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Listening-In Stations

Confidential

Radio Pamphlet
No. 18

Signal Corps, U. S. Army
10-29-18

LISTENING STATIONS are established for the purpose of overhearing telephone conversations and T.P.S. communications of the enemy. Such stations also enable the policing of our own telephone and T.P.S. systems, as they disclose what sort of information the enemy is likely to obtain with his listening stations.

As the possibility of overhearing enemy communications depends upon the proximity of the listening stations to the enemy lines of communication, these stations are generally established rather close to the front line trenches at a point where the enemy lines are not far distant. It has been found that T.P.S. messages, which are transmitted through the earth, and telephone conversations taking place on single-wire ground return circuits are easiest to pick up. Conversation over a two-wire telephone system, well insulated from the ground, is practically impossible to overhear, provided well insulated twisted pair is used. If, however, the insulation of such a circuit fails at some point and one of the wires becomes leaky or grounded, it is quite probable that the conversation will be overheard. Hence, a listening station may be used to indicate to some extent the condition of our own telephone system.

It may happen, for several weeks at a time, that a station in a quiet sector will not hear any signals from the enemy lines, except the testing calls. This should not lead the station personnel to allow its continual vigilance to relax, but they should attend to the usual routine work in strict military fashion. At any moment messages of considerable importance may be overheard, or at any moment our own lines may become damaged to such an extent as to make it possible for the enemy to overhear important messages.

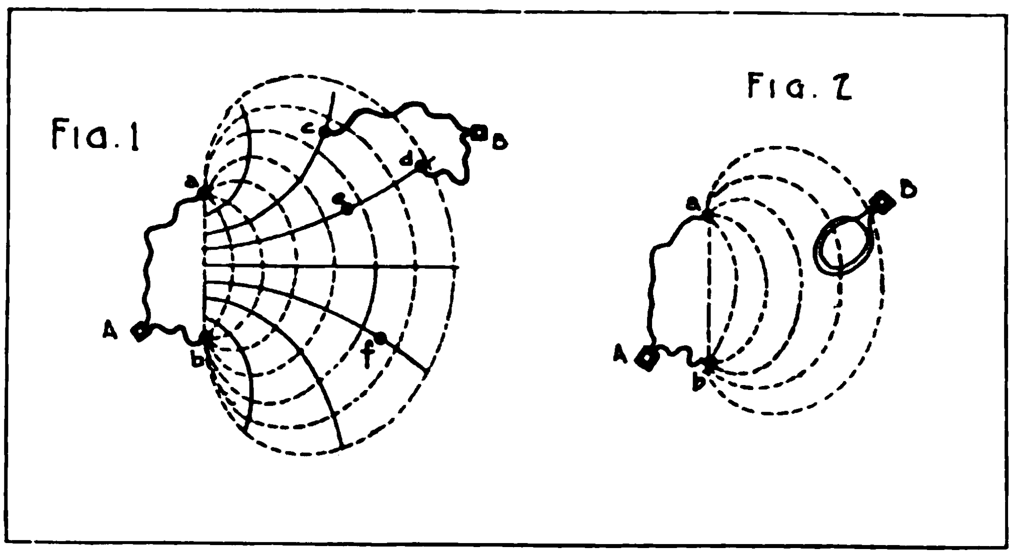
In a sector where there is unusual enemy activity such as prevails before an offensive, it is practically certain that messages of importance will be picked up, due to the greater telephone traffic in the advanced enemy trench lines and to the various artillery units, T.P.S. sets, etc., being advanced nearer to the first line trenches.

The personnel of a listening station should consist of at least three men, each of whom is an experienced radio operator and is thoroughly conversant with the German language, and, if possible, with the French. One man must be on listening duty all the time, night and day. The duty of the others, when not listening, is to maintain the apparatus in good working condition, repair breaks in the line wires, etc.

