COMPOSITE TELEPHONE AND TELEGRAPH SYSTEM

FOR

RAILWAY SERVICE

BULLETIN T-206

Western Electric Company
INCORPORATED

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INTRODUCTORY

The telephone within recent years has become extremely useful and important in railway work. The enforcement of more rapid and frequent train service has compelled many railway companies to provide more adequate means of communication between the old stations, and to bring in touch with these stations, new ones in which there are no attendants. To accomplish this, requires either an enlargement of the existing telegraph system, the installation of a separate telephone system, or the equipment of the existing telegraph lines with telephonic apparatus—in other words, installing a composite telephone and telegraph system.

COMPOSITE TELEPHONE AND TELEGRAPH SYSTEM FOR RAILWAY SERVICE

Our railway composite telephone and telegraph system has been devised for the purpose of enabling telephone and telegraph messages to be transmitted simultaneously over grounded telegraph lines. It is adapted to simple Morse circuits where interruptions in the telegraphic current are of comparatively low frequency and where the change in potential of the current due to the operation of the telegraphic apparatus, is not excessive. Except under favorable conditions, it is not suitable for use on duplex or quadruplex lines, or where machine sending is employed.

A description of this composite system with regard to the construction of the telephonic apparatus, its operation, installation and maintenance, is given on the following pages.

DESCRIPTION AND OPERATION OF THE SYSTEM

The arrangement of a grounded line telegraph system equipped with telephonic apparatus is shown in Figs. 10, 11, 12, 13, 14 and 15, Fig. 10 representing the general plan of a whole or part of a telegraph system thus equipped, and Figs. 11 to 15 inclusive, the station wiring.

From these illustrations it will be noted that on the composited portion of a line there may be three kinds of telephone stations: terminal stations, located at each end of that part of the telegraph line used for telephonic purposes; intermediate stations, located between the terminal stations and portable stations, intended to be carried on a train for emergency use between the terminal stations while the train is at a standstill.

To adapt a telegraph system to telephone operation requires no change in the telegraphic apparatus or in its operation. All that is necessary is to bridge the apparatus at each telegraph station with a condenser and a resistance, and at the telephone stations to connect the telephonic apparatus between the line and ground. A condenser in each telephone set prevents the telegraphic current from passing through the apparatus to ground.

Telephone signaling is accomplished by pressing a button which places high frequency current on the line by means of an interrupter and induction coil, as shown at C, Fig. 16. This current at the signaled station passes through a condenser and howler to ground as at A, Fig. 16, causing the howler to produce a sufficiently loud sound to be readily heard in the station. The talking circuits are shown at B, Fig. 16. Regular local battery talking is used, and a condenser is joined in series with the receiver, which itself is shunted by a retardation coil.

TELEGRAPH STATIONS Each telegraph station on the composited portion of the line is, as already stated, provided with a condenser and a resistance coil. The former is bridged across the telegraph station apparatus outside of the peg switch Figs. 12, 13 and 14, thus providing a by-path for the telephonic talking and signaling currents, which otherwise would be seriously reduced by the impedance of the relays and interrupted by the operation of the keys. The latter, a coil of high non-inductive resistance, is bridged across the telegraph relay so that when telephonic signaling current is applied to the line, any of this current flowing around the condenser will pass through the resistance and so prevent a chattering of the relay.

TELEPHONE STATIONS At each terminal telephone station is located a No. 1312-A telephone set, wired as in Fig. 17, a No. 58-B protector, a No. 48-B retardation coil, and a No. 27-B one-microfarad condenser, connected as shown in Figs. 11 and 15. The retardation coil is joined in series with the line, and the condenser is bridged to ground from that portion of the telegraph line which is not composited. The retardation coil prevents the telephonic currents from passing to ground over the telegraph line beyond the telephone station, but does not impede the telegraphic currents because these are of much lower frequency than those generated by the telephones. This coil and condenser combined prevent the impulses of the telegraphic current from producing annoying disturbances in the telephone instruments. The condenser also aids in the dissipation of any disturbing currents that may reach the telegraph lines from inductive or other causes.

Each intermediate telephone station requires a No. 1312-A telephone set, and a No. 58-B protector. A portable telephone set, which is a form of intermediate station, consists of a No. 1314-A telephone set, wired as in Fig. 18.

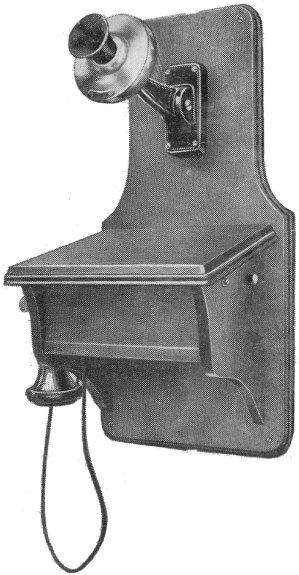
Batteries are installed in all the telephone stations for providing signaling and talking current.

PROTECTION OF THE APPARATUS

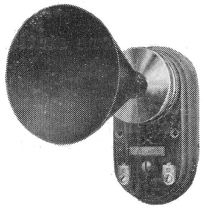
The protective devices installed at each telephone station, not only protect the telephonic apparatus from lightning and abnormal currents, but owing to the fuses, prevent a permanent ground at the cut-outs from interfering with the telegraph service. The No. 58-B protector should be connected in circuit as shown in Figs. 11, 12 and 15, with the fuses next to the line. At intermediate telephone stations, only one side of the protector is used, as there is only one wire connecting the telephone to the line.

LIMITATIONS OF THE COMPOSITE SYSTEM

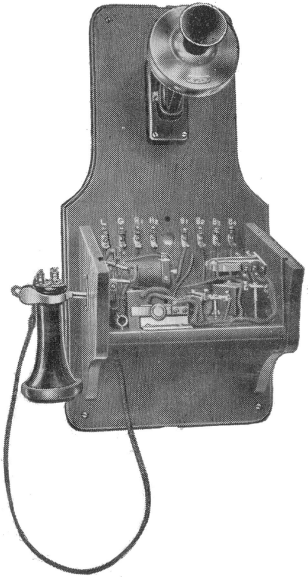
The length of telegraph line and the number of stations with which this composite system can be successfully employed, depend largely upon the character of the telegraph line. On a short line, service will be better and more stations can be operated than on a long line; the length, gage, material of the line wire, and the amount of wire in cable are the more important features which govern the perfect operation of the system.



No. 1312-A Telephone Set, Closed
Fig. 1-A



No. 1-C Howler
Fig. 2



No. 1312-A Telephone Set, Open
Fig. 1-B

In arranging a line for composite service it must be remembered that iron wire is much inferior to copper wire of the same size when used for telephonic transmission, and also that conductors in cable are much less efficient than open wires. Furthermore, paper insulated wires in cables are much more efficient than wires of the same size in rubber insulated cables, on account of the high electrostatic capacity of the latter.

