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THE BUZZERPHONE

Type EE-1

(Confidential)

Wire Communication

Electrical Engineering Pamphlet
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(Note Changes in text)

Signal Corps, U. S. Army
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Makes Possible Secret Telegraphic Communication—Non-Secret Telephone Conversation May be Carried on Simultaneously Over the Same Circuit.

It is a well known fact that military communication by means of telephone and telegraph, which are widely used at the front, is readily picked up by induction and leakage through quite considerable distances. This fault in these systems has made it possible for both the Allies and the enemy to gain valuable information concerning the movements of the opponent by resorting to what has been termed the "listening in" service. Naturally, a form of communication which would be entirely secret was greatly needed, particularly in the forward positions. This need led to the development by the British of the Fullerphone, the American substitute for which is much improved in compactness and weight and scheme of operation, and is called the "buzzerphone." One of the principal differences of the buzzerphone from the Fullerphone is that the former has no potentiometer and requires no adjustments to compensate for ground potentials. The buzzerphone type of signaling device is coming in for more and more extensive use in and near the front line trenches since it reduces to a minimum the possibility of detection of signals through induction or ground leakage. The transmission of general service code signals is the use for which the set is primarily designed, but it may be used simultaneously, without interference, for carrying on a telephone conversation. Such a telephone conversation, however, may be easily picked up by the usual methods and it is therefore not used for any confidential messages. Because of its characteristics, the buzzerphone may be used to largely replace the ordinary telephone and telegraph instruments in the Infantry telephone network within the regiment. There is now an A. E. F. general order specifying that the telephone

shall not be used forward of one mile behind the lines, and that all wire communication in this area shall be by buzzer-phone. This is understood to except the telephone lines from artillery battalions to forward artillery observing posts.

Principle and Description

In general, the system of operation employed in the buzzer-phone is the transmission of unvarying direct current, broken up by a key at the sending end to form dots and dashes, and the reception of these direct current signals at the receiving end through a device which breaks up the direct current into fairly high frequency impulses which are then audible in the ordinary telephone receiver. The device employed for breaking up the current in the receiving circuit is a combination of two microphones and a receiver to produce what is commonly called a "howler." One of these howlers is also employed in the transmitting circuit to break up the signal current in the local circuit, so that the operator can hear his own signals as he sends. To prevent these high frequency impulses from passing out on the line where they could be detected, a combination of inductances and capacitances, called a "filter," is inserted in the circuit and is designed to have such canstants that all variations from the constant output current are smoothed out. The filter likewise eliminates the usual click heard at the beginning and end of the dots and dashes, as it prevents any sudden change in voltage and hence smoothes out the instantaneous rise from zero to normal line voltage, or vice versa, into a gradual change approximating a sine wave with a rate of change so slow that the inductive effect is practically imperceptible. The fact that the current in the line is very small in addition to being practically constant, also aids in the secrecy of transmission.

The circuits for both sending and receiving are combined in one set which is mounted in a wooden box measuring 5⅞ in. x 8⅞ in. x 6 in. high and having a total weight of 11 lb. All apparatus necessary to the operation of the set is self-contained in this box except a telephone hand set which is used when talking over the line and which adds 1½ lb. to the weight of the complete set. The howler, various condensers, ~~inductance coils~~ induction coil and operating switch are mounted on the under side of the panel, which is hinged at

