May 31, 1932. E. DIETZE 1,860,455

LINEMAN'S TEST SET

Filed Sept. 2, 1931

FIG. 1

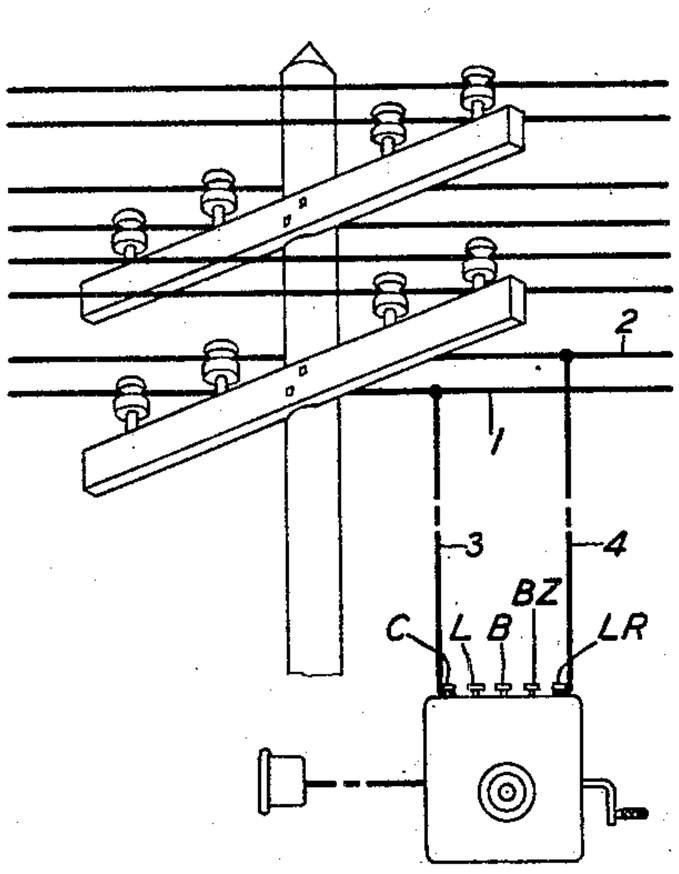


