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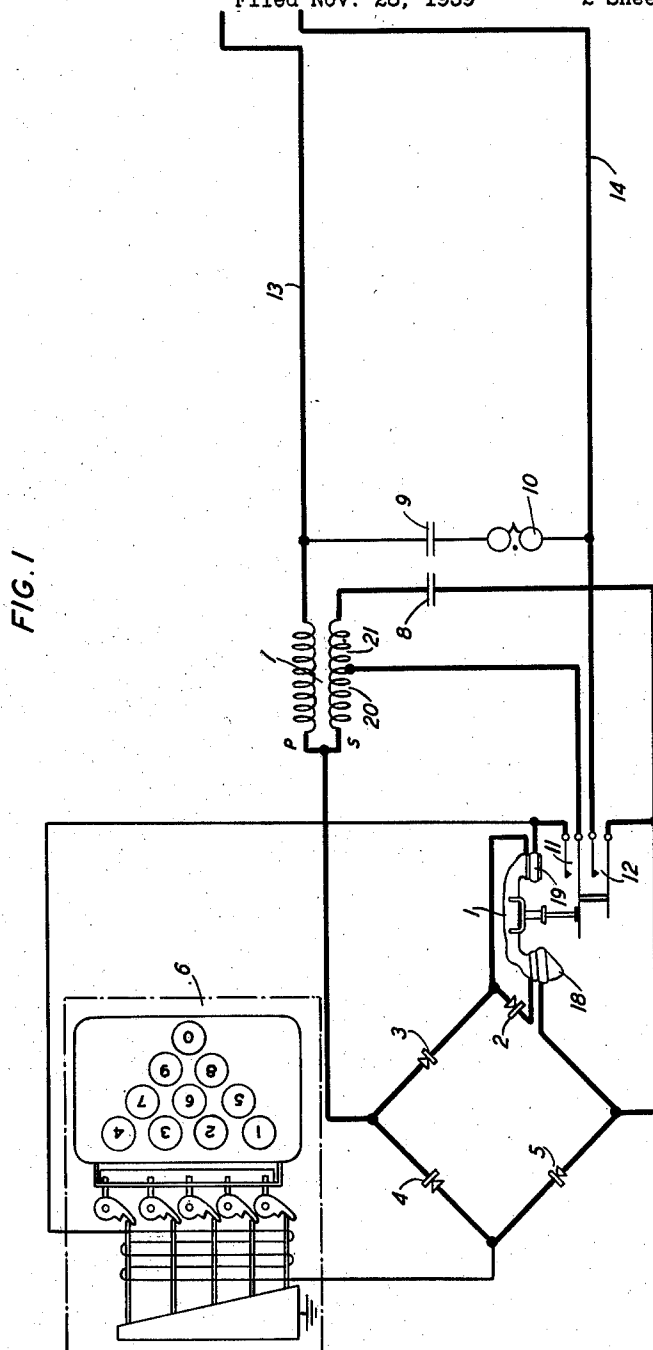
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2,232,398