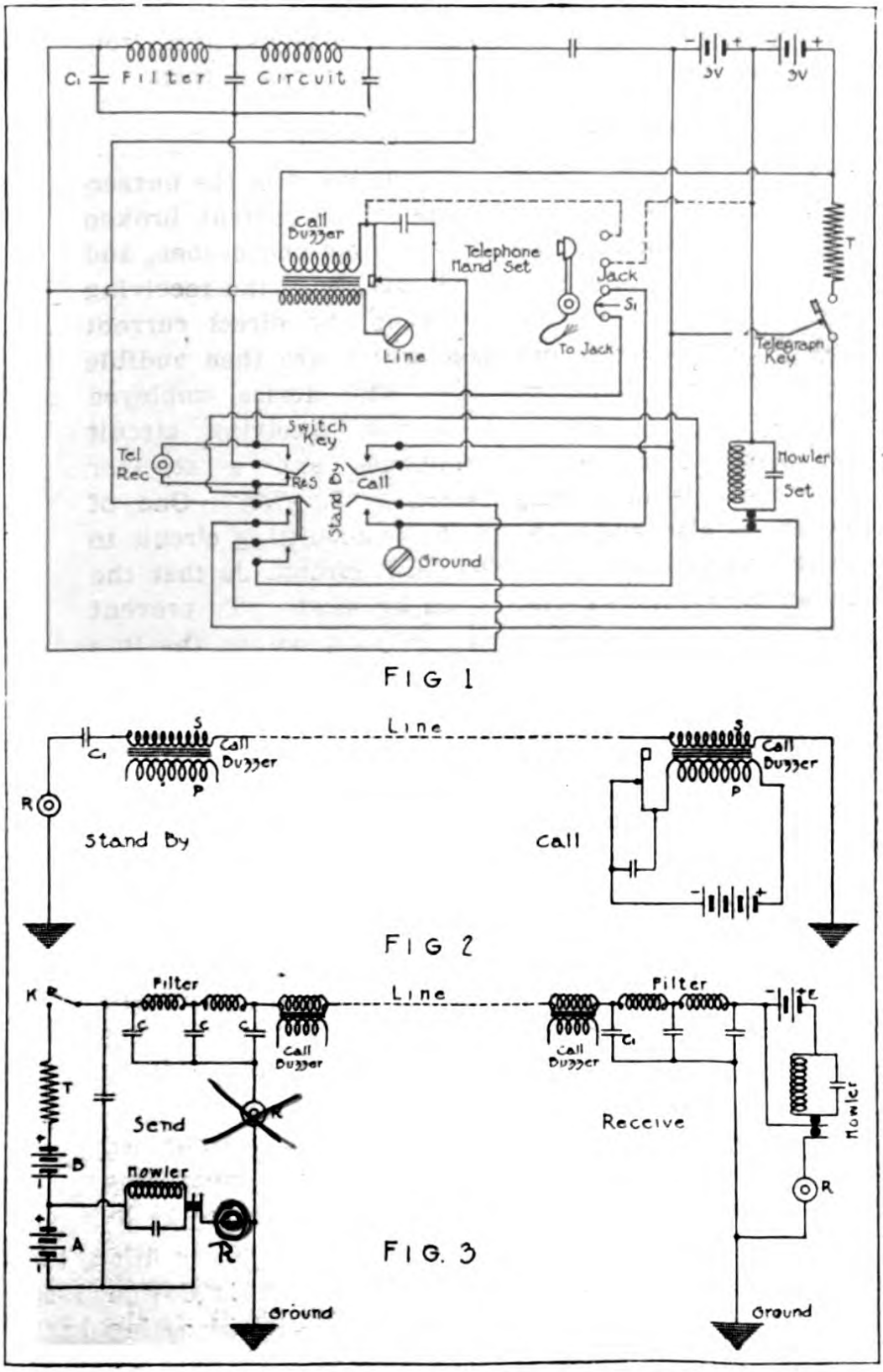

Fig. 1. Schematic Diagram of Complete Buzzerphone Circuits—Fig. 2. "Stand-By" and "Call" Circuit Elements—Fig. 3. "Send" and "Receive" Circuit Elements.