Owing to the many different conditions governing the use of railway composite apparatus, and the variation in these conditions for each particular line, it is impossible to give inflexible rules applicable to every case regarding the length of line over which service can be successfully obtained, or regarding the number of stations which can be successfully operated on a single line. Each particular telegraph line must be considered separately before a definite statement can be made regarding its adaptability for telephone service.

As a general indication of the possibilities of the system, however, it may be stated that successful operation should be practicable over ordinary telegraph lines up to 100 miles in length, and with as many as five intermediate telegraph stations.

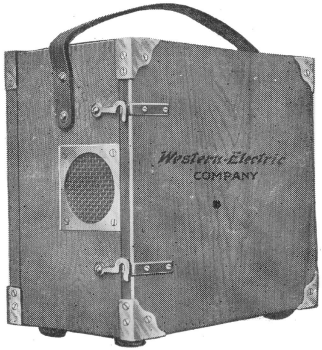
DESCRIPTION OF THE APPARATUS

Brief descriptions of the different kinds of apparatus used to equip a telegraph line for telephone service are here given.

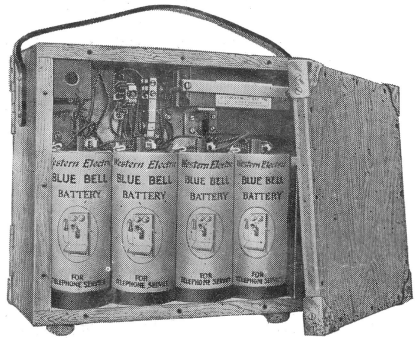
TELEPHONE SETS

We make two types of telephone sets for composite systems: the No. 1312-A set for mounting on the wall of the station, and the No. 1314-A set for portable use. The No. 1312-A telephone set is shown in Fig. 1, A-B. It includes our No. 286-W transmitter, No. 144-A W receiver, and all the necessary talking and signaling apparatus except the dry cells.

The No. 1314-A telephone set is shown in Fig. 3, A-B-C. It is of portable type and includes our No. 228-W transmitter and No. 133-W receiver. It is entirely self contained, the necessary dry cells being inside the case, together with all the talking and signaling apparatus. The box is of substantial hard-wood construction with metal corners, and is divided in two parts by a partition, the dry cells, retardation coil, induction coil, hand switch springs, key springs and condensers being located in the rear, while the transmitter, receiver, howler, interrupter, hand switch lever, signaling key button and rail clamp are in front. Access to the apparatus in the rear is obtained by taking out the screws in the back of the case, and removing the back board, Fig. 3-B.



No. 1314-A Telephone Set, Closed
Fig. 3-A



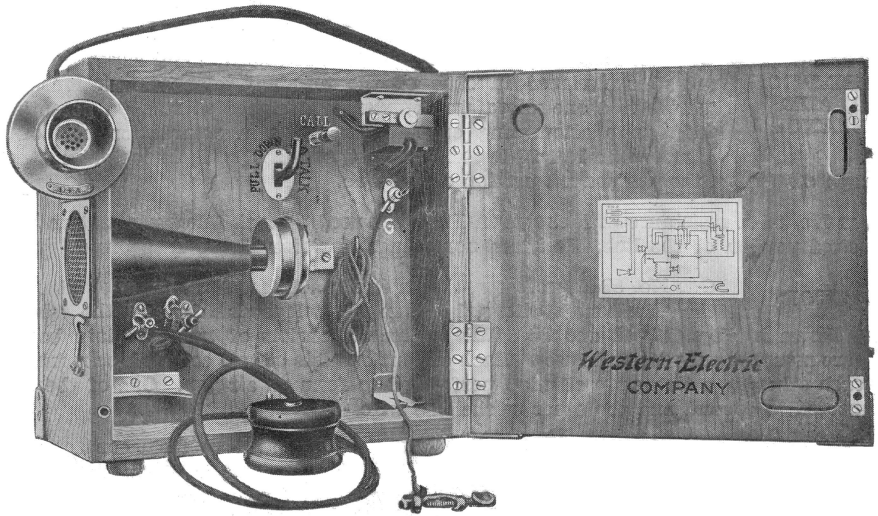
No. 1314-A Telephone Set, Open; Rear View
Showing accessibility of apparatus
Fig. 3-B

The No. 4 line pole shown in Fig. 9, is also a part of this portable equipment. It consists of three 6-foot sections, so arranged that either two or three sections may be used. A 104-foot insulated flexible wire cord is furnished with this pole, soldered to the metal joint on the butt section. The joints on the other two sections have permanent wire connections, from one end to the other, the wire on the end section connecting with a metal hook so that when the pole is jointed together and the hook hung on a bare telegraph wire, the circuit between the line and telephone set is completed. The connection between the set and ground is by means of a rail clamp, made adjustable so as to fit flanges of different sized rails, and connected to the set by a flexible wire cord.

HOWLERS The howler is shown in Fig. 2 and consists of a special form of telephone receiver equipped with resonating horn. The diaphragm is operated by the high frequency signaling currents produced by the interrupter and induction coil. The howlers used in this system are all of the same design but have two different code numbers—No. 1-C and No. 1-B—according to the method of mounting them.

The No. 1-C howler, which is part of the No. 1312-A telephone set, is mounted on a separate base that can be located in any convenient place where the operation of the device will attract attention.

The No. 1-B howler is mounted in the No. 1314-A telephone set which, as previously stated, is designed for portable use.



No. 1314-A Telephone Set, Front View, Open
Fig. 3-C

CONDENSERS RETARDATION COILS, AND RESISTANCE COIL

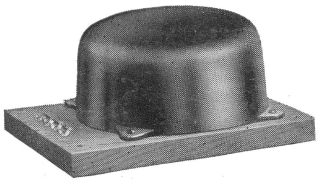
Our No. 27-B condenser and No. 48-A retardation coil shown in Figs. 4 and 5 are placed in each of the terminal telephone stations. The former is a one microfarad condenser designed to stand a potential of 1000 volts alternating current, the latter a retardation coil of 100 ohms. Our No. 27-B condenser, shown in Fig. 5, is installed at each telegraph station on the composited portion of the line.

Our No. 31-A resistance coil, shown in Fig. 7, is used at each telegraph station on the composited portion of the line. It has a non-inductive resistance of 1200 ohms.