The usefulness and success of a listening station depends in a large measure upon the character and knowledge of the non-commissioned officer in direct charge of the work. He should be thoroughly familiar with the operation of the apparatus and the principles guiding the proper installation of the entire system of a listening station, and of the simple electrical theory involved. The officer in charge should himself have had training along these lines, and should be in a position to perfect the instruction of the men under him.

Theory of the Listening-In Systems

Before explaining the principles of the various listening-in systems, it is necessary to give an idea of the mode of propagation of electric currents through the ground in the case of T.P.S. or of single-wire (ground return) telephone communication; also of the various auxiliary phenomena which make it possible to overhear a conversation on an entirely metallic and insulated telephone circuit.



Let A, Fig. 1, represent a T.P.S. sending buzzer, or a telephone transmitter on a grounded telephone circuit, Aa and Ab being the two line wires, grounded at the points a and b. The electric current flows, for instance, in the line wire from A to a, then through the ground from a to b, and then, through the second line wire, from b to A. The ground being a fairly good conductor of electricity, the electric current while flowing through the ground from a to b will not only follow the straight line ab, but will spread through the ground and follow a large number of lines, some of which may extend out two or three miles. The general shape of these lines of current flow may therefore be considered as an electric conductor along which the flow of electric current produces a continuous drop of potential in the direction of the current flow. Equipotential lines can therefore be drawn, as shown by the light solid lines of Fig. 1. Each one of these lines joins the points on the lines of current flow having the same potential.

If, then, two points d and e of the same equipotential line are connected by means of a metallic wire, no current will flow through the wire, since its two extremities are at the same potential. If, however, the two ground connections are made at points c and d not situated on the same equipotential line, a current will flow in the wire cd, and if a telephone receiver B is inserted in this wire, the T.P.S. signals or the telephone conversation sent out from A will be overheard at B. The currents in the wire cBd may be too small to be heard in an ordinary telephone, in which case an amplifier may be inserted in the circuit. Also, if the ground connections are made at c and f, so as to establish a greater difference of potential at the extremities of the line wires of the listening station, the signals at B will be correspondingly louder.

This explanation, which involves only the phenomena of current conduction through the ground, is not complete. There is also an inductive action of the transmitting circuit upon the receiving circuit. This may be explained by the fact that each one of these two circuits is a closed loop, the line wires being short-circuited by the conducting ground. The interrupted buzzer currents or the voice-modulated currents in the transmitting circuit will then induce an emf. in the closed receiving circuits and thus produce a current in it, which may be heard in the telephone receiver, generally after amplification.

These two effects, current conduction through the ground and induction, are distinctly separate phenomena. In the case of grounded transmitting and receiving circuits, the two phenomena add their effects in producing sounds in the telephone receiver. It may be seen, however, that the grounding of the receiving circuit is not essential. A closed loop made entirely of insulated metal wire may be used, Fig. 2. This loop is generally of quite considerable dimensions, 200 to 300 meters in length and 50 to 100 meters in width, and of several turns, generally three or four. When using this method the signals are usually weaker than with a grounded receiving circuit, since only the induction phenomenon is made use of. This is partly compensated by the larger number of turns of the loop, which increases the strength of the inductive effect.

The respective advantages and uses and the actual method of installation of insulated loops and ground line wire receiving circuits will be studied below. It is usually more difficult to overhear telephone conversations than T.P.S., for the currents involved are considerably weaker. Telephone conversations are seldom overheard at a distance exceeding 2 kilometers.

The problem of overhearing conversations taking place over entirely insulated metallic circuits is somewhat different from the previous one, where the grounded line was considered. If the circuit over which conversation is taking place is insulated over its entire length, the only way the telephone currents can act upon some outside circuit is by induction. This inductive effect of the telephone circuit upon the listening circuit can be enormously reduced if the two wires of the telephone line are run parallel and very close together, or if twisted pair is used, since the electromagnetic field of one wire will almost entirely neutralize that of the other. The action of such a circuit being entirely inductive, an insulated loop circuit such as that of Fig. 2 may be used for listening in.