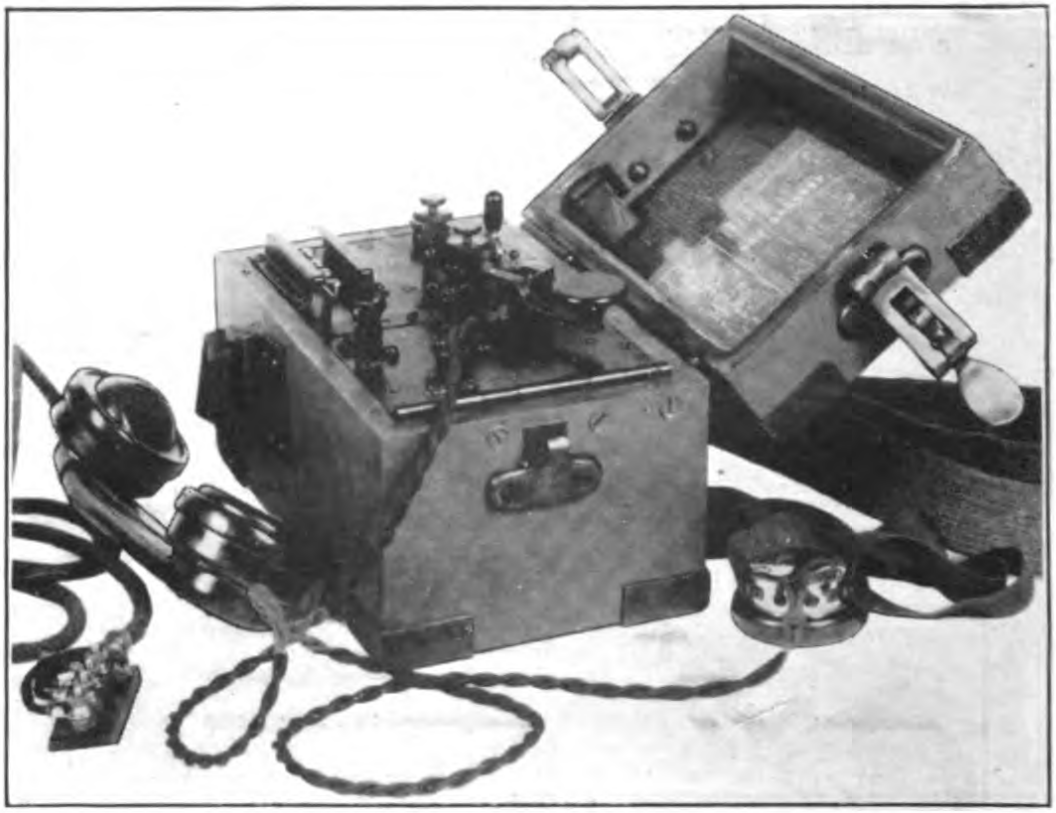

Fig. 4. Panel of EE-1 Buzzerphone—Telephone Hand Set Clip-Jack at Left of Panel, Sending Key in "Receive" Position, and Switch Key at Back Right Corner.

one end of the box and locked when closed by a set screw at the opposite end, Fig. 5. The sending key and the jack for connecting the telephone hand set, and the line and ground binding posts are mounted on top of the panel, Fig. 4. The two, two-cell Signal Corps type A dry batteries producing the 6-volt current to operate the set are installed in the bottom of the box.

The different operating connections of the set are controlled by the three-position switch key and the side-contact switch on the sending key. The switch key is normally in the neutral position which is termed the "Stand-By" position. When receiving or sending, this switch is moved to the "Send-Receive" position. When pulled in the opposite position, the "Call" circuit is completed, but the switch is designed so that it will not remain in this position but will spring back to stand-by. The separation between sending and receiving connections is determined by the position of the jointed sending key. In its normal position it is held over against a side

contact which completes the circuit for receiving signals from another station. When the operator desires to send, he straightens out the key, moving it to the left to the sending position and this opens the receiving circuit. Pressing the key brings the transmitting circuit into play. When he has completed sending signals, he takes his fingers off the key, which then automatically goes back to the receive position.