TELEPHONE SUBSTATION CIRCUIT

Filed Nov. 28, 1939

2 Sheets-Sheet 1



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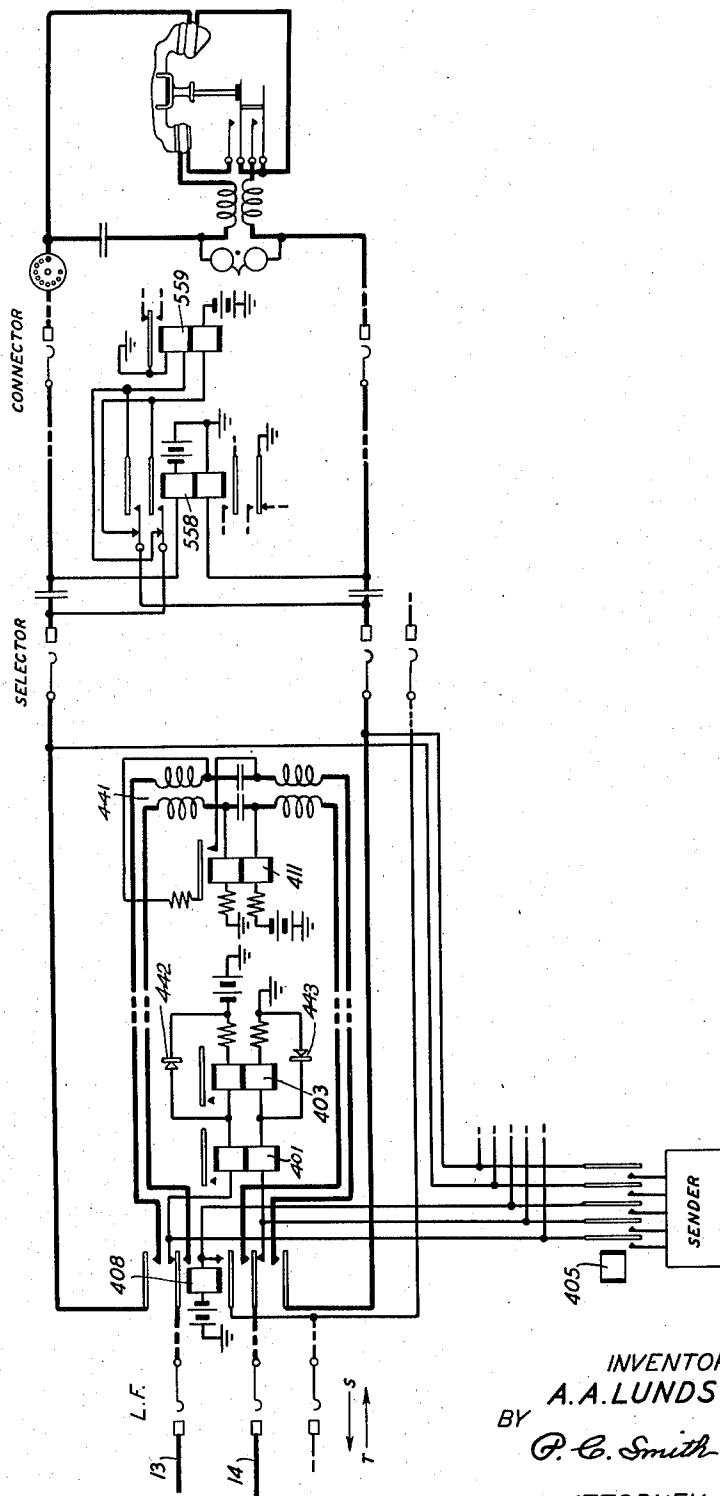
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FIG. 2



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TELEPHONE SUBSTATION CIRCUIT

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Application November 28, 1939, Serial No. 306,467

10 Claims. (Cl. 179—90)

This invention relates to telephone systems and more particularly to a subscriber's substation circuit for a system which is adapted for controlling the establishment of automatic connections between stations in response to alternating current signals transmitted from a calling station which are indicative of the number of a wanted station. In such systems it is often preferable, though not absolutely necessary, that the frequencies of the alternating current signals comprising the designation of the wanted number be within the voice frequency range and when currents within such a range are generated at the calling station for transmission over the line to control apparatus at the central office, care must be exercised to avoid the production of other currents within the range at the time when the signal frequencies are transmitted inasmuch as the responsive apparatus at the central office, though highly selective to the signal frequencies themselves, will, of course, falsely respond to the other currents if they have frequency components of the signal frequencies to which such apparatus is designed to respond.

Such unwanted frequencies are usually produced by mechanical shock to or by noises present in the vicinity of the transmitter and receiver which are in the line circuit at the time the signal frequencies are being produced and transmitted. These frequencies are then superimposed upon or dispersed between said signal currents, thereby giving rise, in the central office, to the false operation of the channel or channels which thus respond to the currents produced by the noises or mechanical shock.

It is the object of the present invention to reduce the production of unwanted frequencies, by noises or mechanical shock that may actuate the transmitter or receiver, by a design of the substation circuit in which the transmitter and receiver are made practically unresponsive to noises or shocks impinging upon them during the time that the signal frequencies are being produced and transmitted, and rendered completely responsive to speech modulations by the time the connection is established and the two subscribers are ready to converse.

