, experiments have proven that in general the larger loops operate with better efficiency, for with a larger loop less turns are needed to give the necessary inductance, and with less turns the amount of distributed capacity is reduced. However, another factor to be considered is that a coil which has the greatest inductance possible for a given length of wire, is a more efficient absorber of radiant energy than another coil of the same inductance but with less number of turns. It is therefore necessary for a given wave length to strike a happy medium between these several factors.

To design a loop aerial in accordance with certain required specifications, is a rather complicated and involved problem. In one respect the loop aerial can be considered as the secondary of a large radio frequency transformer with a variable condenser connected across its terminals for tuning purposes. Essentially a closed oscillation circuit is thus formed, the oscillating frequency depending upon the relative values of the inductance of the loop and the capacity of the tuning condenser. It is common practice to use a 0.0005-Mfd. (23-plate) condenser for loop tuning purposes, although in some cases a 0.00035-Mfd. condenser is used.

In order that the desired wave length range can be covered with this tuning condenser, it is evident that a loop with the correct number of turns must be used. In the following tables are given the correct number of turns to use for square loops of the solenoid type and for spiral loops. In the first table, which is for solenoid loops, the length of one side of the loop measured in inches is given in the first column, and in the second, third and fourth columns are given the number of turns to use when the wires are spaced 1/4, 1/2 and 3/4 inches apart. For example, suppose it is desired to build a square loop which is 24 inches on one side and has the turns spaced one-half inch apart. From the table we see that a total of 13 turns of wire would be needed.

In the second table, which is for spiral loops, is also given the necessary construction data for different size loops. The first column contains the lengths of the diagonal cross-arms of the loop, that is, the distance in inches from one corner of the outer turn to the diagonally opposite corner. The spacing between the successive turns is given in the second column, and the number of turns in the third.

The above data is for loops having a wave length range of from 200 to 600 meters when tuned with a 0.0005-Mfd. condenser.

The actual size of wire used in winding a loop is not so very important, but it should be sufficiently large so as not to incur any serious resistance losses. Practically any size wire between 16 and 22 is quite suitable, although No. 18 stranded wire seems to serve the purpose best. Several wire manufacturers have placed special stranded loop wire on the market in the form of 100-foot rolls. The framework of the loop on which the wire is wound should be rigid and strong enough so as to be capable of being rotated on a vertical axis in order that the loop can easily be adjusted for receiving stations from any direction. In mounting the loop it makes little difference as to whether the sides of the coil are vertical and horizontal, or whether it is tilted at an angle of 45 degrees, so that one diagonal forms the vertical axis.

But the loop should be constructed perfectly symmetrical, and mounted so that it will remain in a fixed position without requiring constant adjusting or resetting.

SOLENOID LOOPS

Size in Inches	Spacing ¼	Spacing ½	Spacing ¾
12	21		
15	17	21	
18	13	17	20
21	12	15	17
24	11	13	14
27	10	11	13
30	9	10	11
33	8	9	10
36	8	9	9

SPIRAL LOOPS

Diagonal in Inches	Spacing in Inches	No. of Turns
21½	9/32	17
26¼	⅜	16
30	7/16	15
35	9/16	14
43	¾	13
52	1	12
66	1⅜	11

LOOP RECEIVING CIRCUITS

Since only a very small amount of electromagnetic energy is intercepted and absorbed by a loop aerial, the receiving circuit used with it must be very sensitive and possess enough amplification in order to convert these small amounts of energy into suitably audible sounds. Especially if it is desired to receive any far distant stations, it is necessary to use a number of stages of radio frequency amplification. It is for this reason that the loop aerial is commonly used only with multitube radio frequency sets and superheterodyne receivers.

The receiving circuits used with loop aerials are very similar to the multi-stage radio frequency amplifier circuits discussed in the previous lessons, except that in this case the loop is regarded as comprising the tuning coil or inductance, and the receiver is tuned to the desired wave length by means of a 23-plate (0.0005-Mfd.) variable condenser shunted across the terminals of the loop. The remainder of the detector and amplifier circuits do not differ from the receiving circuits employing a fixed coupler or variometer as a tuning inductance.

A SIMPLE LOOP RECEIVER

A simple receiving circuit that can be operated from a loop aerial is illustrated in Fig. 3. As illustrated, it consists of two stages of radio frequency amplification, a detector, and two stages of audio amplification. The entire receiver can be built of standard parts and can be depended upon to give satisfactory results.