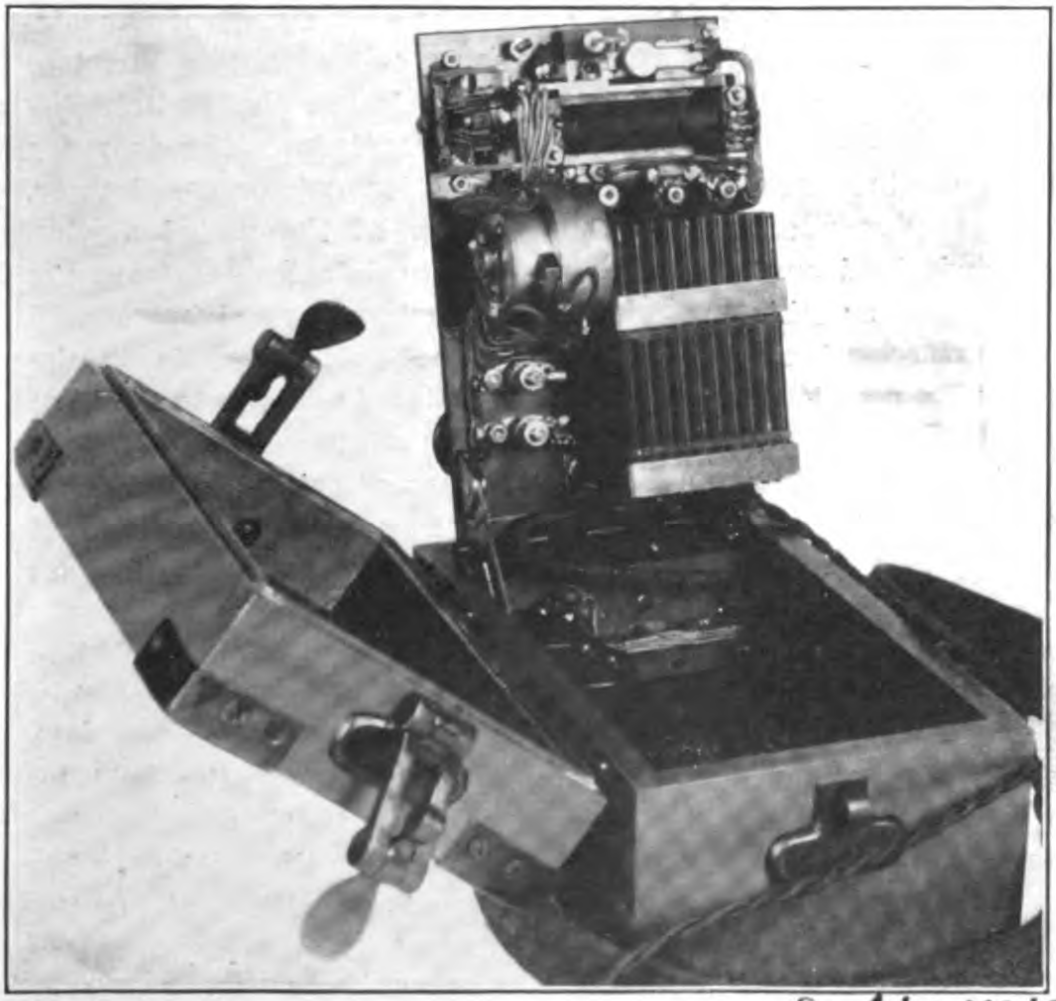

Fig. 5. Howler, Condensers, Switch, Call Buzzer and [redacted] Mounted on Underside of Panel, EE-1 Buzzerphone.

A complete schematic diagram of the buzzerphone circuits is shown in Fig. 1. For simplicity in explaining the circuits for the different positions of the switch key and sending key, this is separated into its elements in Fig. 2 and Fig. 3.

Stations which are to work together are connected by means of a well insulated single wire line, the other side of the sets being grounded, or preferably by means of a complete metallic circuit, if this is available. Two or more sta-

tions may be used on the same line, all stations being bridged between the line and the ground, or between the two lines in the case of a two-wire metallic circuit. When not in use, all stations should have the switch key in the neutral or stand-by position, which gives the simple circuit between line and ground at each station indicated in the left-hand portion of Fig. 2. When an operator desires to call another station, then, he moves his switch key to the call position, pushing it back and forth to give the call signal of the station wanted, or simply to give any call signal if but two stations are connected on the line. When the switch key is in this position, it completes a circuit from the two dry batteries in series, through the induction coil or call buzzer. This produces a tone in the receiver of the called station which is loud enough to be heard several feet away from the station. For this reason, the telephone receiver should never be kept on the ears when the switch key is in the stand-by position and another operator is likely to call, as the call signal would hurt the ear drums.