This and other objects of the invention may be ascertained from a consideration of the following description, appended claims and attached drawings in which:

Fig. 1 shows, schematically, a subscriber's substation circuit comprising a hand instrument, a rectifier bridge consisting of copper-oxide rectifiers poled as indicated, a reed generator for the

production of desired signal currents, an induction coil, condensers and ringer; and

Fig. 2 shows as much of the central office equipment as is necessary for an understanding of the invention.

For the purpose of illustrating the operation of the invention the same is disclosed in conjunction with the telephone system disclosed in my copending application Serial No. 306,466, filed Nov. 28, 1939, in which automatic connections are established by a register sender which is adapted to record line designations in the form of alternating current pulses within the voice frequency range as transmitted thereto from a calling station. In response to this record, the sender operates to selectively position the necessary selectors for reaching the called line after which the sender is dismissed and the two subscribers converse over the established connection. In Fig. 2 of the drawings a skeletonized showing is made of the completed connection as established by the means fully disclosed in the above-mentioned copending application and reference is made thereto for a complete description of all operations not discussed herein. The reference numerals used in Fig. 2 correspond to numerals applied to similar elements in the aforementioned application.

Referring now to the drawings, the removal of the telephone instrument 1 from its cradle causes the closure of contacts 11 and 12 and the completion of a line loop extending from conductor 14, contacts 12, rectifiers 5 and 4, primary winding of induction coil 7 to conductor 13. This loop is completed in the central office end of the line circuit through the windings of a line relay (not shown) having battery connected thereto which operates in consequence to cause a line finder L. F. to find and connect with the terminals of the calling line, all as fully described in the above-mentioned copending application.

The line finder, as part of its circuit organization, comprises a sender connector which, in response to the operation of relay 403 over the line loop, causes the operation of relay 405 by means of which a register sender is connected to the calling station. By virtue of other operations fully described in the above-mentioned copending application, key tone is transmitted to the substation as a signal to the subscriber to transmit the wanted line designation. This he proceeds to do by manipulating the keys of the reed-generating set 6 which is of the type fully disclosed in Patent No. 2,147,710 granted to R. F. Mallina on February 21, 1939, and comprises a permanent

magnet in the field of which are located five reeds surrounded by a coil which is connected from the mid-point between rectifiers 4 and 5 and by way of contacts 11 and winding 20 of coil 7 to the mid-point of rectifiers 3 and 4. These reeds each have a different natural period of vibration, and when plucked singly or in combination by the individual keys of the key-set vibrate in the magnetic field to produce alternating currents whose frequencies are determined by the periodicities of each of the reeds which, as said before, may be within the voice frequency range. Each of these currents is transmitted into the sender where appropriate filtering devices separate the different currents for transmission into as many detector channels each tuned to respond to one of the frequencies produced by the different reeds.

The filtering devices in the sender have no direct current battery connected to them and the only source of direct current present on the line during the time when the subscriber is manipulating the key-set 6 is that supplied through relay 403. Inasmuch as the positive pole of this battery is grounded, the direction of current flow is through the lower winding of relay 403 and parallel rectifier 443, lower winding of relay 401, lower back contacts of relay 408, conductor 14, switchhook contacts 12, rectifiers 5 and 4, primary winding P of induction coil 7, conductor 13, upper back contacts of relay 408, upper winding of relay 401, upper winding of relay 403 and parallel rectifier 442 to battery.

It will be observed that the transmitter 18 of the hand-set is disposed between rectifiers 2 and 5 and that rectifier 2 as well as rectifier 3 are poled so as to oppose the direction of the current flow in the above-traced path. It will be further observed that the coil surrounding the reeds of the generator set 6 is bridged across the rectifier bridge through the receiver 19 of the handset 1 which, in turn, through contacts 11, is bridged through rectifier 3 across winding 20 of the two windings 20 and 21 constituting the secondary S of induction coil 7.