However, in a circuit such as that of Fig. 1, the receiving set B with two ground line wires was shown to be, in fact, a closed loop circuit. It may therefore be used instead of an insulated loop, and it will then not only be acted upon by direct induction, as in the case of the insulated loop, but it will also pick up conductively the currents induced in the ground, if any, by the insulated telephone circuit. Thus, as before, the grounded listening-in circuit may, under certain circumstances, have the advantage over the insulated loop circuit.

Methods of Installation of Listening Stations

The station itself is installed in a deep and dry dugout located about 500 to 1500 yards back of the first lines. Great care is always observed in handling the amplifier and the auxiliary apparatus, to insulate it from the ground and to protect it from mechanical vibrations. This may best be done by mounting it on a table or shelf, resting the amplifier set box on rubber pads.

The wires connecting the apparatus in the dugout to the forward ground connections outside or to the wires making up the listening-in loop must be of heavily insulated wire, such as field wire furnished with T.P.S. sets, which is made of phosphor bronze and is mechanically strong.

In the case of grounded circuits, the grounds are made as far forward as possible, often in no-man's land. These ground connections are best made by burying some metal netting (ground mats) about 1 ft. deep in the bottom of a trench. If no mats are available, or if the installation has to be made very hurriedly, four or five T.P.S. ground rods may be driven in the ground at least 1 ft. deep, at a distance from each other of not less than 2 ft., and connected together. Such a ground is about as effective as a ground mat.