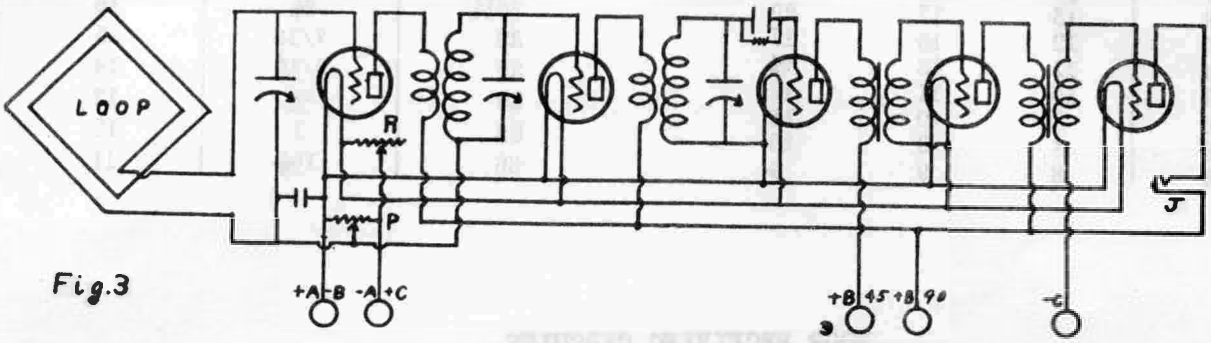


Fig.3

Either a commercially built loop can be used, or a loop can be built from the design data given in a previous paragraph. Care must be taken, however, that the tuning condensers are of the correct capacity both for the loop and for the tuned radio frequency transformers that are used. A 400-ohm potentiometer "P" is used as an oscillation control, and is shunted by a .002-Mfd. fixed condenser to reduce the resistance to the radio frequency currents by forming a by-pass around the potentiometer. Any of the other methods of oscillation control can also be used if desired.

Although only one rheostat is illustrated controlling all five tubes, this rheostat can be omitted and each tube controlled separately by means of fixed resistances of the Amperite type. Tubes of the 201A type or of the 199-type can be used, the latter being desirable when the set is to be used as a portable.

HOW TO OPERATE A T. R. F. SET FROM A LOOP

Frequently it is desired to operate an ordinary tuned radio frequency (T. R. F.) receiver from a loop so as to render available the advantages that a loop offers as to improved tone quality and greater selectivity. Of course, with the change made, the receiver will not be able to tune in as far distant stations as when an outdoor antenna is used.

In a radio frequency receiver there are generally a number of coils, each consisting of a primary and a secondary, and each having its secondary tuned with a variable condenser. The first step is to locate the antenna coil, and then locate the grid wire. This is the wire that leads from one side of the secondary of the coil to the grid terminal of the tube socket and to the stationary plates of the nearest condenser. It is the only part of the circuit in which a change is made. This wire is disconnected from the coil, but the connections to the condenser and socket are left undisturbed. A small single-throw knife switch "S" is then inserted, the disconnected grid wire being joined to one side of the switch and the free end of the secondary coil to the other side. These connections are all illustrated in Fig. 4. A wire is also run from the condenser side of the switch to a special loop terminal binding post L-1.

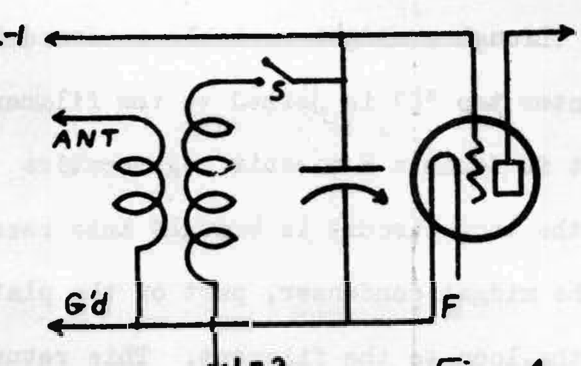


Fig 4.