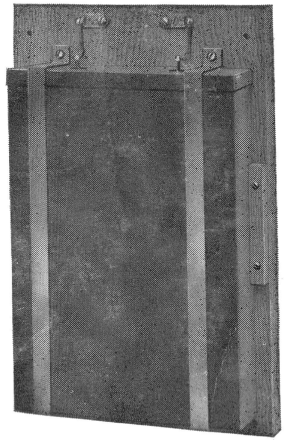
PROTECTOR

Our No. 58-B protector, shown in Fig. 6, should be installed at each of the telephone stations, between the telegraph line and the telephone set, as shown in Figs. 11, 12 and 15. This protector consists of two porcelain bases on which are mounted cut-outs and fuses. Each cut-out consists of two copper blocks insulated from each other by a thin strip of mica, perforated to form an air gap. One of the blocks is connected to ground and the other to the line wire.

A high potential such as results from a lightning discharge or from contact with a high-pressure light or power circuit, will establish a path to ground by arcing across the air gap between the two copper blocks, and the consequent rush of current will, if sufficiently strong, blow the fuse. This gives protection to the telephonic apparatus by isolating it from the line, and prevents interference with the telegraph service.



No. 48-A Retardation Coil
Fig. 4



No. 27-B Condenser
Fig. 5

BATTERY We recommend the Blue Bell dry cell, Fig. 8, for use with the telephone sets on account of its high efficiency and long life. Ten cells are usually employed with the No. 1312-A telephone set, four cells being used for talking and six for signaling. Only four cells are used with the No. 1314-A telephone set. These furnish current for both talking and signaling purposes.

CLASSIFICATION OF APPARATUS Complete lists of the apparatus required in the terminal and intermediate telephone stations and in the telegraph stations on the composited portion of the line, are here given. The apparatus necessary in the portable telephone set for this system is also given.

The apparatus necessary for a terminal telephone station consists of:

1 No. 1312-A telephone set, which includes:

- 1 No. 12-G retardation coil,
- 1 No. 21-D condenser,
- 1 No. 21-H condenser,
- 1 No. 21-U condenser,
- 1 No. 143-B switch hook,
- 1 special No. 5 induction coil with interrupter,
- 1 No. 92, 3-ft. cord,

1 special No. 390-B key,
1 No. 286-W transmitter,
1 No. 144-AW receiver,
1 No. 1-C howler.

10 Blue Bell dry cells.
8 No. 338 cords for dry cells.
1 No. 27-B condenser.
1 No. 48-A retardation coil.
1 No. 58-B protector, which includes:

2 No. 11-C 7-ampere fuses,
2 sets of Nos. 19 and 20 copper protector blocks,
2 No. 10 protector micas.

The apparatus necessary for an intermediate telephone station consists of:

1 No. 1312-A telephone set, which includes:

1 No. 12-G retardation coil,
1 No. 21-D condenser,
1 No. 21-H condenser,
1 No. 21-U condenser,
1 No. 143-B switch hook,

1 special No. 5 induction coil with interrupter,
1 No. 92, 3-ft. cord,
1 special No. 390-B key,
1 No. 286-W transmitter,
1 No. 144-AW receiver,
1 No. 1-C howler.

10 Blue Bell dry cells.

10 No. 338 cords for dry cells.

1 No. 58-B protector, which includes:

2 No. 11-C 7-ampere fuses,
2 sets of Nos. 19 and 20 copper protector blocks,
2 No. 10 protector micas.

The apparatus necessary for a portable telephone outfit consists of:

1 No. 4 Line Pole.

1 No. 1314-A telephone set, which includes:

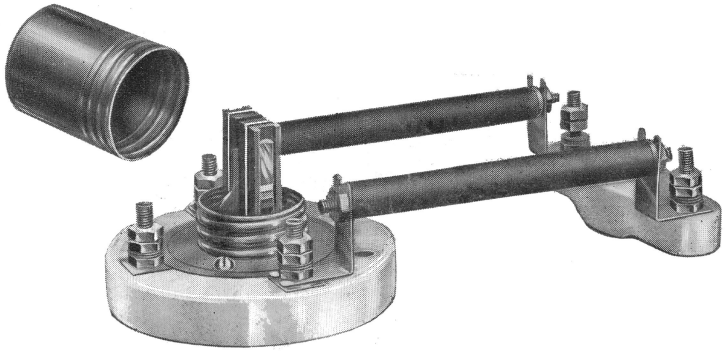
1 No. 12-M retardation coil,
1 No. 21-D condenser,
1 No. 21-H condenser,
1 No. 21-U condenser,
1 No. 140-F switch hook,

1 special No. 390-B key,
1 special No. 5 induction coil with interrupter,
1 No. 311, 3-ft. cord,
1 No. 267, 10-ft. cord,
1 No. 179, 5½-in. cord,
1 No. 1-B howler,
4 Blue Bell dry cells,
1 rail clamp,
1 No. 228-W transmitter,
1 No. 133-W receiver.

The additional apparatus necessary for each telegraph station on the composited portion of the line between the terminal telephone stations consists of:

1 No. 27-B condenser.

1 No. 31-A resistance.



No. 58-B Protector, with cap removed
Fig. 6

INSTALLATION OF THE TELEPHONE APPARATUS

The apparatus must be properly installed or trouble will be experienced in the operation of the system. The small additional cost of properly installed apparatus over poorly installed apparatus is soon counterbalanced by the lower cost of maintenance. Illustrations and descriptions of the various materials and supplies used when installing the apparatus for this system will be found in our catalogue of Telephonic Apparatus and Supplies.

A terminal telephone station and an intermediate telephone station properly equipped with apparatus and wired for railway composite work, are shown respectively in Figs. 20 and 21.

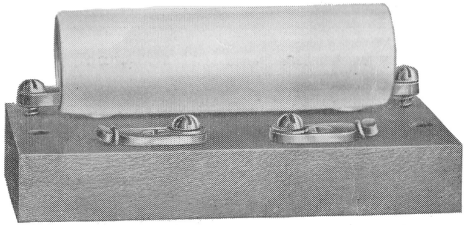
Location and Mounting

TELEPHONE SET The No. 1312-A telephone set should be mounted so that the mouthpiece of the transmitter will be adapted to the height of the users. It should be placed where doors or movable furniture will not come in contact with it, and where it will not interfere with persons passing through the room. Damp walls and vibrating partitions should be avoided as a support for the set, and any location within two feet of a window that is liable to be opened, is undesirable. For unavoidably noisy locations, telephone booths are advantageous; these booths are listed in the catalogue referred to in the preceding paragraph.

The telephone set must be securely fastened to the wall. If it cannot be placed flush with the surface on account of projections, it should be blocked out from the wall with wooden strips, the strips being fastened to the wall with screws, toggle or expansion bolts, and the set afterwards screwed to the strips.

