July 20, 1943. W. H. T. HOLDEN 2,324,624

COMMUNICATION SYSTEM

Filed Oct. 15, 1941 2 Sheets-Sheet 1

FIG. 2

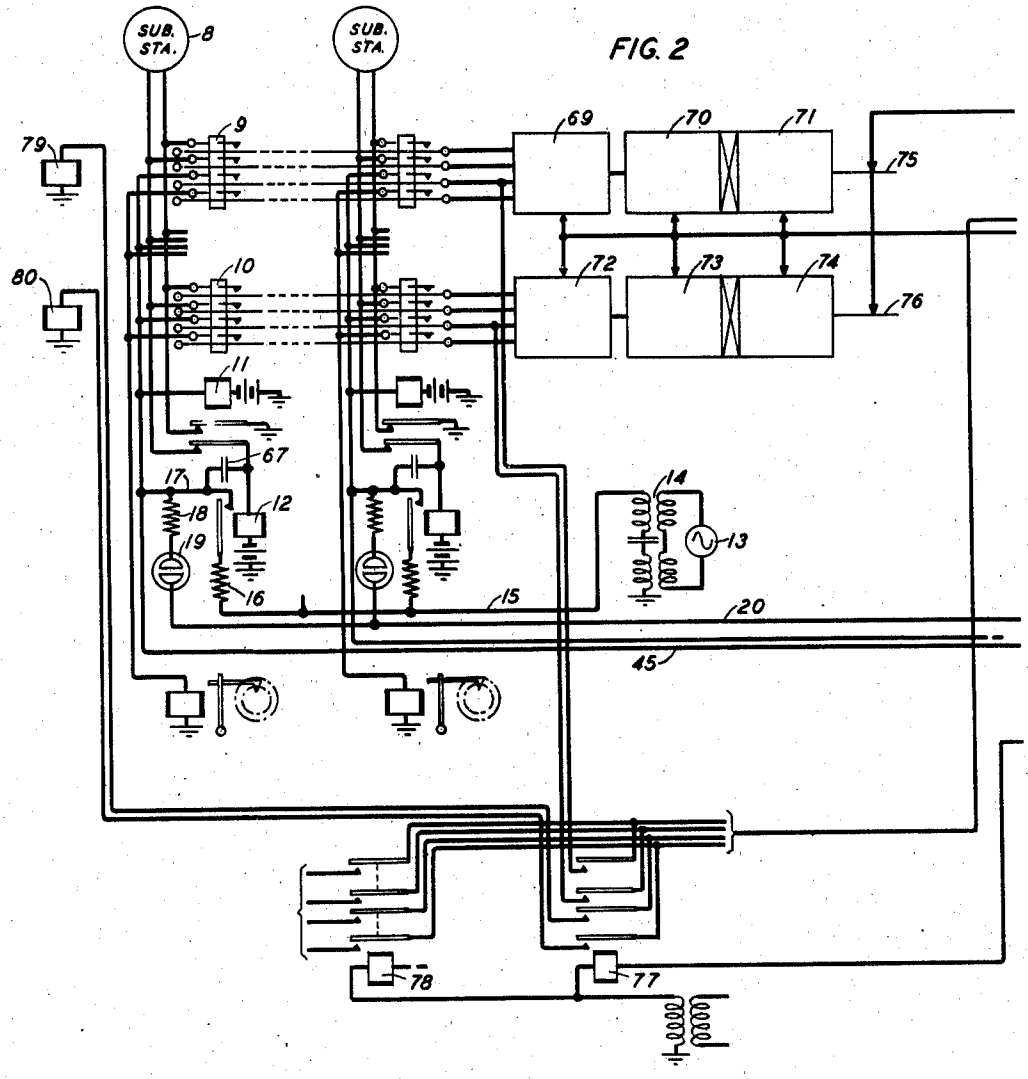

FIG. 1

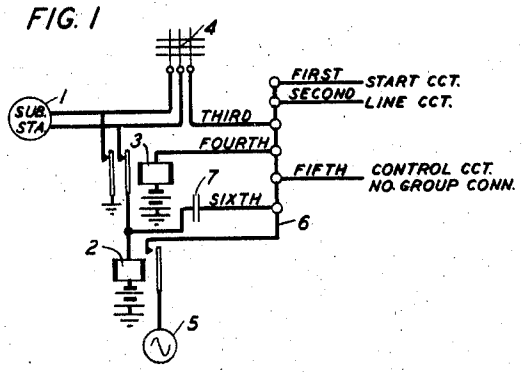

FIG. 4

FIG 2	FIG 3

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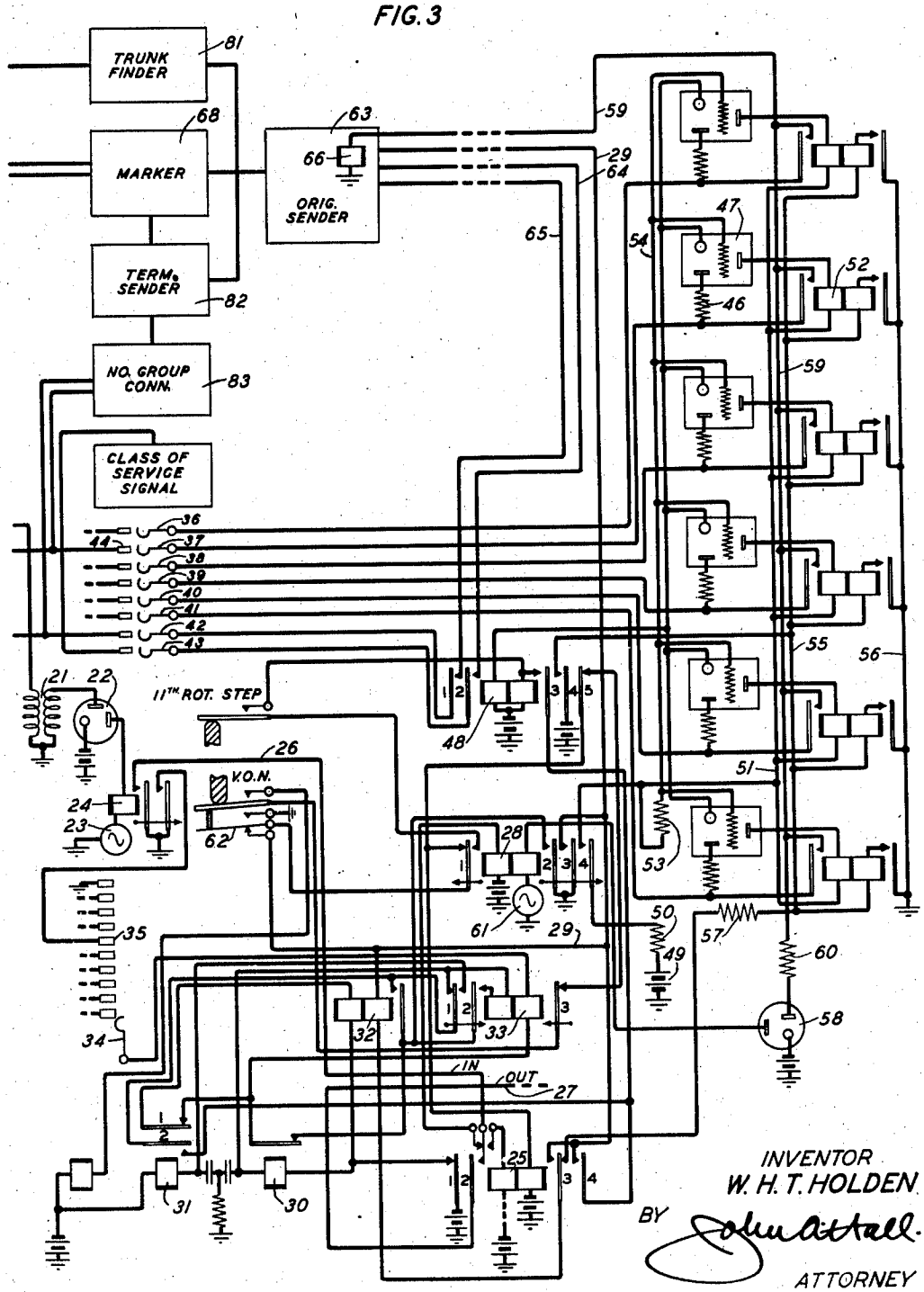
FIG. 3



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Patented July 20, 1943

2,324,624

UNITED STATES PATENT OFFICE

2,324,624

COMMUNICATION SYSTEM

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Application October 15, 1941, Serial No. 414,992

5 Claims. (Cl. 179—18)

This invention relates to communication systems and particularly to machine switching systems for extending a communication channel serially through a multistage connection.

The object of the invention is to produce an economical and simple switching system. Each subscriber's line is provided at the central office with a simple relay which responds to switchhook and dial operation on the line and which controls the complete establishment of the serial multistage connection. Each subscriber's line is effectively divided at the central office end into a single conductor signaling path and a two conductor communication channel. The signaling path is extended by a line finder arrangement into a sender which responds to the line relay to record the complete designation of the desired communication channel. Thereafter, such communication channel is established under sender control by an entirely separate train of switches. Effectively, therefore, one train of switches is used for signaling purposes and another train is used for communication purposes. A magnet individual to the line and individual to one of said communication channel switches is used as a cut-off relay for said line relay.