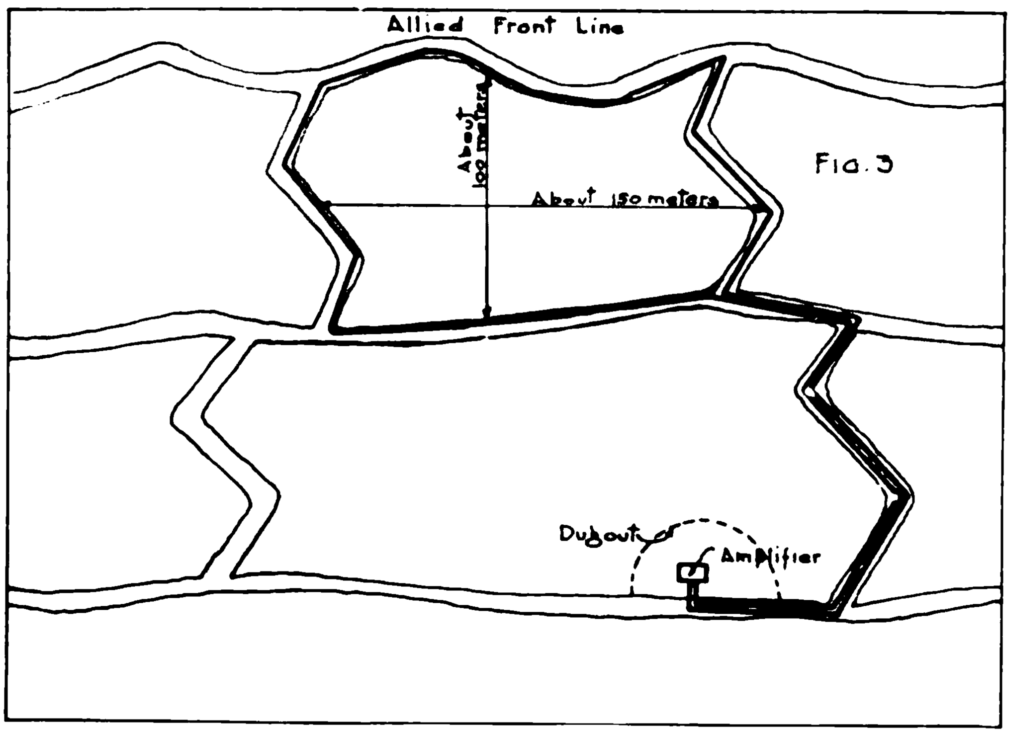


FIG. 3

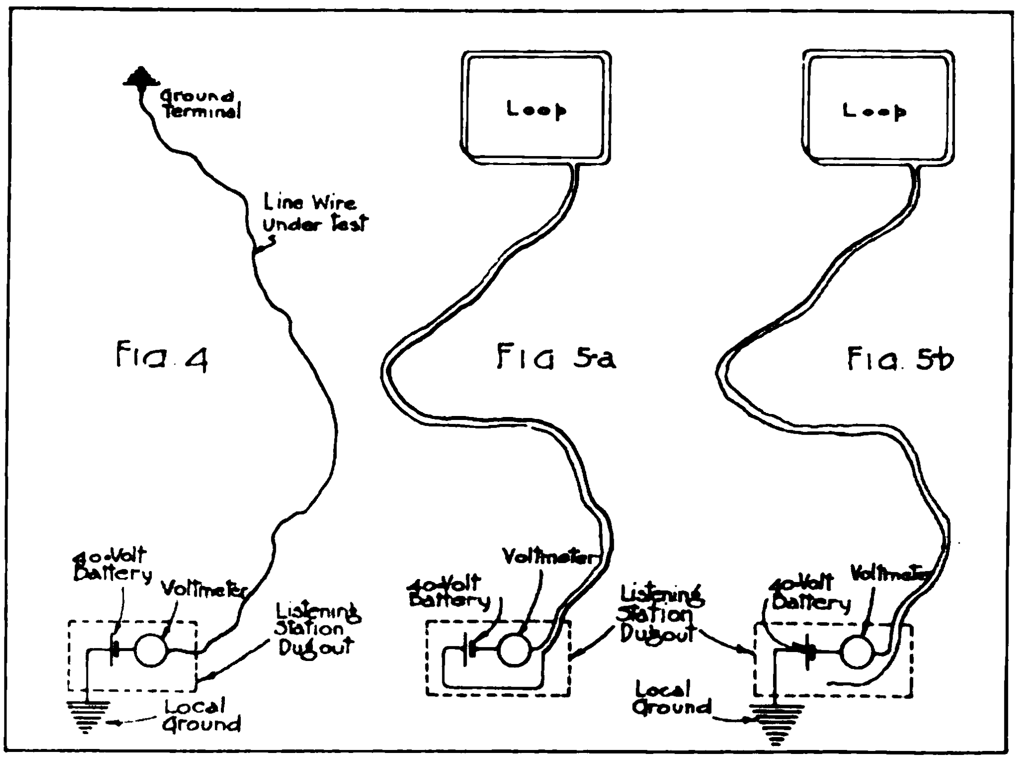
The wires connecting these grounds to the amplifier are run very close together whenever possible, either on the ground or tied by means of cords to short wooden poles, in order that the moisture on the earth's surface may not damage the insulation. No porcelain insulators are required. These wires should be run in a trench separate from that provided for the telephone and telegraph lines, so that the latter will not produce too great interference by induction.

In case a loop circuit is used, the loop is made up of the same kind of wire, also preferably tied to short wooden poles. The wire is run around a block of earth included between two lateral trenches and two communicating trenches, the latter being preferably not used for heavy traffic, Fig. 3. The loop should be of large size, and of at least three turns. A wire is tapped off at every turn and led into the amplifier dugout.

Testing Out Line Wires and Loop

An essential condition is that the insulation of the wire be in perfect condition at all times. A method for testing out this insulation is given below.