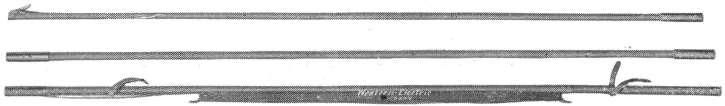
In fastening the telephone set to a brick, cement or stone wall, holes are first drilled in the wall at the proper position for the screws. Wooden plugs are then driven securely into the holes, and the telephone set screwed to these plugs. Care must be taken in plugging the holes in the wall to see that thoroughly dry wood is used, and that the plugs are large enough to hold securely. Another method consists in first fastening a board, or two wooden strips to the wall as just explained and then screwing the telephone set to this support. As an alternative to these methods expansion bolts may be used. To mount the telephone set on a hollow-tile wall, holes should be drilled through the tiles and toggle bolts used.

HOWLER The howler used in connection with the wall telephone set may be located in any convenient place where its operation will attract attention. It is advisable, however, to mount it at a sufficient distance from the set so that it will not be handled by persons telephoning, and its adjustment thereby altered.



No. 31-A Resistance Coil
Fig. 7

Improved
Blue Bell Battery
Fig. 8



No. 4 Line Pole
Fig. 9

CONDENSERS The No. 27-B condenser should be located as near to the telegraph line or the peg switch as possible, care being taken to avoid damp locations and places where it would be exposed to mechanical injury. The No. 27-B condenser may be fastened to the wall or table. The No. 48-A retardation coil should be mounted on the table or on a shelf, as it is not arranged to be fastened to the wall.

RESISTANCE COIL The No. 31-A resistance should be mounted at some convenient point near the telegraphic apparatus, such as beside the telegraph relay on the table, under the table, or on the wall.

PROTECTOR The No. 58-B protector should be mounted upon the inner wall of the building as near as possible to the point where connection is made with the telegraph line. An asbestos mat, such as our No. 48 protector mounting, should be placed beneath it.

BATTERY The battery should be placed near the set in some out-of-the-way place, unexposed to mechanical injury and dampness, but accessible for inspection and renewals. The cells should be connected in series, that is, the carbon of one

cell should be connected to the zinc of the next throughout the battery, our No. 338 cords being used for this purpose. Care should be taken to connect the terminal leads from the battery to the proper binding posts of the telephone set as shown in Figs. 11, 12 and 15. A diagram of this part of the wiring will also be found in each telephone, so no trouble should be experienced in making the proper connections.

Inside Wiring

SIZE OF WIRE With the exception of the ground wire from the protector, all interior wires from the telegraph line or the peg switch to the telephonic apparatus, should be of rubber covered and braided copper, not smaller than No. 19 B. & S. gage. The ground wire from the protector should be of copper not smaller than No. 18 B. & S. gage, and should be rubber covered and braided; if exposed to mechanical injury, it should be of No. 14 B. & S. gage, rubber covered and braided.

LOCATION All inside wires should be installed in a neat, safe, and workmanlike manner. Where it is impossible to conceal the wires, they should be run along the door or window casings against the plaster, in the molding, or in the groove at the top of the baseboard. The wires should not be run across the ceiling unless absolutely necessary, and when placed on the wall they should run either vertically or horizontally, for the sake of appearances. If it be necessary to install wires in the base-

ment or where they are exposed to mechanical injury, care must be taken to protect them by some suitable means such as molding or conduit. Damp localities should be avoided for all inside wires.

PROTECTION Where necessary to run the wires across pipes or other conducting materials, they should be protected by tubing, or by two wrappings of insulating tape for a distance of at least one inch beyond each side of the pipe or conducting material. Whenever practicable, the wires should be run above pipes rather than under them.

Where it is necessary for the telegraph or telephone wires to cross any exposed electric light or power circuits, they should be at least six inches distant from them, unless encased in porcelain tubes, circular loom or similar conduit. If the telephone or telegraph wires be thus encased, the conduit should project at least six inches on either side of the electric light or power wires and should be firmly secured with tape to prevent it from slipping out of place.

FASTENERS The wires should be fastened so as not to injure their insulation. Fiber cleats, insulated staples, or "Milonite" nails driven between the insulated wires, may be used. Each insulated staple should enclose but one wire, and care must be taken not to drive the fastener through the insulation. Uninsulated staples should not be used. Under no circumstances should coils or knots be made in any of the wires.

SPLICES

Splices in interior wires should always be soldered. A resin flux should be used in place of acids or paste, because of the injurious effect of the acid or paste upon the wires. After the joint is made, it should be carefully wrapped with rubber tape, the thickness of the wrapping to be at least as great as the regular insulation on the wire. When joints are made in twisted pair wire, there should be at least four inches lengthwise along the pair between the joints in the two wires.

GROUND CONNECTIONS

Where a telegraph equipment is already installed in an office, the ground wire of that equipment may be used for the telephone set and protector, connection with it being usually made at the peg switch. Where no telegraph equipment is installed, it will be necessary to run a ground wire. This wire as previously stated, should be either No. 14 or No. 18 B. & S. gage copper wire; it should be free from spirals, coils, knots or sharp bends, and should be run as directly as possible to the ground connection, which may be either a metal rod driven into permanently damp earth, or a water or gas pipe connected to the street mains which are in service.

When a ground rod is used, it must be sufficiently long to extend above the earth level, so that the ground wire can be soldered to it. When ground connections are made to pipes, the point of contact should be made as near the mains as possible, and water pipes should be chosen in preference to gas pipes. In case it is necessary to use gas pipes, the connection should be made between the meter and the street mains.

Water or gas pipes which are to serve as ground rods should be thoroughly cleaned and tinned at the part where the ground wire is to be attached, after which the wire should be wrapped tightly around the pipe and soldered to it.

If it be difficult to secure a good soldered connection, the pipe should be thoroughly cleaned and a ground clamp used; this must be securely fastened to the pipe at the cleaned portion and the ground wire attached to it.

MAINTENANCE

Careful maintenance of the apparatus used for railway composite service is as important as proper installation, if good service is to be rendered.

REPAIRS When repairs are needed either in the apparatus or in the wiring, it is important that they be made promptly and permanently. Rush work, short cuts, skimped material, and other attempts to hasten the completion of repair work at the expense of thoroughness, should be avoided. Temporary makeshifts necessitate frequent additional repairs and changes; they are a source of continual trouble, interrupted service, and in the end, prove very expensive.

If, for any reason, it be necessary to change the interior wiring, the new wires should be placed with due regard to the rules given in the preceding part of this bulletin. If it be necessary to replace apparatus or parts of apparatus, care should be taken to see that the connections are properly made, splices well soldered and taped, and that the whole work presents a finished and workmanlike appearance when completed. To provide for cases of emergency, a stock of supplies such as copper protector blocks, protector micas, and fuses should be carried.

LOCATING TROUBLE When the system is not working properly, the trouble may be due to the line being out of order, to a defect in the apparatus or wiring in the telegraph stations; or to a defect in the apparatus or wiring in the telephone stations.

Line trouble is cleared by the usual methods employed in all telegraph systems.