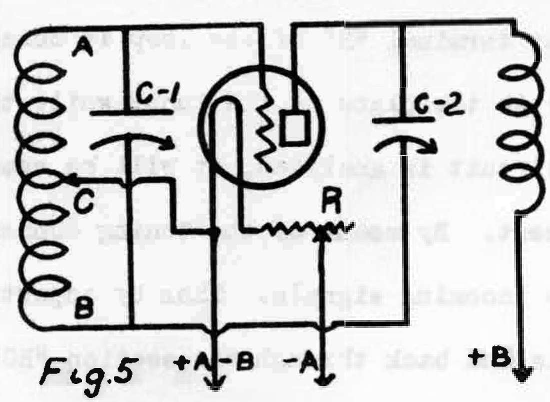


Fig.5

If the opposite side of the secondary is connected to the primary and grounded, then the other side of the loop is joined directly to the ground terminal. But if the primary and secondary are not joined, then another wire must be run from the rotor plates of the condenser to a second loop terminal L-2. This wire is also illustrated in the figure. When the set is to be operated from a loop, the switch "S" is opened and the loop terminals connected to L-1 and L-2.

When this change is being made, care must be taken that the first condenser is of the correct capacity to properly tune the loop that is to be used, or else the entire wave length range cannot be covered.

THE THREE-TAP LOOP

An ingenious scheme for increasing the operating efficiency of a loop aerial is to tap the loop at the center of its winding and then connect the loop in the manner illustrated in Fig. 5.

Since the loop is really only a large inductance coil, it can be represented as is illustrated in the figure. "A" and "B" are the two terminals of the loop while "C" is the center tap. The tuning condenser is connected across the loop as in any case, and one terminal "A" of the loop is connected directly to the grid of the tube. However, the other terminal "B" of the loop is connected through a midget variable condenser C-2 directly to the plate of the tube, while the center tap "C" is joined to the filament. If the circuit is analyzed, it will be seen that it forms a 2-circuit regenerative arrangement. By means of the tuning condenser the loop circuit is brought into resonance with the incoming signals. Then by adjusting the midget condenser, part of the plate energy is fed back through the section "BC" of the loop to the filament. This returned plate energy strengthens the original signal oscillations with the result that more intensive voltage pulsations are impressed on the grid of the tube. This in turn produces louder output signals in the ear-phones or loudspeaker.

Besides producing louder signals, the addition of this regenerative feature to the loop aerial also has several other very important advantages. Regeneration means less effective circuit resistance, and the lower the resistance of the circuit, the sharper it will tune and the more sensitive it will be to very feeble oscillation from distant stations. The 3-tap loop is more selective and better for long distance reception.

Also, with the ordinary two-terminal loop, one end of the loop (the filament end) is at ground potential, and the loop also acts as a capacity (condenser) antenna as well as an inductance antenna. But with a 3-tap arrangement both halves of the loop are balanced with respect to the ground or filament circuit. This completely eliminates the capacity or ordinary antenna effect, and permits the loop to act purely as an inductance or coil antenna. The result is that the loop is much more directional in its receiving qualities.

Summing up the advantages of the 3-tap loop we see that they consist of - increased selectivity (sharper tuning), greater sensitivity, and on account of its being more directional, less interference and less static. Any loop designed to cover the desired wave length range can be adapted to this three-tap system by bringing out a lead or tap from the center of the winding. By changing the circuit arrangement and adding a midget condenser so as to conform to Fig. 5, the various advantages outlined can then be rendered available.

AN EFFICIENT 3-TUBE LOOP RECEIVER

An excellent and simple, yet efficient, three-tube receiver can be arranged by employing a 3-tap loop; and unless extremely long distance reception is desired, the receiver can be depended upon to give very satisfactory and pleasing results. The selectivity is very good, and excellent loud-speaker volume can be had on local and nearby stations.

The general circuit arrangement of the loop receiver is illustrated in Fig. 6. As is illustrated, a regenerative detector is used with a 3-tap loop, and the detector output is then amplified through two stages of transformer coupled audio frequency amplification. Only high grade parts should be used and fine results can be expected. The cost of the set is also very moderate.