FIG. 3

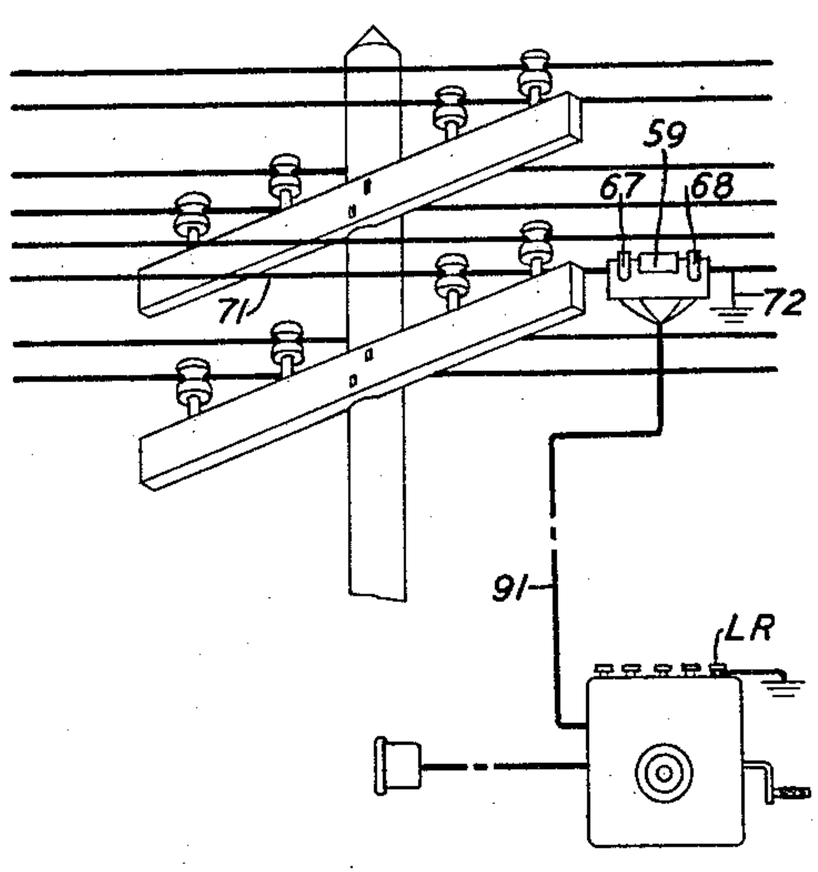
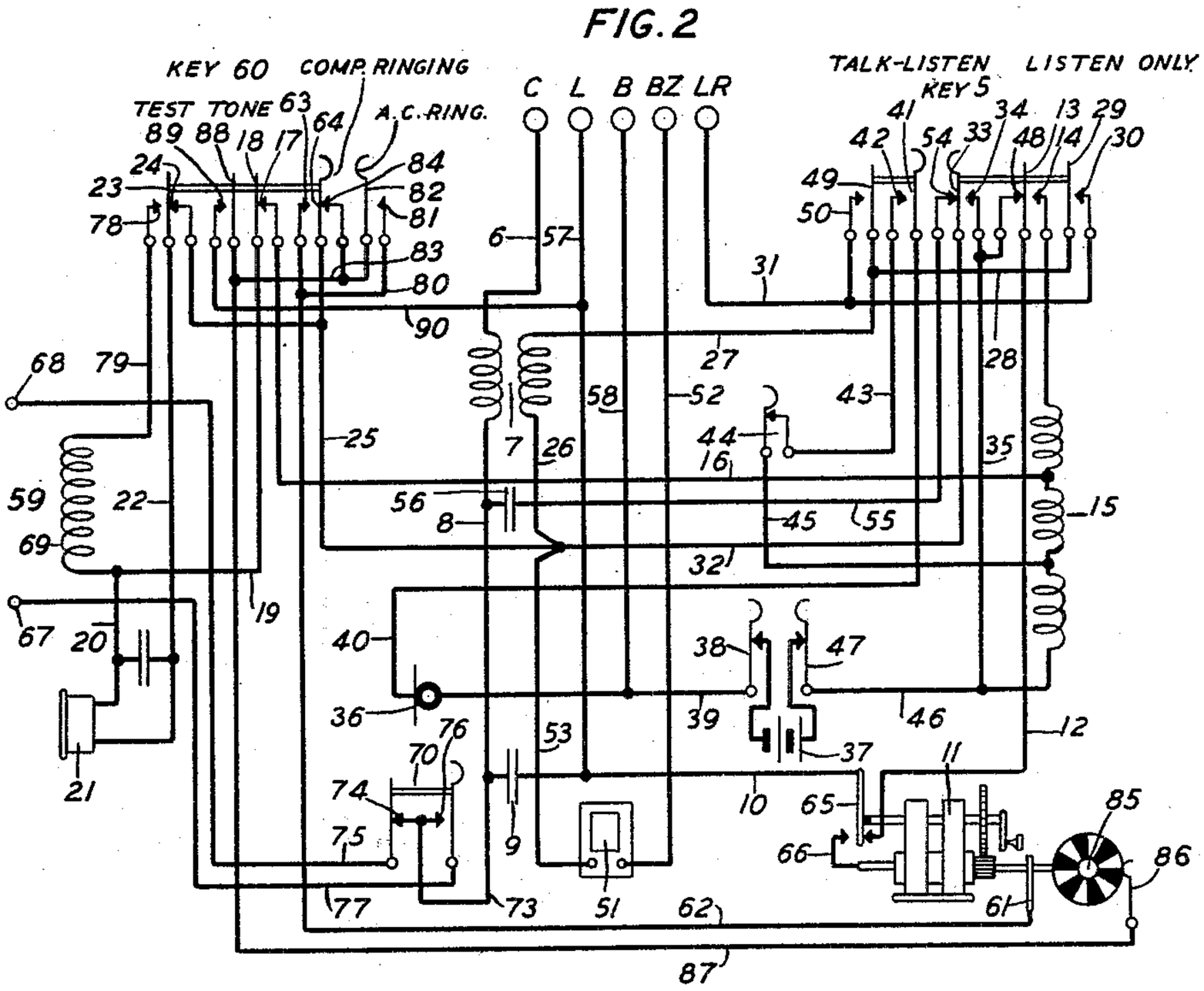