Now since the direction of direct current flowing through relay 403 during the transmission of the alternating currents generated by the manipulation of reed generator 6 is such as to cause very little of the direct current to flow through the transmitter 18 due to the poling of the rectifiers 2 and 3, and since it is well known that the efficiency of a transmitter in producing undulating currents from any movement of the diaphragm due to any force acting thereupon such as, for example, that due to sound waves or shocks, is materially affected by the quantity of direct current flowing through it at the time, it is clear that any force acting upon the diaphragm during the manipulation of the key-set 6 and, therefore, during the transmission of the alternating current signals produced thereby will have no practical effect in causing the production by the transmitter of any alternating currents that would be superimposed upon or dispersed between those produced by the key-set 6 during the period of signaling. In consequence, therefore, the alternating current signals produced by the generator 6 will be transmitted into the sender free and clear of any other alternating current components which would ordinarily be produced by noises impinging upon or mechanical shock to the diaphragm of the transmitter if direct current were flowing through it at the time.

It is to be noted that rectifier units 5 and 4

place a shunt on the transmitter 18 in series with the high back resistance of rectifier units 2 and 3. It is, then, not only the back resistance of units 2 and 3 but the low forward resistance of units 5 and 4 which reduces to a very considerable extent the direct current from the line that would otherwise flow through the transmitter. Furthermore, any small alternating current set up by the transmitter because of the small residual direct current flowing through it will be attenuated, of course, by the high back resistance of rectifier units 2 and 3 and the low forward shunting resistance of rectifier units 4 and 5 so that the transmitter 18 is not only desensitized by the reduction of direct current flowing through it but, in effect, an attenuating resistance circuit to any alternating current developed in the transmitter is placed between it and the rest of the substation circuit.

The receiver 19, being a coupling mechanism between the substation circuit and the mechanical motion of its diaphragm, is capable of converting loud noises and more particularly mechanical shock into electrical pulses which, for short line conditions, may be of sufficient magnitude to falsely operate the frequency selective channel filters at the central office. Therefore, during the signaling condition, the receiver 19 is separated from its usual connection to the induction coil 7 at the junction of the primary and secondary windings thereof by the high back resistance of rectifier unit 3. The introduction of the resistance of unit 3 creates a loss to electrical disturbance set up by receiver 19 which is of sufficient extent to reduce them below a level which would cause false channel operation. The rectifier unit 3 is selected with this in mind and also to meet the requirement that the subscriber shall be able to hear in the receiver 19 the key tone which is to advise him of the time when he may start keying the wanted telephone number on the key-set 6.

The currents produced by the reed generator key-set 6 are transmitted over a circuit comprising rectifier 4, winding 20 of the coil 7 and contacts 11 of the switchhook. Corresponding currents are induced through the primary winding of said coil and transmitted into the sender. In the ordinary telephone station circuit the impedance of induction coil 7 is computed to provide maximum transmission efficiency in conjunction with the impedance of the receiver 19. In the present invention, the coil of the reed generator set 6 is bridged, during signaling, across the receiver winding 20 of the induction coil 7 through contacts 11 and the low forward resistance of rectifier 4 and it is equally desirable that the signal currents generated by the reed generator be likewise transmitted at highest efficiency through the coil 7. However, since the constants of the coil cannot be changed from what these constants must be to provide for maximum transmission efficiency with respect to the receiver 19, equal transmission efficiency with the coil of the reed generator set 6 is attained, according to my invention, by designing the impedance of the coil of the generator to be equal to that when looking into winding 20 of the coil 7, for an average line connection.

With the efficiency of the reed generator coil made a maximum for the connection shown in Fig. 1, said coil may be bridged by means of the rectifier bridge across the receiver winding 20 of coil 7 with the maximum economy of switchhook contacts. This is in contrast with the past

practice in which the impedance of the coil, not matching that looking into the receiver winding 20 of coil 7, additional switchhook contacts are necessary to connect the reed generator so as to avoid shunting the ringer and thus its ringing current through the reed generator coil, which was done by connecting the reed generator on the conductor 13 side of the line between ringer 10 and the ringing condenser 9.