Trouble at telegraph stations equipped with telephone apparatus, must be either in the telegraph apparatus, the No. 27-B condenser, or in the No. 31-A resistance. Trouble in the telegraph apparatus should be cleared in the usual way. If the condenser is short-circuited, no telegraph messages can be sent from that station; if the condenser is open, there will be poor telephonic transmission beyond the break. In case the No. 31-A resistance is open, the telephone signaling currents may cause a chattering of the relay.

Trouble at telephone stations may be traced to a ground across the protector blocks, to a loose or open connection between the telephone set and telegraph line, such as an

open fuse; to defects in the apparatus or wiring of the signaling circuit in the set (represented by the light lines in Fig. 19) to defects in the apparatus or wiring of the talking circuit in the set (represented by the heavy lines in Fig. 19); or to an open ground connection. Such troubles will not ordinarily interfere with the continued operation of the telegraph apparatus, but in any case, the following tests and remedies should quickly locate and remedy the defects and place the system in operation.

SIGNALING TROUBLE

When able to talk satisfactorily over a line but unable to signal other stations, it is well to first ascertain whether the interrupter operates when the signaling key is depressed. If it does not, test the battery, and if that is all right, try a different adjustment of the contact screw on the interrupter.

If the interrupter operates satisfactorily and it is impossible to signal other stations, ascertain whether signaling current is delivered to the line when the key is depressed. This may be determined by replacing the receiver on the hook and disconnecting the line wire from terminal "L," Fig. 17, short-circuiting the terminals "L" and "H 2," and then pressing the signaling key, which should operate the howler at the home station.

If the local howler does not then operate, it indicates that the trouble is in the telephone set at this station, and that the contacts of the switch hook and of the signaling key should be examined to see that they make good contact with each other. If this does

not clear the trouble it is advisable to look for an exhausted battery, loose connections, broken wires, or an open in the No. 21-U condenser.

An exhausted battery can be detected by bridging a low-reading voltmeter or battery gauge across each of the six signaling cells of the No. 1312-A telephone set or across each of the four signaling cells in the No. 1314-A telephone set, while the switch hook is in the proper position for talking and the signaling key closed for one minute. If the cells are not exhausted, the total pressure under normal working conditions should be at least 0.7 volt per cell. Loose connections or broken wires can readily be found by inspection. To test for an open in the condenser, short-circuit its terminals; if the howler then operates it indicates a defective condenser.

If the howler at the signaling station operates satisfactorily after disconnecting the line wire and short-circuiting terminals "L" and "H 2," it indicates that the trouble is not in the telephone set. It may however, be due to arcing at the open space cut-outs in the signaling station, or to trouble at the receiving station where the howler may be out of adjustment or open, the No. 21-U condenser defective, or to an open circuit in the wiring. The removal of the copper blocks in the open space cut-outs at the signaling station will therefore, determine at this stage in the tests whether the trouble is in the distant station.

At the receiving station, the method of procedure would be as follows: The terminal "L," Fig. 17, should be connected to "H 1." If the howler then operates, it indicates

an open in the No. 21-U condenser. If however, the howler does not operate, the next step would be to test the howler separately. This is done by connecting it directly to one battery cell and listening for a click at the instant the circuit thus formed is closed. If no click is heard, the trouble is in the howler; otherwise it must be an open circuit in the wiring.

ADJUSTMENT OF THE HOWLERS

The sound emitted by the howler can be varied by moving the diaphragm nearer to or further away from the magnets. One method of adjusting the howler is to have the most distant station keep signaling current on the line until the shell containing the diaphragm has been adjusted to give the desired tone; the locking ring may then be used to fix the shell firmly in place. As the locking of the metal shell in place tends to move the shell slightly away from the magnet, due allowance should be made in adjusting the howler to guard against this action throwing the howler out of adjustment.

It sometimes happens that the magnets in the howler become demagnetized or weakened after being in service for a long time. In this case, the howler should be replaced by a new one and the defective howler returned for repairs.

TRANSMITTING TROUBLE

If the transmission is poor, that is, if there is trouble in receiving messages at a distant station while messages are clearly received at the home station, the speaker should talk clearly, with his lips close to the mouthpiece of the transmitter. If the transmission is still unsatisfactory, the trouble may

be an open in a condenser at an intermediate telegraph station (see Fig. 10); in the primary or secondary of the talking circuit in the sending station (see B, Fig. 16, and heavy line circuit in Fig. 19); or in the secondary (receiving) circuit of the receiving station (see B, Fig. 16, and heavy line circuit in Fig. 19.)

If in the condenser at an intermediate telegraph station, the trouble is undoubtedly an open, which although interfering with the transmission of the voice beyond the break, will not interfere with its reaching a station on the same side of the break as the sending station. If in the primary or the secondary of the talking circuit in the sending station, the receiving station will have no trouble in hearing messages transmitted to it from other stations on the line. On the other hand, if the trouble is in the secondary (receiving) circuit of the receiving station, the sending station will have no trouble in transmitting to other stations.

To test for trouble in the talking circuit of the sending station, place the receiver to the ear, and if the secondary circuit is not open and there be no defective apparatus in it, the usual low sounds characteristic of aerial lines, will be heard. These sounds vary in intensity according to the length of the line and its exposure to other electric circuits, but they are seldom of sufficient intensity to interfere with telephonic transmission. If the secondary circuit is thus found to be all right, the primary circuit is then tested by listening in the receiver while speaking into the transmitter or tapping it gently. These sounds will be distinctly heard in the receiver if the primary circuit is in good working

order, or a click will be heard in the receiver when the switch hook is operated. If such sounds are not heard, the apparatus and wiring in the secondary circuit should be examined, and the battery inspected for an open circuit.

A battery test with an ammeter is here recommended. This test is made by connecting the ammeter in the primary circuit, and after the receiver has been off the switch hook for one minute, noting the current in the ammeter. If the battery is working perfectly, it should give a current of more than 0.14 ampere after it has been thus connected for one minute. This corresponds to a voltage of approximately 2.8 across the terminals of the talking battery while the latter is under load, that is, furnishing current to the primary circuit.

If the condensers on the line are not defective, and there be no trouble in the talking circuit, it is in all probability in the receiving circuit at the distant station.

RECEIVING TROUBLE

If unable to hear distinctly, and there is no difficulty in transmitting messages either in the local or the distant station, it indicates trouble in the secondary circuit of the telephone set. This circuit, as shown at B, Fig. 16, consists of the secondary of the induction coil, the No. 21-D condenser, receiver in multiple with the No. 12-G retardation coil, the switch hook and ground. A thorough inspection should be made of all parts of this circuit for poor connections, and if none be found, an examination should be made of the apparatus in the secondary circuit for defects and poor adjustments.