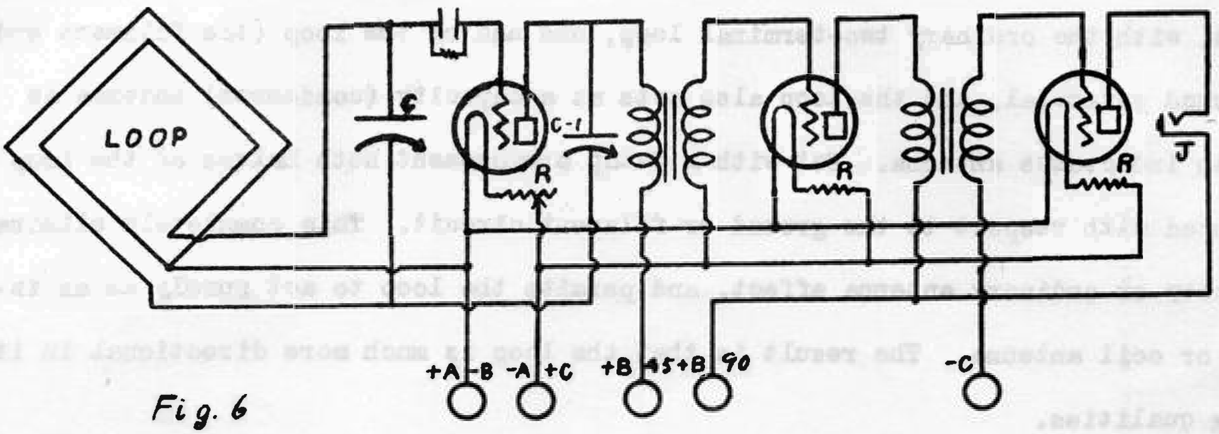


Fig. 6

Any standard 3-tap loop can be used. It is tuned by means of a .0005-Mfd. variable condenser. For best results any condenser that does not have a "live" shaft can be used. The entire set can be nicely arranged on a 7x14 inch panel. The material on the baseboard should be laid out so that all connecting wires are as short as possible, as short leads with all joints well soldered tend toward maximum operating efficiency and sharp tuning. The small feed-back condenser should be of the midget type with a capacity of approximately .000045 Mfds. It is connected into the circuit with the stator plates to the plate of the tube and the rotor plates toward the loop, otherwise interference from body capacitymay be experienced. For good tone quality high grade audio transformers should be employed, preferably of a 3 or 3½ to 1 ratio. Fixed resistors of the Amperite type can be used for the filaments of the amplifier tubes, but for the detector tube a rheostat is more desirable. The circuit is very simple to follow, and the wiring process is also not difficult. Busbar wire can be used, although the tendency is toward the point to point method of wiring with the aid of insulated flexible wire. It is a good idea to mount the grid condenser and leak difectly on the grid post of the detector socket.

The set will function very nicely with dry cell tubes of the 199-type, but somewhat fuller volume will be obtained with 201-A tubes supplied with current from a 6-volt stofage battery. A detector tube of the 200-A type is recommended, and in this case, the grid retufn should be made to the negative side of the filament instead of the positive side as is illustrated in the circuit in Fig. 6.

To operate the set, the filament switch is turned on and the tunind condenser is slowly adjusted until a station whistle is heafd. The midget condenser is then turned until the whistle disappears. Lastly, the detector rheostat is adjusted until the signals come in clear. After the midget condenser and rheostat have once been properly set, the vafious stations can be tuned in by means of the large tuning condenser. Of coufse, the loop must always be fotated so as to point towafd the desired station.

A LOOP INTERFERENCE LOCATER

The difectional receiving qualities of a loop aerial can be used to good advantage to locate sources of troublesome radio interference, such as a sparking motor, a defective high-tension line insulator, a faulty transformer, an arcing ground on a power line, etc. Any such faulty electrical device acts like a small transmitting station and causes a continuous sefies of electric waves to be sent out into space. These waves afe intercepted by all receiving antennas in the vicinity, with the fesult that disturbing noises are pfoduced in the radio sets. Genefally the electfic power companies will be only too glad to coopefate in the elimination of such interference soufces. But the hardest part is often to locate these trouble spots, and fof this purpose a sensitive loop aerial feceivef serves very well.

An effective and convenient circuit arrangement to use for building an interference locater is illustrated in Fig. 7. It consists of a loop which is tuned by means of a 0.0005-Mfd. condenser. The received oscillations are impressed on the grid circuit of a regenerative detector, regeneration being effected by means of a variometer connected into the plate circuit. The addition of regeneration renders the receiver very sensitive. A stage of audio frequency amplification is also added to increase the volume of the output. For best results the entire receiver should be enclosed with a copper or aluminum shield so that there will be no stray pick-ups within the set.