The circuit in use during the process of calling is indicated at the right of Fig. 2. The alternating current received at the called station, due to the call connection, passes through the secondary of the call buzzer, the condenser C_1 of the filter, and through the telephone receiver to ground. When a station is called, both the calling and called operators immediately place their switch keys in the send-receive position. The called operator then acknowledges the call by operating his sending key and giving an O. K. or repeating his station call signal. The called operator then releases his sending key, which returns to the receive position, giving the circuit shown at the right of Fig. 3, and the sending operator straightens out his key and proceeds to send, the circuit at the left of Fig. 3 then representing that which is in use in his set. The two connections of Fig. 3 are then alternated back and forth in the two stations, as they communicate.

As soon as the switch key is placed in the send-receive position, a local circuit through one dry cell and the howler is established, causing the latter to vibrate continuously. This howler is made up of a transmitter and receiver element enclosed in a rigid case, the two elements having a common diaphragm. The transmitter element has two microphone capsules, one of which is utilized in causing the howler

to vibrate, while the other is used simply for transforming the direct current signals into a high frequency tone current. This howler does not actually interrupt the current, but it serves to change the resistance in the circuit to produce a current varying between certain limits at a frequency of about 500 cycles per second.

When the sending operator closes his sending key, K, Fig. 3, he completes a circuit from the line through the high impedence coils of the filter, through a high resistance coil T, the two batteries in series and the outer transmitter capsule of the howler to ground. The howler transforms the direct current into a pulsating current which makes the signals audible in the receiver at the sending station. These fluctuations in the current, however, are prevented from going out over the line by the filter, the high impedance coils of which prevent any sudden change in the current, and the condensers absorb the changes which occur in the local circuit.

When the direct current dots and dashes are received at the receiving station, they pass through the impedance coils of the filter, through the outer capsule of the howler to the receiver and ground. Since the howler is constantly vibrating, the constant current signals received are transformed into high frequency impulses which can be heard in the receiver. In both the receiving and sending circuits, the secondary of the call buzzer is in series with the line, but it has no particular function ~~except to add desirable resistance in the circuit.~~ The purpose of this coil comes into play in operating the call signal and also when using the hand telephone set, as it then serves as an ordinary telephone transformer. The coil is in reality an ordinary transformer with a buzzer added.

When it is desired to talk over the line and thus more readily transmit unconfidential matter, the connector fastened to the telephone hand set cord is pushed into position in the clip-jack on the face of the panel. Placing the connector in the jack opens a spring switch which normally short circuits the two terminals of the jack to which the receiver of the hand set is connected. With this connector in place and the switch key in the send-receive or stand-by position, telephone conversation may be carried on in the ordinary manner. It must be remembered, however, that any messages sent over the line by telephone are not confidential and are readily picked up by the enemy. If the switch key is in the

send-receive position at the time a telephone conversation is carried on, there is no interference between the telephone and Morse communication. If the switch key is in the stand-by position, the telephone conversation can be heard in the head set or buzzerphone receiver. When the buzzerphone call signal is used, it causes a loud noise in the hand telephone set and interrupts the talking. The reason that there is no interference between the incoming telephone and Morse messages is that the high frequency voice current coming in from the outside line is stopped by the inductance coils, but readily passes through the first condenser C_1 of the filter circuit, Fig. 1, and thence through the telephone hand set receiver to ground. The constant direct current of the Morse signals is obstructed by the condensers, but passes through the inductances of the filter and is subsequently broken up by the howler as explained above. Telephone and Morse currents originating within the set are likewise separated at the filter so that they do not interfere with each other. If the switch key is in the stand-by position, the buzzerphone receiver is in series with the hand set receiver, and hence the voice current may be heard in the buzzerphone receiver, while the switch key is in this position. When the switch key is at send-receive, and the hand set is plugged in, the hand set receiver is in series with the line or ground where the Morse signal current is constant direct current and hence not audible, while the head set receiver is in a local circuit wherein the current is broken up by the howler to make it audible. This can be clearly seen by drawing in a receiver in series with the line between "ground" and the first branch-off above, in the right-hand portion of Fig. 3.