The line relay is a high speed sensitive relay controlling only a single make contact. This relay controls a circuit having two branches, a first branch controlling a start circuit for a line finder and a second branch appearing in and extensible by said line finder. The first branch contains an electronic circuit closing tube which responds to a switchhook operation on the line to close the start circuit of the line finder. When the calling line appearing in its second branch circuit in the line finder is found, the said electronic circuit closing tube in the first branch is quenched and thereafter maintains the start circuit open. The line relay thereafter responds to dial operation and pulses the complete designation of the desired communication channel over the said second branch via said line finder into a sender. It should be noted that while a sender is a preferred arrangement, this may nevertheless be replaced by a train of step-by-step switches which will set up a by-path to the desired termination which will thereupon control the establishment over a separate path of a parallel communication channel in accordance with well-known principles.

This invention is characterized by the use of alternating current in the signaling path. The operation of the line relay connects a source of alternating current on the signaling path so that the start circuit is energized by alternating current and the line finder has to seek an alternating current potential rather than the usual direct current marginal condition.

The line relay is connected to the single conductor signaling path which it controls by an alternating current transmission path. The main function of this arrangement is to transmit dial tone to the calling subscriber when the signaling path has been properly extended to a sender. Another feature of this arrangement is the transmission toward the subscriber of a portion of the alternating current which characterizes the line as calling in the line finder and which appears as a distinctive tone to the subscriber and which acts as a signal to indicate that the line relay has operated. While such a signal is of little use commercially from the standpoint of the average subscriber it is of considerable use to repairmen and testers. Since it does not interfere with the use of the station or disturb the subscriber it is a desirable feature.

When the line finder has properly extended the single conductor signaling path to a sender a dial tone is applied thereto and through the connection to the line relay is transmitted to the calling subscriber. This is distinctively different from the said line relay tone and will not be confused therewith.

Another feature is a means in the terminating switches which will prevent the establishment of a connection to a line if either the ordinary busy test potential or the alternating current applied by the line relay appears on the line. Since the dialing period is comparatively lengthy the line must be guarded from intrusion from the time a calling subscriber first operates his switchhook until he has completed the dialing operation and the communication channel is completed. During this period the alternating current applied by the line relay to the double branch signaling circuit is also applied to the third or sleeve wire appearance of the line in the terminating switches.

Another feature of the invention is pulsing by alternating current. When a subscriber makes a call the line relay responds and energizes the said double branch signaling circuit by applying alternating current thereto. This acts first to start the line finder, second as a calling line marking potential in the line finder and third as a means to energize the pulse responsive relay in the sender. When the subscriber operates his dial the line relay responds to the pulses and interrupts the flow of alternating current to the sender accordingly. The pulse responsive relay

in the sender then responds to this interrupted alternating current and operates the sender accordingly.

A feature of the invention is a line circuit comprising an appearance in a switch for extending the line, a magnet of the switch individual to the line and an individual line relay connected through cut-off contacts of said individual magnet to said line. The line relay connects a source of alternating current to a single conductor signaling path which has a plurality of branches. A first branch leads to and operates a start circuit for a line finder. A second branch leads to an appearance in the line finder which may be extended by the line finder to a sender or other pulse responsive means. A third branch leads to an appearance in the switch for extending the line and acts as a means for holding the said magnet energized during the maintenance of a connection to the line. A fourth branch leads to the said magnet. A fifth branch leads to a control circuit from which a busy test of the line may be made and which acts to energize the said magnet if the line is found to be idle. The said busy testing means will respond to either the connection of alternating current to the signaling conductor during the dialing period on the line or the direct current connection thereto for the operation of the said magnet during the maintenance of a connection to the line. And lastly, there is a sixth branch of the signaling conductor leading through an alternating current transmission path to the winding of the line relay whereby alternating current either from the said source of alternating current or from a dial tone means in the sender may be transmitted to the calling subscriber.

Other features will appear in the following description.

The drawings consist of two sheets having four figures, as follows:

Fig. 1 is a schematic circuit diagram showing the essential elements of the present invention;

Fig. 2 is a circuit digram showing in detail the line circuits, indicating partly in detail and showing partly schematically the switching means for extending the communication channels to and from the lines;

Fig. 3 is a circuit diagram showing certain details of a line finder circuit for extending the signaling circuit of the line circuits to a sender, which together with other means for controlling the switching means is shown schematically; and

Fig. 4 indicates how Figs. 2 and 3 are to be joined to provide a complete circuit diagram.