ADJUSTMENT OF THE RETARDATION COIL

The No. 12-G retardation coil in our No. 1312-A telephone set has an iron core which can be moved in or out and secured in any position to vary the impedance and regulate the amount of current shunted around the receiver. If disturbing noises become troublesome in the receiver, the iron core should be moved out of the retardation coil to reduce the impedance of the coil and permit more current to pass around the receiver. On the other hand, to maintain the volume of the sounds received, the amount of current diverted from the receiver should be as small as consistent with the necessary freedom from the disturbing noises. The core should therefore be withdrawn from the coil no further than is necessary to obtain the desired result.

In the No. 1314-A telephone set the iron core is permanently adjusted in the No. 12-M retardation coil there used, because the disturbing noises vary at different points along the telegraph line, and owing to the temporary use of the set, do not warrant re-adjusting the core every time the set is put in service at a different point.

RECEIVER DEFECTS

In case the trouble cannot be remedied by means of the retardation coil, it may be found in the receiver itself. Trouble in receivers may be caused by dust or dirt settling upon the pole faces of the magnet and damping the vibrations of the diaphragm. To clear this trouble, the receiver cap should be unscrewed and the pole faces of the magnet wiped perfectly clean.

"Buckled diaphragms" are sometimes a cause of trouble in telephone receivers. The buckling is generally caused by pencil points or other sharp objects being pushed against the diaphragm and denting it. When a diaphragm has thus been injured, it should be replaced by a new one. Occasionally, weakened receiver magnets are a source of trouble. If they are not sufficiently strong to hold the diaphragm to them when the receiver cap is removed and the receiver given a vigorous shaking in the direction of its length, a new receiver is necessary.

The receiver cord will in time become worn or possibly injured so as to cause trouble by opening the circuit either intermittently or permanently. As the wire strands within the cord may be broken without the appearance of the cord betraying it, this trouble is difficult to locate without tests. If the wires in the receiver cord be broken so as to open the receiver circuit, or if the winding of the coils in the receiver be open, no sound will be heard in the receiver.

A good method of testing a receiver and its cords for an open circuit, is first to connect the leads from one battery cell directly to the receiver terminals. If the receiver does not give an audible click at the instant this circuit is completed, and the diaphragm is in proper position, it may be safely assumed that the wiring in the receiver is open and will have to be repaired. If the click is heard, the receiver is all right. Then the cords should be tested by connecting them to the receiver and repeating the test, a click in the

receiver upon connecting the battery to the cords indicating no break in them, and the absence of the click indicating that there is a break. A worn cord that is breaking the circuit intermittently might not be detected by such a test, but if the cord be bent or shaken while the receiver is held to the ear, a scraping sound will be heard whenever the cord is bent so as to open the circuit.

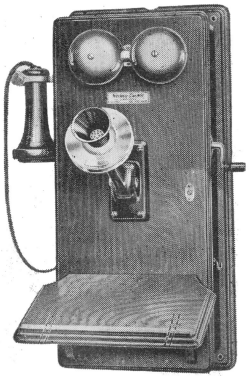
TESTS AND REMEDIES FOR GROUNDS

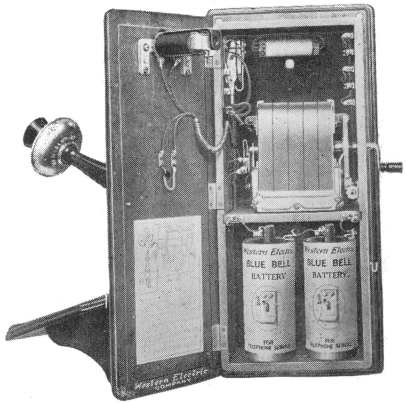
Ground troubles may be due to foreign matter between the copper blocks of the No. 58-B protector, to a defective No. 21-D or No. 21-U condenser in the telephones, to a defective No. 27-B condenser, or to a cross between the primary and secondary parts of the talking circuit. To determine if the trouble is in the protector, remove the metal cap and pull out both of the copper protector blocks. If this clears the ground, they should be cleaned and replaced, and if necessary, new No. 10 micas should be used in place of the old ones. Under no circumstances should cardboard or paper be substituted for the mica.

If the trouble is not in the protector, and the separation of the line wire from the protector or telephone set clears the ground, the condensers and wiring in the telephone set should next be tested. If the trouble is noticeable only when the receiver is on the hook, the No. 21-U condenser should be investigated. If however, the ground occurs only when the receiver is off the hook, the No. 21-D condenser is probably causing the trouble, and should be remedied.

In case either the No. 21-D or the No. 21-U condenser be found defective, any available condenser which will clear the trouble temporarily may be inserted between the telegraph line and the telephone set until the defective condenser is replaced. If no suitable condenser is at hand, disconnect the telephone from the line until repairs can be made.

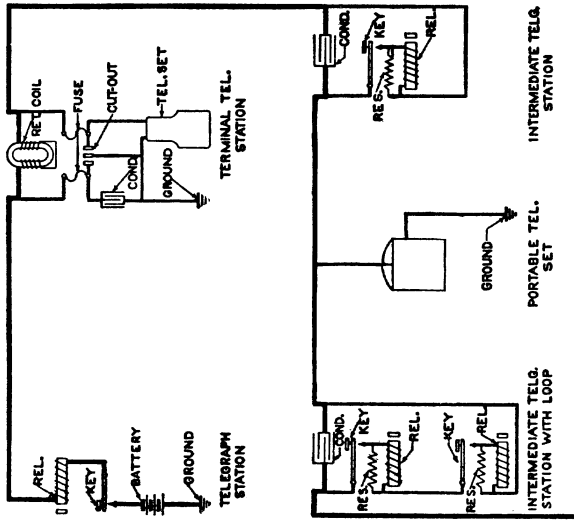
In a terminal station, a ground may occur at the No. 27-B condenser equipment, due to a short circuit in the condenser. To determine whether this is the trouble, remove the ground wire from that equipment; if the trouble then ceases, it indicates that the condenser is defective. To clear the trouble temporarily, the ground connection may be left off the condenser. In doing this, however, the ground connection of the telephone set, which is usually made at this point, must not be disturbed, as this would leave the telephone out of service.