FIG. 2



INVENTOR
E. DIETZE
BY
ATTORNEY

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UNITED STATES PATENT OFFICE

EGINHARD DIETZE, OF WESTFIELD, NEW JERSEY, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK

LINEMAN'S TEST SET

Application filed September 2, 1931. Serial No. 560,853.

This invention relates to test sets and more particularly to a lineman's test set which may be attached to open-wire lines to make tests of the conditions existing therein and the location of faults in the line.

The object of this invention is to provide a test set which may be used in making tests on transmission lines, particularly telephone and telegraph lines, and including lines used in connection with carrier and repeater systems.

A feature of this invention resides in the inclusion in a test set of this kind, of a filter which makes possible the use of this test set in connection with carrier lines.

Another feature resides in the design of the inductance coil which makes the test set adaptable for use in connection with repeater circuits.

It is common practice now when a telephone or telegraph line becomes broken, short-circuited, grounded or some other unstandard condition occurs, for a lineman to be sent out from a central station to make tests of the line to locate and rectify the fault.

The lineman carries a telephone set which he can connect to the transmission line to determine the character and location of the fault.

The test set carried by the lineman is also provided with facilities for connecting the set to transmission lines in which there is no faulty condition existing so that the lineman may communicate with and receive instructions from the wire chief at the central office.

In standard lineman's test sets heretofore used the connecting of the set with lines over which messages were being transmitted by means of carrier currents would cause unbalance of the repeaters, cross-talk between carrier channels, interference with carrier channels and interference with the transmission of the messages thereover. The lineman's set, being of comparatively low impedance to the high frequency carrier currents, would have a tendency to short-circuit the lines and interfere with the transmission of messages. The connecting of the set to the transmission lines would reduce the impedance of the lines on the side of the repeater where the test set was connected. Carrier current passing into the set and out to the line again would be modulated by the iron in the set thus causing cross-talk between the carrier channels. If the lineman tried to converse with the wire chief over a carrier line the voice currents from the lineman's set containing components within the carrier range would be superimposed on the carrier current. Due care therefore had to be exercised by the lineman in connecting his portable set with a line for the purpose of establishing communication between his set and the central office that a carrier line was not selected. If a lineman should happen to connect his set with a busy carrier line it would cause unbalance of the repeaters and cross-talk between the lines.

Test sets heretofore used were also of such low impedance that connection of the set into a system including repeaters would unbalance the repeaters and cause a transmission loss sufficient to cause interference with the transmission of messages.

In the present invention in which a filter has been included in the lineman's test set and the impedance of the set has been increased by the employment of a comparatively high impedance ratio in the induction coil, the test set may be connected to any transmission line in the system without causing unbalance of the repeaters and cross-talk between the different channels in the case of a carrier line and communication may be had by the lineman with the central office even though the carrier channel is in use without interference with the carrier conversation. The only restrictions in the use of a line by the lineman for the purpose of carrying on

a conversation are that the line connected with must be in its standard condition and that the voice channel of such line is not being used.

Carrier currents employed in the transmission of telephone messages are usually at a frequency above 2000 cycles. The filter in the test set of the present invention therefore should be designed to cut off at about 2000 cycles to enable a lineman and a wire chief to converse over a channel below the carrier. It is to be understood, therefore, that the filter included in the test set will cut off at a frequency below that of any of the carrier currents employed in the transmission system with which the set is to be used.