Testing the Insulation of the Ground Line Wires.—A good ground connection is first established in the amplifier dugout, or at close proximity to the station, and the ground line wire under test is connected to this local ground through a voltmeter and a 40-volt battery. The dry batteries of the amplifier may be used for this purpose, see Fig. 4. If the line



is in good condition, the voltmeter reading should be only slightly less than the direct voltage across the battery—10 per cent less perhaps. If it is more than 25 per cent below the battery voltage, the line should be examined for breaks and for poor ground connection.

Testing a Loop Circuit.—In case of a loop circuit, two tests, one for insulation and one for continuity of the circuit, are available. Connecting the two terminals of the incoming line wires to the voltmeter and 40-volt battery, Fig. 5-a, the voltmeter reading should be almost exactly the same as the direct voltage across the battery terminals. If no reading is obtained on the voltmeter, the line or the loop must be broken at some point.

The other test consists of insulating the end of one of the incoming wires and grounding the other one to the local ground through the battery and voltmeter, Fig. 5-b. No reading should be obtained on the voltmeter if the insulation is in good condition.

To repair a break in the wire, peel back the insulation from the broken ends, thus exposing the copper or phosphor bronze wires. Scrape these clean and twist them together tightly. Cover the splice with rubber tape, wound around tightly, and cover finally with a layer of friction tape for protection.

Methods of Dealing With Interference

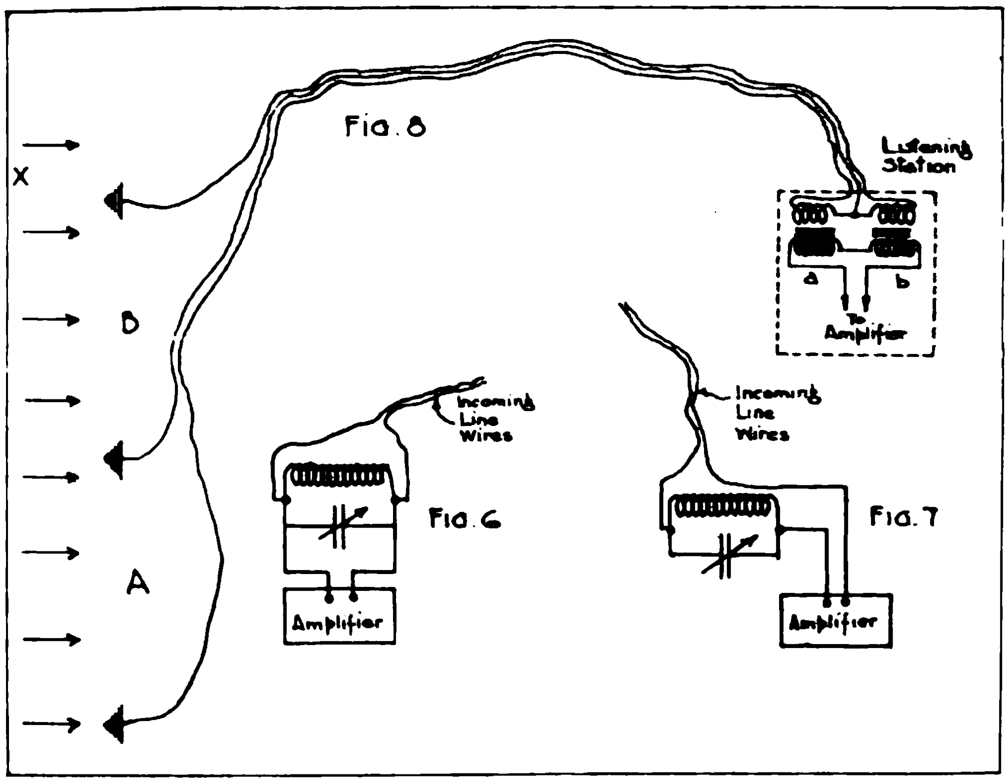
The general care of the amplifier and usual precautions to be observed when using it will not be taken up here. Any two-stage or more amplifiers may be used. Full instructions regarding the amplifiers of the types SCR-72, SCR-72-B, SCR-76 and SCR-76-A sets are given in Radio Pamphlets Nos. 10, 15 and 27.