When the sender has received the called line designation it proceeds to selectively position the appropriate train of selectors to reach the terminals of the called line, after which relay 408 is operated, the sender is dismissed and the called line rung. When the called subscriber removes his receiver from the switchhook relay 558 is operated over a path extending from ground through its lower winding, ring conductor and called line loop back to the tip conductor, upper winding of said relay to battery. Relay 558 operates and by closing its upper transfer contacts reverses the connection of battery and ground through the windings of relay 559 to the calling side of the connection for supervisory purposes.

It will be observed that with relay 408 operated, relay 403 no longer supplies current to the calling line loop but that another source of current is now available through the windings of relay 411. Since the polarity of the battery through relay 411 is opposite to that of the battery through relay 403, the direction of the resulting current flowing over the line circuit is likewise in the opposite direction so that current now flows from ground through the upper winding of relay 411 and current limiting resistance, left winding of repeat coil 441, inner upper front contacts of relay 403, via conductor 13, primary winding P of coil 7, rectifiers 3 and 2, transmitter 18, switchhook contacts 12, conductor 14, middle lower front contacts of relay 403, left lower winding of repeat coil 441, thence to battery through the current limiting resistance and the lower winding of relay 411. Direct current now flows through the transmitter to restore its efficiency in changing sound waves into undulating currents.

For the talking condition in which the line direct current flows in the direction just described, the generator coil of the key-set 6 is effectively separated from the substation circuit by the high back resistances of rectifier units 4 and 5. Likewise by virtue of the high back resistances of units 4 and 5 a negligible shunt loss is placed on the transmitter and also across the receiver winding 20 of coil 7. For this condition, of course, rectifier units 3 and 2 have low resistances and they cause only a negligible loss to the receiver and transmitter which are in effect connected back to their normal positions in the circuit for speech transmission.

In effect the rectifier bridge has acted as a group of switches to first connect the generator coil to the circuit, switch out the transmitter and put loss in the receiver circuit for the signaling condition and then, for talking, to effectively switch the generator coil out of the circuit and to switch the transmitter and receiver into the circuit.

What is claimed is:

1. In a telephone system, a subscriber's line over which alternating signal currents and talking currents are transmitted, a subscriber's substation set connected to said line, said substation set comprising a transmitter, a receiver, an

induction coil, a rectifier network bridged between said induction coil and said transmitter, and a multifrequency current generator bridged across said induction coil and having an image impedance equal to that of said induction coil when looking thereinto.

2. In a telephone system, a subscriber's line over which alternating signal currents and talking currents are transmitted, a subscriber's substation set connected to said line, said substation set comprising a transmitter, a receiver, an induction coil, a rectifier bridge having two arms serially connected with said transmitter and said line through the primary winding of said induction coil, said receiver being connectable to said line through one arm of said bridge and through the secondary winding of said induction coil, and a multifrequency current generator connected to said line through a third arm of said bridge and through the secondary winding of said induction coil in parallel with said receiver and said transmitter, said generator having an image impedance equal to that of said induction coil when looking thereinto.

3. In a telephone system, a subscriber's line over which alternating signal currents and talking currents are transmitted, a subscriber's substation set connected to said line, said substation set comprising a transmitter, a receiver, a switchhook having two pairs of switchhook contacts, an induction coil, a rectifier bridge in one arm of which said transmitter is connected in series with said line through the primary winding of said induction coil upon the closure of one pair of said contacts, said receiver being connected through another arm through the secondary winding of said induction coil upon the closure of the second pair of said contacts and a multifrequency current generator connected to said line through a third arm of said bridge and through said secondary winding of said induction coil upon the closure of said second pair of contacts, said generator having an image impedance equal to that of said induction coil when looking thereinto.

4. In a telephone system, a subscriber's line, a source of current for supplying direct current to said line, a subscriber's substation set connected to said line comprising a transmitter and a bridge having a rectifying unit in each arm thereof, means for connecting said transmitter across said line in series with two arms of said bridge, the rectifying units of which arms are so poled as to offer a high impedance to the flow of current from said source through said transmitter, a multifrequency current generator, means for associating said generator with said line through the rectifying unit of a third arm of said bridge which is so poled as to offer a low impedance in the circuit through said generator, and means for reversing the connection of said source to said line whereupon the rectifier units of said two arms offer a low impedance to the flow of current through said transmitter and the rectifier unit of said third arm offers a high impedance to the flow of current through said generator.