In the drawings,

Figure 1 represents a plurality of open-wire lines mounted on a pole and a lineman's test set connected to a pair of line wires over which communication may be had with the central office;

Fig. 2 is a schematic of the test set of the present invention; and

Fig. 3 represents the test set employed as a fault locating device to locate a ground on a line and connected by an exploring coil with a line wire which has become grounded.

The test set when used by a lineman to communicate with the wire chief may be connected as shown in Fig. 1 to the line wires 1 and 2 through the binding posts C and LR of the set by means of a suitable connecting device commonly used for the purpose, not shown in detail in this drawing but indicated so that a complete circuit may be traced through the line wires and the test set as comprising conductors 3 and 4. When the test set has been connected to the transmission lines 1 and 2, the lineman operates the key 5 to the listen-only position which, as illustrated in Fig. 2 is in a right-hand direction. A circuit for listening which may be traced through the schematic Fig. 2 in conjunction with Fig. 1 is thereupon established from the line wires through the set as follows: line wire 1, conductor 3, binding post C, conductor 6, left-hand winding of retardation coil 7, conductor 8, condenser 9, conductor 10, normal contacts of generator 11, conductor 12, spring contact 13, contact 14, the upper winding of induction coil 15, conductor 16, contact 17, spring contact 18, conductor 19, conductor 20, receiver 21, conductor 22, spring contact 23, contact 24, conductor 25, conductor 26, right-hand winding of retardation coil 7, conductor 27, conductor 28, spring contact 29, contact 30, conductor 31, binding post LR, conductor 4, to line wire 2. A shunt including the other two windings of the induction coil is also included in this circuit as follows: from conductor 25 to conductor 32, spring contact 33, contact 34, conductor 35, the lower and middle windings of induction coil 15 to conductor 16.

If the lineman wants to talk to the wire chief, key 5 is moved to the talk and listen position which, as shown in the schematic Fig. 2, is in a left-hand direction. This operation of the key 5 will cut in the transmitter 36 of the lineman's set establishing a local circuit for the transmitter as follows: negative terminal of local battery 37, battery clip 38, conductor 39, transmitter 36, conductor 40, spring contact 41, contact 42, conductor 43, receiver switch 44, conductor 45, the primary winding of induction coil 15, conductor 46, battery clip 47, to the positive terminal of local battery 37.

The talking and listening circuits of the set when the key 5 is in the talk-listen position may be traced as follows: line wire 1, conductor 3 to the C binding post, conductor 6, left-hand winding of retardation coil 7, conductor 8, condenser 9, conductor 10, normal contacts of generator 11, conductor 12, spring contact 13, contact 48, conductor 35, the primary and secondary windings of induction coil 15, conductor 16, contact 17, spring contact 18, conductor 19, conductor 20, receiver 21, conductor 22, spring contact 23, contact 24, conductor 25, conductor 26, right-hand winding of retardation coil 7, conductor 27, spring contact 49, contact 50, conductor 31 to LR binding post, conductor 4, to line wire 2. The local circuit for the transmitter 36 is closed by the operation of key 5 as above described and is operative with this talk-listen circuit.

A buzzer 51 is provided in the lineman's test set so that the lineman may be signaled by the wire chief. When the lineman wishes to place his test set in condition so that the buzzer 51 may be operated from the central office, he connects the conductor 3 leading from the line wire 1 to the binding post BZ and moves the key 5 to the listen-only position. This connection puts the buzzer 51 in circuit with the line as follows: line wire 1, conductor 3, to the binding post BZ, conductor 52, buzzer 51, conductor 53, conductor 26, right-hand winding of retardation coil 7, conductor 27, conductor 28, spring contact 29, contact 30, conductor 31, binding post LR, conductor 4, to line wire 2. With the circuit established as above described, the wire chief may cause operation of the buzzer 51 in the lineman's test set to indicate to the lineman that the wire chief wishes to converse with him. On operation of the buzzer 51, the lineman will change the line connection from the binding post BZ to either binding post C or binding post L, leave the key 5 in the listen-only position or move the key 5 to the talk-listen position, and receive whatever instructions the wire chief wishes to transmit to him.