Leaky Lines and Ground Potential

The principal causes of interference in the transmission of signals are likely to be leaky lines and ground potential. The presence of ground potential does not affect the secrecy of signals at all, and is not particularly detrimental as long as the sending signals produce a change in the tone heard in the receiver distinct enough so that the signals can be read. With a badly leaky line and a high ground potential, however, the leakage current may be of such value that if it happens to be opposing the line current, it will be stronger than the latter and the signals will come in reversed and be

impossible to read. The EE-1 buzzerphone is designed to transmit satisfactory signals over a one-wire grounded circuit in the presence of a ground potential at any station of as high as 1 volt with a leak of not less than 50,000 ohms resistance. If a ground potential of 1½ volts is encountered, the line leak must not be less than 100,000 ohms. If the ground potential is but ½ volt, a line leakage as low as 25,000 ohms will not destroy the secrecy and clearness of the signals.

The indication of the presence of a ground potential is a steady tone in the head receiver when the switch key is in the send-receive position and the sending keys of all stations bridged on the line are in the receiving position. If the line is well insulated, this tone will disappear when the sending key is straightened out to open the receiving side-contact, as this cuts the receiver off the exterior circuit. If the tone continues to be heard after the sending key is straightened out, this is an indication that the line is leaky. Ordinarily, if the line leak is not too great, even if the tone does continue after straightening out the sending key, it will be sufficiently reduced ~~by the signal current~~ to make the signals readily distinguishable. In the absence of appreciable ground potential, satisfactory signals can be obtained over a line with a leak to ground as low as 100 ohms. No adjustment of the set is necessary to compensate for ground potential conditions.

On a well insulated line, satisfactory signals can be obtained through a resistance as high as ~~100,000~~ ohms and against ground potentials of any value either steady or varying. In the absence of appreciable ground potential, several stations may receive code signals simultaneously, by having them bridged between the line and the ground, or between the two wires if a two-wire metallic circuit is used. However, each set ~~in the receiving position~~ introduces a leak from line to ground of about 4000 ohms, and hence in the presence of ground potential of any particular moment, not more than one set on a line should be ~~in the~~ receiving ~~position~~ at a time. For this reason, when considerable ground potential is known to exist, operators should be careful to move the switch key to the send-receive position momentarily, before attempting to use the line for code. If the line is already in use for Morse purposes, the operator should switch back immediately to stand-by in order to avoid having the additional 4000 ohm

leak to ground and possibly so weaken the signals being sent as to make their clear reception impossible.

Grounding Buzzerphone Lines

The best operation of the buzzerphone will be obtained when the ground has the lowest obtainable resistance. The better the ground, the greater the line leakage and ground potential which can be encountered and still get through satisfactory signals. The grounds at all stations on a line should be made of the same material; that is, they should all be galvanized iron grounds, black iron grounds, or other good grounds, but there should not be a combination of the different types on a single line. Two grounds of different materials produce a ground potential between them which is very undesirable and unnecessary. Under ordinary conditions of moderate line leakage, a black iron ground rod will give the lowest ground potential, or the lowest steady tone in the receiver. Under varying conditions of line leakage, however, galvanized iron ground rods will generally give readable signals through worse conditions of ground potential and poor insulation than other types of grounds. The type of ground rods furnished with a set are the Signal Corps type D rods (S. C. Manual No. 3, page 353). These rods are 9 in. long x ¼ in. thick and are hexagonal in shape. They are pointed at one end and bent into a circular handle at the other. A machine screw on the top of the handle is provided for connecting on the ground wire leading to the set.