In listening work the messages and signals to be received are generally quite faint, and it is therefore important that foreign noises be eliminated as much as possible. Such noises are produced in the amplifier by foreign currents entering the ground line wires, or inducing currents in the receiving circuits. Such currents may be due to leaky transmission lines in the neighborhood of the station, currents from motors, generators, friendly T.P.S. stations, etc., also "strays," or currents induced in the ground under certain atmospheric conditions. A number of schemes have been devised which serve to eliminate these noises to greater or less degree.

Generally speaking, the loop system is less affected by stray currents than the grounded circuit. At the same time, it is often less effective than the grounded line systems, because the loop cannot be installed as near the enemy lines. Also, the loop requires more wire, and is generally more difficult to maintain in good condition.

The methods of eliminating interference are, however, similar for the two systems, and some are given below. Before using any of these methods it is necessary to ascertain whether the interfering currents are due to a single source in a well-defined direction, such as currents from a certain T.P.S. station, or from a single motor, generator, etc., or whether the currents come from several directions, such as a number of motors or T.P.S. stations installed over a sector of front, or a long distribution line running parallel to the listening base line. The following methods have been used extensively by the French Army:

(a) In case the interference is produced by currents of various frequencies, or of a frequency distinctly different from that of the T.P.S. buzzer or voice currents it is desired to receive, the amplifier input terminals may be shunted by an oscillatory circuit, Fig. 6, tuned to the frequency of the currents it is desired to receive.

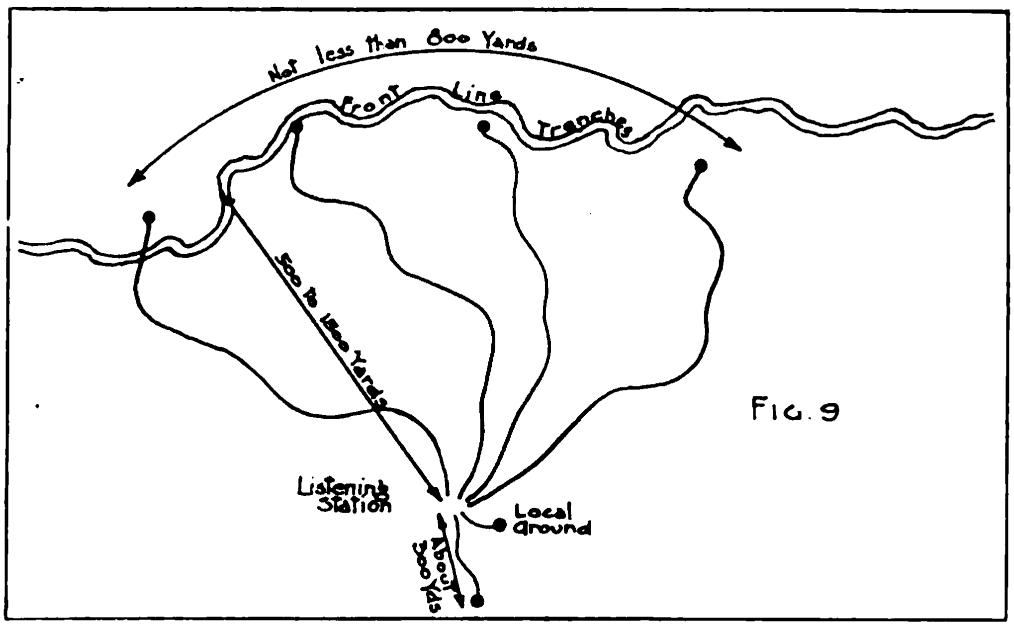


This circuit having higher impedance for that frequency than any other frequency, will allow most of the current to flow into the amplifier. For currents of any other frequency it will shunt most of the current, and therefore weaken the interfering noises in the amplifier.