Should the lineman be working in a system in which no carrier lines and no repeaters

are used, he may be in order to reduce the impedance in the set, use the binding post L in place of the binding post C for connecting to the line wire 1. By connecting to the line wires in this manner, the left-hand winding of the retardation coil 7 and the condenser 9 are eliminated. Assuming that the binding post L is employed in place of the binding post C and that the key 5 has been moved to talk-listen position, the communication circuit would be as follows: In from the line wire 1 to binding post L, conductor 57, conductor 10, normal contacts of generator 11, conductor 12, spring contact 13, contact 48, conductor 35, the primary and secondary windings of induction coil 15, conductor 16, contact 17, spring contact 18, conductor 19, conductor 20, receiver 21, conductor 22, spring contact 23, contact 24, conductor 25, conductor 26, right-hand winding of retardation coil 7, conductor 27, spring contact 49, contact 50, conductor 31, to the binding post LR, conductor 4, out to the line wire 2. The movement of the key 5 to talk-listen position also completes the local circuit for the transmitter 36.

The binding post B is provided so that the set may be used in making D. C. continuity tests. In making such tests the binding post B and binding post LR of the set are employed and the key 5 is moved to the listen only position. Assuming that such a test is to be made in a metallic system the binding post B of the set is connected to one of a pair of line wires and the binding post LR of the set is connected to the other line wire of the pair. The following circuit is thereupon completed through the set. In from the line wire 1, conductor 3, binding post B, conductor 58, conductor 39, battery clip 38, battery 37, battery clip 47, conductor 46, the primary and secondary windings of induction coil 15, conductor 16, contact 17, spring contact 18, conductor 19, conductor 20, receiver 21, conductor 22, spring contact 23, contact 24, conductor 25, conductor 26, right-hand winding of retardation coil 7, conductor 27, conductor 28, spring contact 29, contact 30, conductor 31, binding post LR, conductor 4 to line wire 2. Upon completion of this circuit the receiver in the test set will produce a click if the line is in normal condition. If a D. C. continuity test is to be made on a single wire or ground system the same binding posts of the set are used, one of the binding posts being connected to the line to be tested and the other binding post connected to ground.

A generator 11 is provided in the lineman's set for ringing through the line to a central station and also for making tests through an exploring coil 59 as will be later explained.

When the lineman is working on a line in a local battery system and wishes to communicate with the central office, he connects the binding post L and binding post LR of the test set to a pair of the line wires. He then operates the key 60 to the right or AC ring position and the key 5 to the listen only position. By operating the generator 11 he then generates an A. C. ringing current over a circuit as follows: contact 61 of the generator 11, conductor 62, conductor 80, contact 81, spring contact 82, conductor 83, contact 84, spring contact 64, conductor 25, conductor 26, right-hand winding of retardation coil 7, conductor 27, conductor 28, spring contact 29, contact 30, conductor 31, to binding post LR, conductor 4 and then out to the line, in from the line through conductor 3, to binding post L, conductor 57, conductor 10, spring contact 65, contact 66, to the opposite side of the coil of generator 11.

For composite ringing over the line the key 60 is set in the position shown in Fig. 2 and the set is connected to the line wires through the binding posts C and LR. A ringing circuit through the commutator 85 and brush 86, of the generator 11 is then as follows: line wire 1, conductor 3, binding post C, conductor 6, left-hand winding of retardation coil 7, conductor 8, condenser 9, conductor 10, spring contact 65 of generator 11, contact 66, commutator 85, brush 86, conductor 87, conductor 83, contact 84, spring contact 64, conductor 25, conductor 26, right-hand winding of retardation coil 7, conductor 27, conductor 28, spring contact 29, contact 30, conductor 31, binding post LR, conductor 4 to line wire 2.