It is undesirable to use a ground rod for the buzzerphone which is at the same time in use for any other purpose, as interference of signals will probably result. In ordinary soils, it will generally be sufficient to separate grounds for different purposes by 20 ft. or more. This, of course, does not apply in the case of a good ground of negligible resistance such as a water pipe or gaspipe system which may be used as a common ground for many purposes.

and resistance of grounds

Testing and Precautions

The normal Morse signal current on a buzzerphone line is about 60 microamp., this varying slightly with ground potential conditions. This current is greater than is necessary to give good signals over a perfectly insulated line, but is necessary in order that readable signals may be received

under the conditions of line leakage and ground potential which frequently prevail.

The telephone hand set which forms a part of the buzzerphone provides a convenient means of testing out the buzzerphone. If tone signals or clicks at the beginning and end of dots and dashes are heard in the hand set during Morse operation, these are due to defects in either the sending or receiving circuits of the set and they should be cleared before further operation. The set should never be used for confidential communication when either the tone signals or clicks are audible in the hand set since under these conditions the signals are readily overheard by induction or ground leakage methods. When this trouble is experienced, the set should be replaced. It is desirable to make a test of this character once a day, to ascertain if the condensers and inductance coils in the filter are all right.

In case there is no hand set with the buzzerphone, the set may be similarly tested by operating the sending key on one station and listening in at the other station while the key at the latter is in the stand-by position, to see if any clicks or tone can be heard. The reverse test is then made, the other station sending while the first station listens with the switch key in the stand-by position. If the buzzerphone is operating properly, there should be no tone or click heard in the buzzerphone receiver when the switch key is in the stand-by position.

Tone signals heard in the head receiver when there is no operator sending from another station, will probably be due to leakage either through the line or through the ground from another buzzerphone or telegraph line in the vicinity. Such signals due to ground leakage will not occur except where the ground rods of the two lines are very close together.

It must be remembered that telephone conversations and calling by means of the switch key are readily overheard at considerable distances by inductive or ground leakage methods, and that the telephone hand set should therefore never be used for transmitting any information of the least confidential nature. The Morse signals should always be used for any message which would be of slightest value to the enemy as these can be picked up only from ground connections within a few feet of the buzzerphone ground or by actually tapping the buzzerphone line. Even tapping the line will not

disclose the signals, except with the help of the very most efficient detecting apparatus.

Operators should not touch or rest their hands or clothing on the terminals of the set at any time, either when sending or receiving or when the set is at stand-by, as this may make the tone signals audible on the line or produce a leak from line to ground which would confuse signals at other stations on the line.