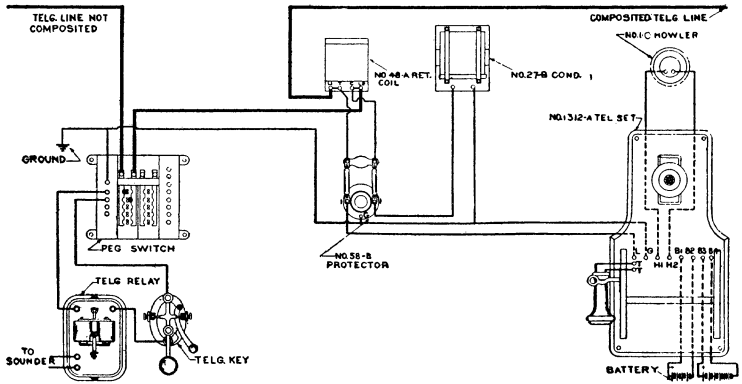


No. 1317-S Telephone Set, Closed **No. 1317-S Telephone Set, Open**

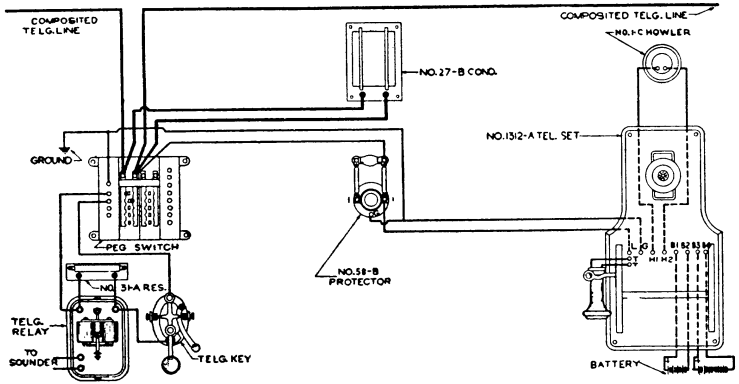
Standard Telephone Set, also used for Railway Service