In addition to using the set for communicating with the central office, the lineman uses it for testing a line and locating faults therein. The test set is equipped with an exploring coil 59 which may be connected to a line through the terminals 67 and 68 so that a pick-up coil 69 is inductively associated with the line wire. A switch 70 is also provided in the test set so that currents from the generator 11 may be made to enter a line wire at different points relative to the pick-up coil 69 to determine the direction of a fault in the line wire relative to the exploring coil 59.

The exploring coil 59 is of the type disclosed in O. A. Shann Patent 1,724,973 and is used in the same manner as described therein; for instance, when a test is to be made for a ground on a line wire, the exploring coil 59 is connected by means of a cable 91 to the line wire 71 as shown in Fig. 3 at the points 67 and 68 and the pick-up coil 69 is inductively associated with the line wire 71. The test set is then connected to ground through the binding post LR, usually by means of a ground connecting device carried by the lineman. The switch 70 is then thrown to the right as shown in Fig. 2. The key 60 is moved to the left and the key 5 is thrown to the listen only position. The lineman while listening with the receiver 21, op-

erates the generator 11 to put current over the line wire 71. Assuming that the ground on the line wire 71 is to the right of the exploring coil 59 and the connection 68 as shown at 72 in Fig. 3, current from the generator 11 will flow through conductor 10, condenser 9, conductor 73, left-hand contact 74 of switch 70, conductor 75, contact 68 through line wire 71 to ground at 72 and no tone will be produced in the receiver 21. This will indicate to the lineman that the ground on the line wire 71 is in the direction to the right of the exploring coil 59. To make certain of this fact, however, the lineman will throw the switch 70 to the left and operate the generator 11 again. Current from the generator 11 will then flow through conductor 73, contact 76 of switch 70, conductor 77 and enter the line wire 71 at 67 to the left of the pick-up coil 69 and travel in a right-hand direction to the grounded point 72 in the line wire 71. Current will then be induced in the pick-up coil 69 to operate the receiver 21. A tone will then be produced by the receiver 21 which will indicate to the lineman that the current from the generator 11 is passing in a right-hand direction from the connection 67 and hence to the right of the exploring coil 59 and that the ground on the line wire 71 is in that direction. Assuming that the switch 70 is thrown to the right, as shown in Fig. 2 the circuit including the generator 11 and the line wire 71 under test is as follows: grounded binding post LR, conductor 31, contact 30, spring contact 29, conductor 28, conductor 27, right-hand winding of retardation coil 7, conductor 26, conductor 25, spring contact 64, contact 63, conductor 62, contact 61, through the coil of the generator 11, contact 66, spring contact 65, conductor 10, condenser 9, conductor 73, operated contact 74 of switch 70, conductor 75, contact 68 to the line wire 71 under test to ground 72. With the switch 70 thrown to the left, the circuit including the generator 11 and the line 71 under test will be the same as above described with the exception that instead of the current from the generator 11 passing over the conductor 75 from switch 70 through the contact 68 and the line wire 71, current will pass through contact 76, of switch 70, conductor 77, to contact 67 on the left-hand side of the pick-up coil 69 to the line under test and to ground. In making such tests the movement of key 60 to the left closes a shunt path across the generator 11 from contact 61 through the commutator 85, brush 86, conductor 87, spring contact 88, contact 89, conductor 90, conductor 57, conductor 10, spring contact 65, contact 66 to the other side of generator 11.

When the receiver 21 is to be used in connection with the exploring coil 59 for making tests, the inductive circuit including the pick-up coil 69 and receiver 21 is closed by moving the key 60 to the left. This circuit is as follows: contact 78, conductor 79, through the pick-up coil 69, conductor 20, receiver 21, conductor 22, spring contact 23 which is closed against contact 78.