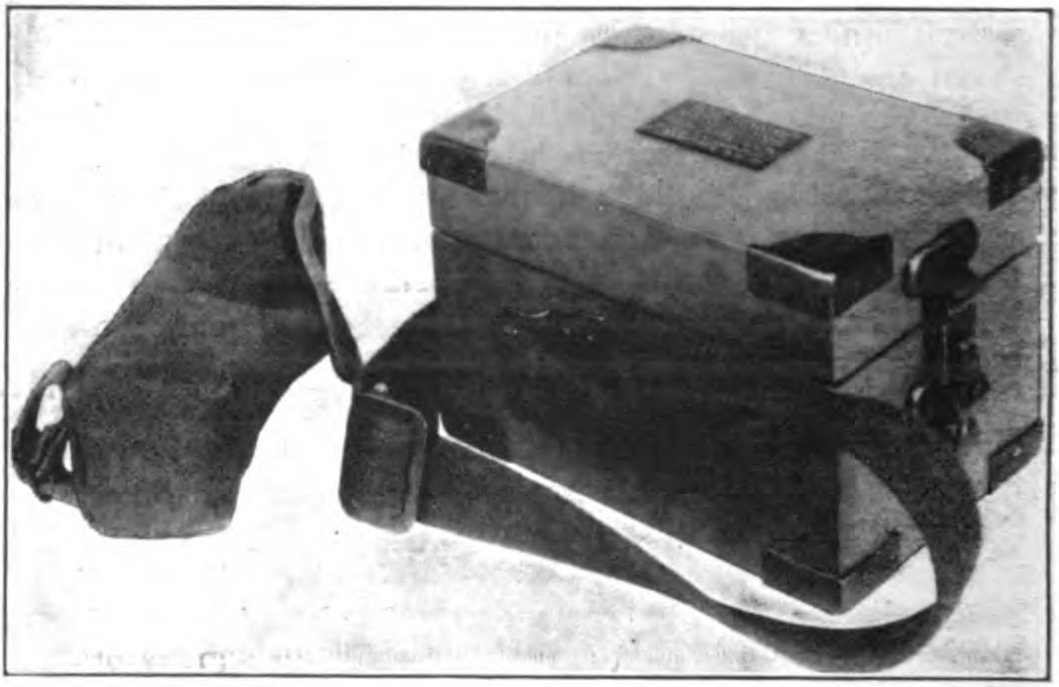

Fig. 6. Buzzerphone Case Closed and Telephone Hand Set in Canvas Case at Left.

When not sending or receiving, the switch key should always be kept at the stand-by position as the set otherwise forms a low resistance leak from line to ground, and also, because any other position makes it impossible for that station to be called.

The line and ground should always be connected to the proper terminals as indicated at the terminals in order to secure the most satisfactory signals under all conditions of ground potential and line leakage. The connections in the set are so chosen as to maintain the line at positive potential to ground, and also in such a manner that the more common ground potentials encountered add their potential to the emf. of the signals, rather than oppose it. This indicates the importance of proper connections.

If the howler fails to operate upon moving the switch key to the send-receive position, it will generally be found that the trouble is at the battery. No attempt should be made to adjust the microphones since the manufacturer's adjustment is not easily disturbed and it is difficult to make adjustment in the field. If the howler is found to be defective, it should be replaced.

Specific Details of Operation

1. Connect the line to the binding post marked "Line." Install the ground and make connections from it to the binding post marked "Ground."

2. Move the switch key to the "Send-Receive" position and listen in the head set to ascertain if the line is already in use for Morse signals. If so, push back to "Stand-By" and wait a short time before listening in again. Repeat until the line is found clear.

3. Move the switch key to "Call", giving just a buzz or two if but one other station is connected on the line, or the proper predetermined signal to call the station wanted if several are bridged on the same line.

4. Move the switch key to "Send-Receive" immediately and listen in the head set for acknowledgment in Morse signals, this being given in a repetition of the call signals of the station called. If no acknowledgment is received, repeat the call.

5. When acknowledgment is received, straighten out the key by moving the handle to the left and proceed to send the desired signals.

6. When finished sending, take the hand off the sending key which will then spring back to close the side or receiving contact, when the set is again ready for receiving any return message.

7. A set not in use should always have the switch key at "Stand-By." When in this position, if your station is called, move the switch key to "Send-Receive," straighten out the sending key and acknowledge the call. Then let go of the sending key and listen.

8. To break in while receiving signals, if they are not understood or if it is more urgent to send signals than to receive the ones being transmitted, move the sending key to the left to open the receiving contact. This will interrupt the incom-

ing signals and on any but a very poor line will so far reduce the tone of the signals in the sending station that the operator there will know the circuit has been opened and will stop sending.

9. The sending operator, in such a case, should immediately release his sending key and listen for signals. If none are received and the conditions prevail for sometime, it is a fair indication that the line has been cut by a shell at some point, or that the receiving operator has been forced to remove his set to another position.

10. When working on a leaky line and it is desired to break in, the change in tone in the sending set upon opening the receiving contact on the receiving set may not be great enough so that the sending operator will notice the reduction. In this case the receiving operator may interrupt by using the call signal. ~~This should never be done unless absolutely necessary, for the call signal will be very unpleasant on the ears of the operator having the head set in place to send Morse.~~