5. In a telephone system, a subscriber's line, a source of current for supplying direct current to said line, a subscriber's substation set connected to said line comprising a transmitter, a receiver, an induction coil and a bridge having a rectifying unit in each arm thereof, means for connecting said transmitter across said line in series with the primary winding of said coil and

with two arms of said bridge, the rectifying units of which arms are so poled as to offer a high impedance to the flow of current from said source through said transmitter, said receiver being connected in series with the secondary winding of said coil and with one of said two arms of said bridge, a multifrequency current generator, means for associating said generator with said line through the rectifying unit of a third arm of said bridge which is so poled as to offer a low impedance in the circuit through said generator, and means for reversing the connection of said source to said line whereupon the rectifier units of said two arms offer a low impedance to the flow of current through said transmitter and the rectifier unit of said third arm offers a high impedance to the flow of current through said generator.

6. In a telephone system, a subscriber's line, a source of current for supplying direct current to said line, a subscriber's substation set connected to said line comprising a transmitter, a receiver, an induction coil and a bridge having a rectifying unit in each arm thereof, means for connecting said transmitter across said line in series with the primary winding of said coil and with two arms of said bridge and for connecting said receiver in series with one of said two arms and with the secondary winding of said coil, the rectifying units of which arms are so poled as to offer a high impedance to the flow of current from said source through said transmitter and to introduce a loss to electrical disturbances set up by the vibration of the receiver diaphragm, a multifrequency current generator, means for associating said generator with said line through the rectifier unit of a third arm of said bridge which is poled to offer a low impedance in the circuit through said generator, and means for reversing the connection of said source to said line whereupon the rectifier units of said two arms offer a low impedance to the flow of current through said transmitter and said receiver and the rectifier unit of said third arm offers a high impedance to the flow of current through said generator.

7. In a telephone system, a subscriber's line, a source of current for supplying direct current to said line, a subscriber's substation set connected to said line comprising a transmitter, a receiver, an induction coil and a bridge having a rectifying unit in each arm thereof, means for connecting said transmitter across said line in series with the primary winding of said coil and with two arms of said bridge, for connecting said

receiver in series with one of said two arms and with the secondary winding of said coil, the rectifying units of which arms are so poled as to offer a high impedance to the flow of current from said source through said transmitter and to introduce a loss to electrical disturbances set up by the vibration of the receiver diaphragm, and for connecting the oppositely poled units of the other arms of said bridge in shunt of said transmitter for shunting said current from the transmitter, a multifrequency current generator, means for associating said generator with said line through the rectifier unit of one of said latter arms which is so poled as to offer a low impedance in the circuit through said generator, and means for reversing the connection of said source to said line whereupon the rectifier units of said first arms offer a low impedance to the flow of current through said transmitter and said receiver and the rectifier unit in the circuit of said generator offers a high impedance to the flow of current through said generator.

8. In a telephone system, the combination with a subscriber's line and a subscriber's set that includes a transmitter, a rectifier bridge connected to said line having four arms in one of which is included said transmitter, two adjoining arms of said bridge comprising rectifiers disposed to conduct current in one direction and the two other adjoining arms of said bridge including the arm that contains said transmitter, comprising rectifiers disposed to conduct current in the opposite direction whereby current will flow through said transmitter when current is flowing through the line in one direction and will not flow through said transmitter when current is flowing through the line in the opposite direction.

9. In a telephone system, a line, a subscriber's station upon said line comprising a transmitter and a rectifier bridge for said transmitter, said rectifier bridge being poled to permit the transmission of direct current through said transmitter in but one direction.

10. In a subscriber's telephone station adapted for the generation and transmission of signal frequency currents over a telephone line connected thereto, said station being provided with a transmitter and receiver, means in shunt of said transmitter for by-passing battery currents over said telephone line during the generation and transmission of said signal currents, said means being ineffective to shunt said transmitter when the battery current flows in the opposite direction.

ALEXIS A. LUNDSTROM. 55