When the test set is connected through the binding post C and binding post LR to a pair of line wires on which carrier currents are being used in the transmission of messages, the filter comprising the coils 7 and the condenser 56 offers a sufficiently high impedance to the comparatively high frequency carrier currents to prevent unbalance of the system by the set. The lineman, however, may converse with the wire chief over a channel below that of the carrier.

By increasing the impedance ratio of the induction coil in the set especially for the listen-only condition so that the total impedance of the set is sufficient substantially to prevent the entrance into the set of current from a system in which repeaters are employed, connection of the set to a system including repeaters may be accomplished without causing unbalance of the system. The induction coil 15, therefore, included in this test set is of such high impedance as to raise the total impedance of the set to an extent to prevent unbalance of the system including repeaters.

With the impedance of the test set raised by designing the induction coil of sufficiently high impedance coil to prevent unbalance of a system employing repeaters and the inclusion of the filter which will prevent unbalance of the repeaters, cross-talk between the channels and interference with the carrier channels on lines over which carrier currents are being used in the transmission of messages, the test set may be connected to any transmission line and communication had between the lineman and the wire chief at the central office.

To further disclose this invention and show the effect of bridging the lineman's test set equipped with the filter as described, across a carrier line the following mathematical formulæ are presented which show how the modulated current in the carrier line produced by the connection of the test set to this line, is reduced by the filter.

Assuming that the set is connected to a pair of line wires through the binding posts C and LR as shown in Fig. 1 and that the line wires are carrier lines. Then let,

Z_O = Characteristic impedance of filter

Z_A = Impedance of filter terminated in

$$\frac{Z_L}{2}$$

Z_B = Impedance of filter terminated in Z_S

α = Attenuation of filter

Z_L = Impedance of line

Z_S = Impedance of test set

μ = Voltage amplification factor of test set acting as a modulator
E = Voltage generated in the carrier line
Current delivered into filter:

$$I_1 = \frac{E}{Z_L + 2Z_O}$$

(assuming filter terminated in Z_0)
Current delivered into test set:

$$I_2 = \frac{E\epsilon^{-\alpha}}{Z_L + 2Z_O} \quad \frac{Z_A + Z_O}{Z_A + Z_S}$$

Voltage applied across test set:

$$E_O = \frac{E\epsilon^{-\alpha}(Z_A + Z_O)Z_S}{(Z_L + 2Z_O) \quad (Z_A + Z_S)}$$

Modulated voltage generated by test set:

$$E' = \mu E_O$$

Modulated current into filter: (assuming filter terminated in Z_0)

$$I_1 = \frac{E'}{Z_{S'} + Z_{O'}}$$

Modulated current in line with filter in test set:

$$I_{2'} = \frac{E'^{-\alpha}}{(Z_{S'} + Z_{O'})} \quad \frac{Z_{B'} + Z_{O'}}{(2Z_{B'} + Z_{L'})} =$$

$$\frac{\mu E\epsilon^{-2\alpha}(ZA + ZO) \quad ZS \quad (Z'B + Z'O)}{(Z_L + 2Z_O) \quad (Z_A + Z_S) \quad (Z_{S'} + Z_{O'}) \quad (2Z_{B'} + Z_{L'})}$$

Impedances marked "'" apply at frequency of modulated current.

In a similar way, the modulated current in the line without the filter in the test set:

$$I_{3'} = \frac{\mu E Z_S}{(Z_L + 2Z_S) \quad (Z_{L'} + 2Z_{S'})}$$

The ratio

$$\frac{I_{2'}}{I_{3'}} = \frac{(Z_A + Z_O) \quad (Z_L + 2Z_S) \quad (Z_{B'} + Z_{O'})}{(Z_A + Z_S) \quad (Z_L + 2Z_O) \quad (Z_{S'} + Z_{O'})} \quad \frac{(Z_{L'} + 2Z_{S'})}{(Z_{L'} + 2Z_{B'})} \epsilon - 2\alpha$$