(b) In case of an interfering current of a well defined frequency, such as that of a long a. c. transmission line, an oscillatory circuit tuned to that frequency may be placed in series with the amplifier, Fig. 7. The interfering noises will thus be reduced, the oscillatory circuit having highest impedance for that frequency.

(c) In case of a non-directional disturbance, such as that produced by a long transmission line, the arrangement of Fig. 8 is made. It consists of a "balanced" circuit comprising two identical listening-in circuits, disposed symmetrically with respect to the disturbing current. Each of the circuits A and B is connected to the primary winding a and b, respectively, of a small iron core transformer. The two secondary windings are so connected that the emf.'s induced in them by the equal interfering currents flowing in the two primaries will counterbalance each other. No noise is then produced in the amplifier until some conversation or signals occur at a point x which affects one of the two listening circuits more than the other, thus producing an unbalance of fluxes in the two transformers and, therefore, a current in the amplifier.

Another method which has been devised by the Signal Corps, United States Army, is outlined below.



A number of grounds are installed along the first line trenches, or in no man's land as near the enemy lines as possible, Fig. 9, and each is connected to the listening station in a dugout by means of heavily insulated wire, as explained above. A local ground is also installed at the station itself and one in back of the station, about 300 yd. away. The distance between the extreme grounds should not be less than 800 yd.

In the station dugout the incoming line wires are then properly tagged and all connected to three dial switches, as shown in Fig. 10. Two methods are used to operate this station, according to whether the interference is directional or non-directional.

Non-Directional Interference.—Two of the dial switches are connected to the amplifier input terminals through the medium of two 10,000-ohm rheostats. A .5-mfd. condenser is also connected across the amplifier terminals. The dial switches are then adjusted until two ground line wires are found for which