SIMPLIFIED ARRANGEMENT OF LINE RAILWAY COMPOSITE SYSTEM. Fig. 10

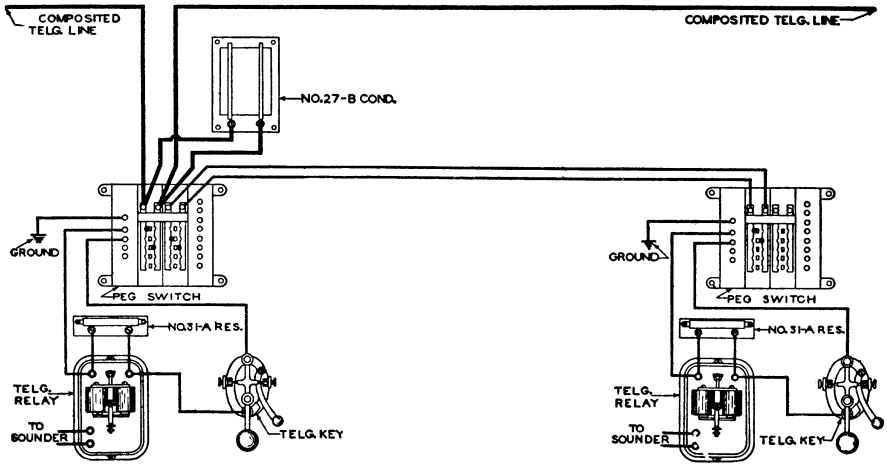


TELEGRAPH AND TERMINAL TELEPHONE STATION
RAILWAY COMPOSITE SYSTEM
Fig. 11

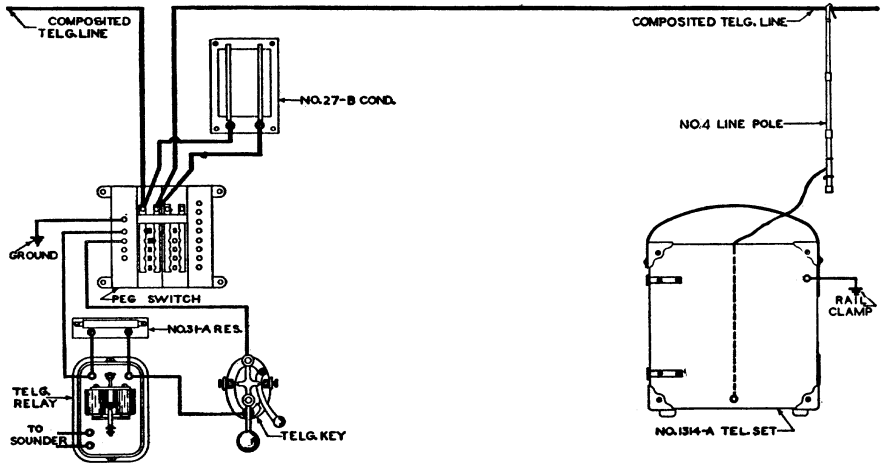


INTERMEDIATE TELEGRAPH AND TELEPHONE STATION RAILWAY COMPOSITE SYSTEM

Fig. 12



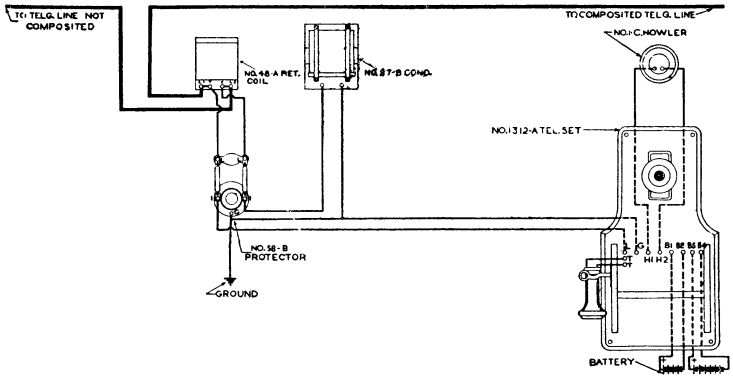
INTERMEDIATE TELEGRAPH STATION WITH LOOP RAILWAY COMPOSITE SYSTEM
Fig. 13



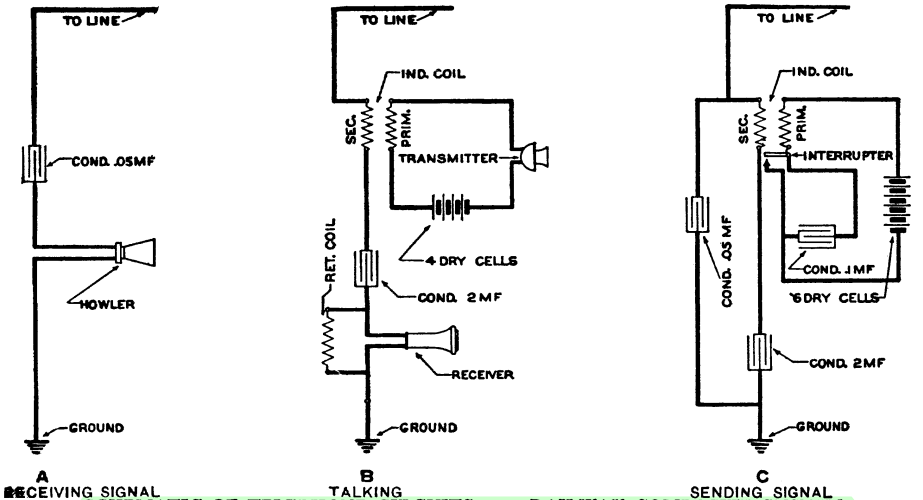
INTERMEDIATE TELEGRAPH STATION **PORTABLE TELEPHONE SET**

RAILWAY COMPOSITE SYSTEM

Fig.14

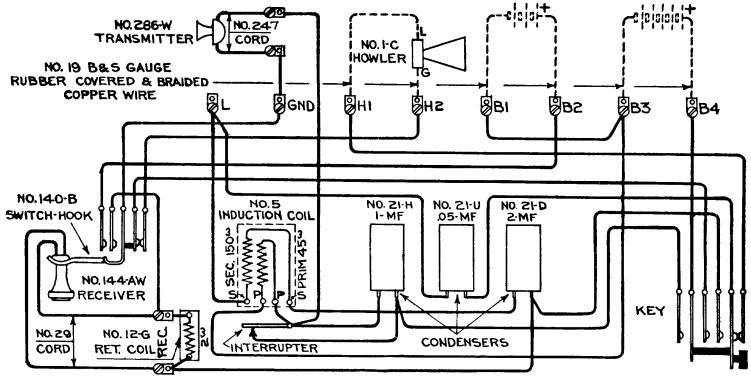


TERMINAL TELEPHONE STATION
RAILWAY COMPOSITE SYSTEM
Fig. 15

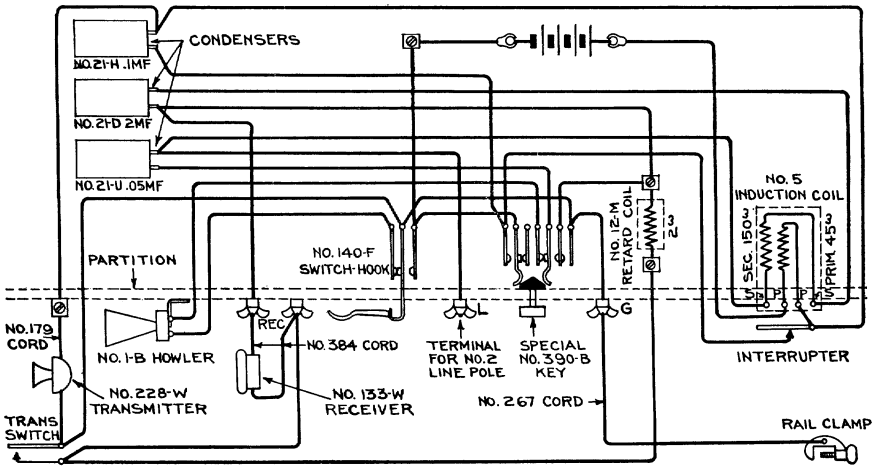


SCHEMATIC OF TELEPHONE CIRCUITS RAILWAY COMPOSITE SYSTEM

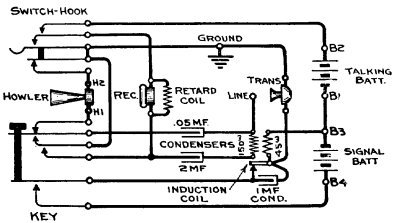
Fig. 16



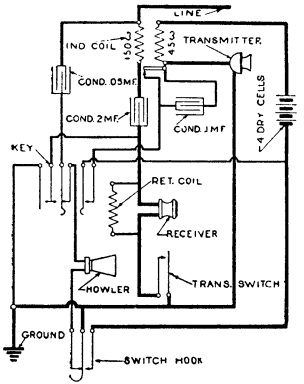
WIRING OF No. 1312-A TELEPHONE SET
RAILWAY COMPOSITE SYSTEM
Fig. 17



WIRING OF No. 1314-A TELEPHONE SET
RAILWAY COMPOSITE SYSTEM
Fig. 18

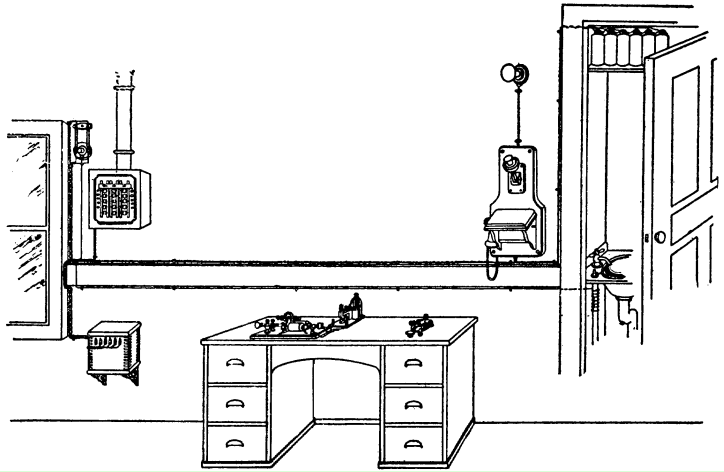


No. 1312-A TELEPHONE SET

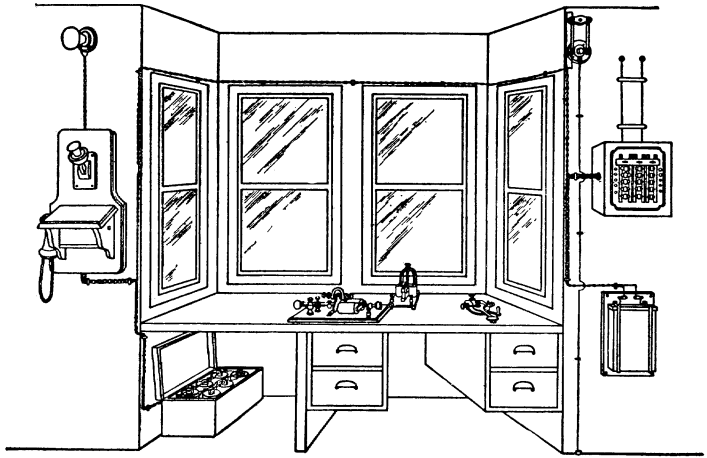


No. 1314-A TELEPHONE SET

SIMPLIFIED CIRCUITS OF TELEPHONE SETS
RAILWAY COMPOSITE SYSTEM
Fig. 19



ARRANGEMENT OF APPARATUS TELEGRAPH AND TERMINAL TELEPHONE STATION
RAILWAY COMPOSITE SYSTEM
Fig. 20



ARRANGEMENT OF APPARATUS INTERMEDIATE TELEGRAPH AND TELEPHONE STATION
RAILWAY COMPOSITE SYSTEM
Fig. 21