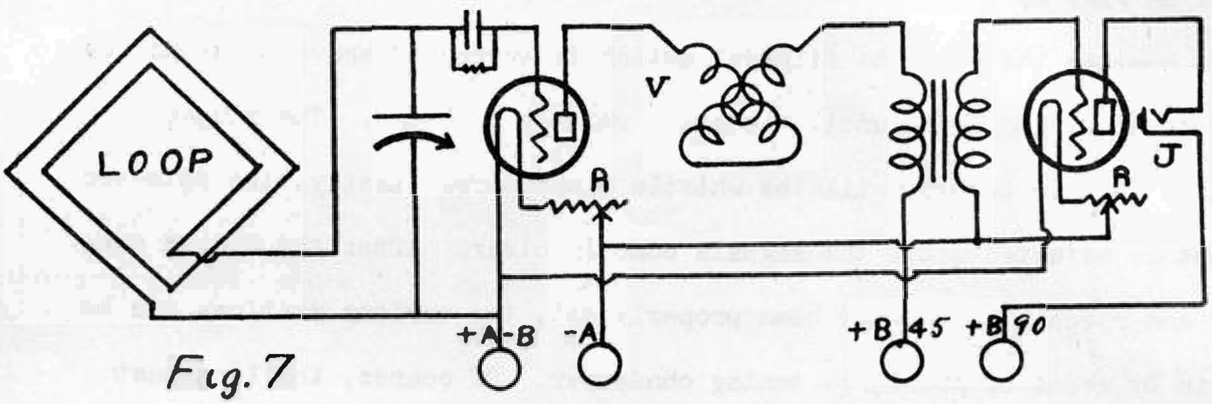


Fig. 7

To use the receiver, a map is first obtained of the district where the interference exists. The receiver is then put into operation, and the loop slowly rotated until the signals are heard with maximum intensity. The direction of the loop is then shown by means of a line drawn on the map. The receiver is then moved to another spot which is at least several hundred feet away, and another hearing is taken. The position of the loop is again drawn on the map. The source of trouble will then be found near the spot where the two lines intersect, and a careful inspection of the surroundings will quickly locate it. Frequently, of course, it may require a number of different observations until the actual spot is really located, but with careful work no difficulty should be experienced.

THE RADIO COMPASS OR DIRECTION FINDER

The directional features of loop receiving aerials are further made use of in the direction finders or radio compasses that are used by ships at sea to determine their position or to locate another nearby boat that may be in distress. Although it is impossible to take up at this time the complete details and facts about these instruments, a direction finder consists essentially of a loop aerial that is tuned by means of a variable condenser and connected to a highly sensitive radio receiver. The loop is mounted on a vertical shaft, to which is also attached a pointer that moves over a horizontal circular scale graduated according to the points of a compass.

The government has stationed along the shore a series of beacons, that is, radio transmitters that send out regular signals similar to the light flashes sent out by lighthouses. If a ship wants to get its location, a number of these beacons are tuned in. From a chart before him the operator can tell where these beacons are located, and from the direction in which the loop was pointing in each case he can determine the exact position of the ship at sea.

Similarly, if a shore station wants to determine the location of a ship, the signals sent out by the ship are tuned in at a number of these shore stations. The findings of each are then sent in to a central station, and from these reports the exact location of the ship can then be determined accurately. In the same manner a ship in distress is located and information as to its position is sent out to nearby ships.

ON THE LOOP ACTION OF COILS

Frequently a receiving set is described as being so sensitive that it will work without any aerial or ground. But, after all, such action really is not desirable.

That a receiving set will work without an aerial or ground, is due to one or more of the coils within it acting like miniature loops and picking up the energy directly.

is merely a form of coil having a large diameter compared to its length. Practically any coil when properly placed so as to intercept the radio waves as they pass through space, can act as a loop and receive directly. Of course, coils of the toroidal or binocular type are exceptions.

To render a set incapable of such loop reception, the coils should be placed so that they cannot pick up any energy. When a coil is set on end, that is, with its axis in a vertical direction, its loop action is destroyed and it cannot intercept any of the passing waves. With a smaller set employing but one coupler it is simple enough to accomplish this; but in the multitube sets of the neutrodyne or tuned radio frequency type, it cannot be done. In such cases the first coil should be set vertically so that no pick-up can occur, for the energy from this coil undergoes more amplification than that of the others. The second coil should then be placed horizontally and parallel with the panel, and the third coil also horizontally but at right angles to the panel. With this arrangement least disturbance will occur due to internal energy absorption.

In any set employing tuned radio frequency amplification it is very important that the first coil be placed in a vertical position. Failure to do so will invariably result in troublesome interference which often cannot be eliminated. Yet correcting the position of the first coil will do the trick.

This pick-up action must also be guarded against in superheterodyne receivers. These circuits are ultra-sensitive and will greatly amplify any electrical oscillations that can be picked up. It is very important that the oscillator coupler as well as any other coils be mounted vertically, or trouble is sure to result.

EXAMINATION QUESTIONS ON FOLLOWING PAGE.