gives the reduction due to the filter in the modulated current produced by the test set. When at all frequencies $Z_O = Z_S$ it is also $Z_B = Z_S$ and this ratio

$$\frac{I_{2'}}{I_{3'}} = \epsilon - 2\alpha.$$

The filter in addition should be designed to present a high impedance when viewed from the line so as to prevent transmission loss or unbalance of the repeaters. The condition that $Z_O = Z_S$, therefore may not represent the best design of the filter, and it may be necessary to have $Z_O > Z_S$. In that case the general formulæ given above instead of the simple expression $\epsilon - 2\alpha$, has to be used in computing the reduction in the modulated current by the filter.

What is claimed is:

1. A lineman's telephone set to be connected to lines in a signaling system in which carrier currents are employed in the transmission of signals, said telephone set including a filter to prevent cross-talk between the carrier channels and interference with the carrier conversation by the telephone set.

2. A lineman's telephone set to be connected to transmission lines in a signaling system in which repeaters are employed in the transmission of signals, said telephone set including an induction coil which prevents unbalance of the repeaters and prevents a transmission loss sufficient to interfere with the transmission of messages.

3. A lineman's test set including means for connecting the test set to a line wire of a signaling system for testing the condition of the line wire, means for sending test currents over the line wire, means for connecting the test set to other line wires of a signaling system so that communication may be had between a lineman and an attendant at the central office and a filter in the test set to prevent cross-talk between carrier channels and interference with carrier conversations should the lineman connect the set to the line wires of a carrier system.

4. A lineman's test set including an exploring coil for connecting to a line wire of a signaling system to test the condition of the line wire, means for sending a test current over the line wire, means for connecting the set to other line wires of a signaling system so that a lineman may use the set for communication with a wire chief at a central office, and a filter in the test set designed to prevent modulation of carrier currents by the iron in the test set to prevent cross-talk between carrier channels should the lineman connect the set to the line wires of a carrier system.

5. A lineman's test set including an exploring coil for connecting to a line wire of a signaling system to test the condition of the line wire, means for sending a test current over the line wire, means for connecting the set to other line wires of the signaling system so that a lineman may use the set for communication with the wire chief at the central office and a filter in the test set designed to cut off at about 2000 cycles to prevent interference by the set with a carrier system when the lineman connects the set to such a system.

6. A lineman's test set including means for determining and locating a fault in the transmission line, means for communicating over other transmission lines including carrier lines with the wire chief at a central office and a filter presenting a high impedance to carrier currents to prevent attenuation of carrier currents by the test set.

7. A lineman's test set for locating unstandard conditions in transmission lines and

for communicating over other lines with the central office comprising means for connecting the test set to a line for testing, means for connecting the set to other lines for communicating with the central office, means for receiving and sending test pulsations over the test line and a filter to prevent unbalance by the test set of the repeaters on the line used for communication.

8. A lineman's test set including means for connecting the test set to a line wire of a signaling system for testing the condition of the line wire, means for connecting the test set to other line wires of a signaling system so that communication may be had between the lineman and an attendant at the central office and a filter in the test set designed to cut off at about 2000 cycles to prevent any current from the lineman's transmitter having components in the range of a carrier from reaching the line to avoid the lineman's conversation interfering with the carrier conversation should the lineman connect the set to the line wires of a carrier system.

9. A lineman's test set including means for connecting the test set to a line wire of a signaling system for testing the condition of the line wire, means for connecting the test set to other line wires of a signaling system so that communication may be had between the lineman and an attendant at the central office and a filter in the test set designed to cut off at about 2000 cycles to prevent any currents from the lineman's transmitter having components above 2000 cycles from reaching the line to prevent the lineman's conversation interfering with the carrier conversation should the lineman connect the set to the line wires of a carrier system.

In testimony whereof I have signed my name to this specification this 31st day of August, 1931.

EGINHARD DIETZE.