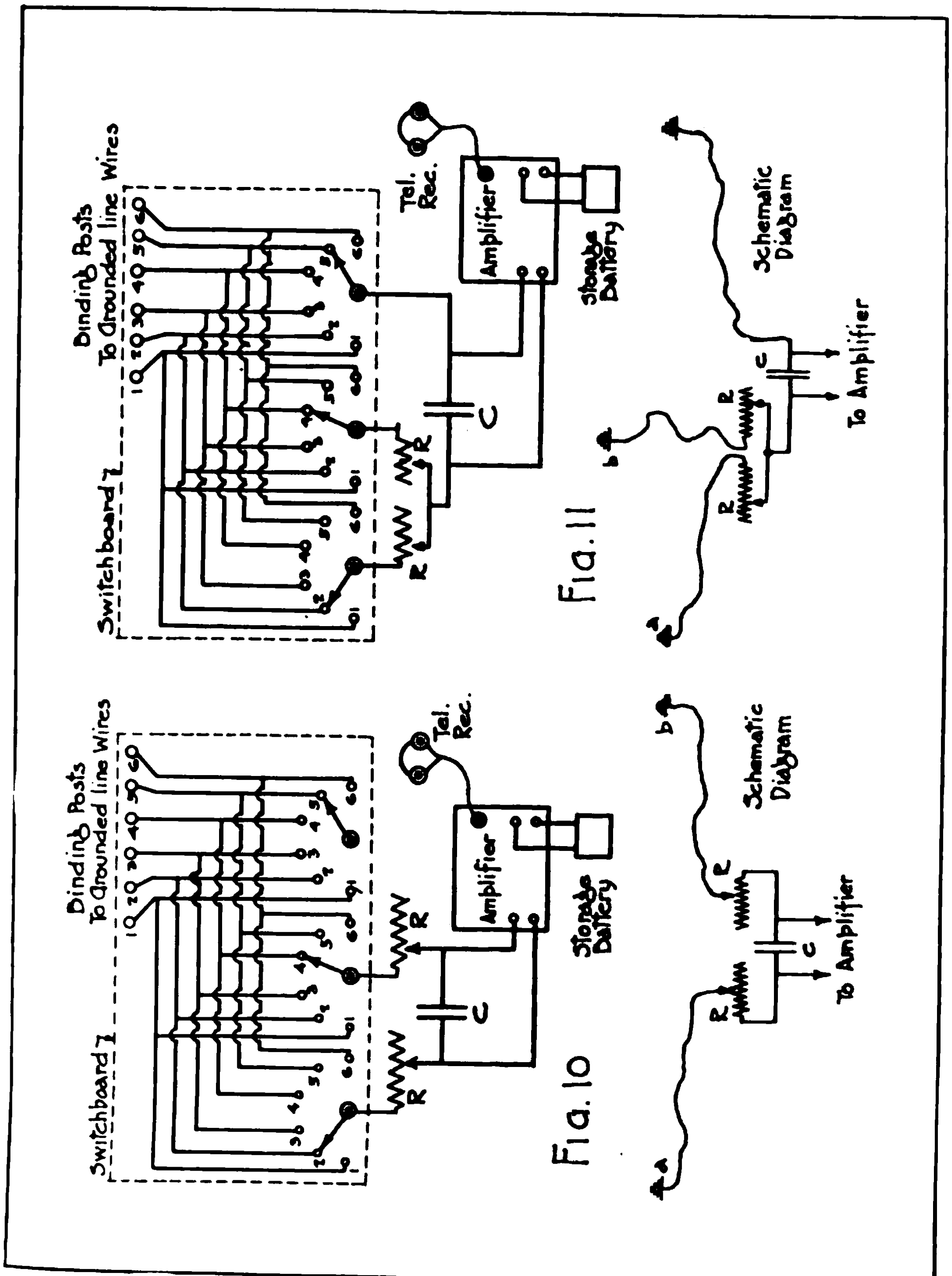


Fig. 10

Fig. 11

the disturbing noises are a minimum. For this position (see schematic diagram, Fig. 10) the two grounds a and b are, among those available, the nearest to an equipotential line of the electrostatic field created by the interfering current. The use of these two grounds will then minimize the disturbance while receiving. The purpose of the resistances RR is to absorb interfering currents of a frequency of less than about 600 cycles per second. They are adjusted for each setting of the dial switches until a combination of grounds and resistances is obtained which gives the minimum interference and readable signals. The condenser C acts as a short circuit for high frequency disturbances, such as radio signals, which are sometimes heard without this precaution.

Directional Interference.—The connections to be made in case of directional interference such as coming from a buzzer, or machine in some definite direction, are shown in Fig. 11. The rheostats and dial switches are adjusted until the disturbance is a minimum. The connections are then as shown in the schematic diagram, Fig. 11. The resistances and condenser serve the same purpose as above, and the disturbing currents, affecting both ground lines a and b, will neutralize their effects in those circuits.

Equipment Available

Attention is invited to the fact that none of the apparatus referred to in connection with the problems of interference is available in the U. S. A. as standard Signal Corps equipment, except the amplifier, ground rods, ground mats and line wires. In other words, the special equipment needed for listening-in work must be devised from materials at hand, if needed. The resistance and condenser units needed, as indicated in Fig. 10 and Fig. 11, may perhaps be secured by requisitioning telephone line testing resistances and standard condensers described in S. C. Manual No. 3, Chapter 4, or by securing a replacement condenser of about the right capacitance, designed for some radio set and maintained in stock in the supply depot. An audibility meter might serve as the variable resistance. The conditions referred to in this paragraph apply to training work in the United States, but it is understood that suitable equipment is available in France for the use of the Field Signal Battalions attached to Army headquarters.

The listening-in stations are maintained by Army and Corps Field Signal Battalions and such special apparatus is issued to them as is needed. The Division Battalions should be informed in this work but need not try to secure suitable equipment for actually undertaking the work.