The invention is shown schematically in Fig. 1. A telephone substation 1 is extended by a pair of wires to a central office line circuit represented by the remainder of the diagram. A line relay 2 is connected through the contacts of a magnet 3 to the line wires. The device 4 represents a switch for extending a communication channel to and from the line to substation 1. The line relay 2 is responsive to both switchhook and dial control over the line. When a call is made, relay 2 responds and connects a source of alternating current 5 to a signal circuit 6, having six branches. The first effect is to energize the start circuit of a line finder over the first branch circuit which line finder thereupon seeks a terminal to which this alternating current is connected over the second branch thereof. During this time a portion of the alternating current is diverted over the sixth branch circuit through a condenser 7 to the winding of the line relay and thence to the substation 1 where it acts as a signal that the line relay has properly operated. When the line finder finds the calling line the first branch circuit is rendered ineffective and the second branch circuit is extended to a sender. A dial tone is returned over the second branch circuit and thence through the sixth branch circuit for transmission to the calling line as a signal that dialing may commence. Line relay 2 responds to the dialing of the complete line designation of the called line. When the controlling circuits are ready a ground to operate the magnet 3 of the calling line is returned over the second branch circuit to the fourth branch circuit and a ground is connected over the fifth branch circuit to the fourth branch circuit of the called line for operating the magnet 3 of the called line. When the communication channel is extended by the switch 4 a ground is returned over the sleeve conductor through said switch to the third branch circuit to hold the magnet 3 operated. The operation of magnet 3 cuts off the line relay 2 and releases the common apparatus.

The device 4 is preferably a crossbar switch having a row of contact sets individual to the line to substation 1. The magnet 3 is thus individual to the line as well as individual to the switch 4.

It is to be noted that the fifth branch circuit extends to the control means which includes a number group connector where the line as a called line is tested for its busy or idle condition. During the dialing period this fifth branch circuit is connected to alternating current through the contacts of the line relay and during the establishment of the communication channel the fifth branch circuit is connected to ground for the operation of the magnet 3. The busy test means in the number group connector is therefore arranged to respond to either this alternating current or to ground.

It should further be noted that the relay 2 is here illustrated as a conventional type electromagnetic relay. The requirement is that it be sensitive and fast enough acting to repeat without distortion the dial pulses. For this purpose the Ellwood relay consisting of a pair of magnetic reeds sealed longitudinally in a small glass tube immersed in an inert gas and having their free ends slightly overlapping, the unit being inserted in the center of a coil, forms an ideal device for this purpose. Such an Ellwood relay is extremely fast and sensitive and is very economical. Its use is here possible because only a single make contact is needed.

In more detail the operation is as follows. Substation 8 is connected to a line having a plurality of outlets represented by the contact sets 9 and 10 controlled by an individual magnet 11 in a crossbar switch. A single make contact line relay 12 is individual to the line and will respond to signal operations over the line until it is cut off by the energization of the hold magnet 11. When a call is made relay 12 responds, whereby alternating current from a source 13 connected to conductor 15 by a transformer 14 is passed through a resistance 16 and the contacts of relay 12 to the signaling circuit 17. This alternating current then flows through a first branch of the signaling circuit 17, including the resistance 18, the line diode 19, common start wire 20, through a winding of transformer 21 to ground. The application of alternating current to signaling circuit 17 at this time when it is assumed that the other branches of the signaling circuit are

idle will cause the line diode 19 to break down and become conducting. The result is that a current will now flow through the other winding of transformer 21, an anode of tube 22, the cathode of this tube to battery and ground. This discharge current will then render another path through this tube conducting whereby current from the source 23 during one-half of each cycle will energize slow-releasing relay 24. This will act to start a line finder.

Relay 25 will mark the line finder here partly detailed as busy or idle. If it is busy then relay 25 will be operated, so that ground connected to conductor 26 by relay 24 will be extended over the front contact and armature 2 of relay 25 to the out conductor 27 where it connects to the in conductor, corresponding to conductor 26, of the next line finder. If the line finder of Fig. 3 is idle as we will assume it to be, then ground on conductor 26 will be extended through the normal contacts of armature 2 of relay 25, to the left-hand winding of relay 28, and thence to battery and ground. Relay 28 will respond and by its armature 3 will ground the sleeve lead 29. A circuit can now be traced from ground armature 2 and front contact of relay 28, back contact and armature of vertical magnet 30, back contact and armature 1 of rotary magnet 31, left-hand winding of relay 32, back contact and armature 1 of relay 25 to battery. Relay 32 operates and closes a circuit for vertical magnet 30 which may be traced from ground, armature 2 and front contact of relay 28, armature and front contact of relay 32, armature 1 and back contact of relay 33, winding of vertical magnet 30, back contact and armature 1 of relay 25 to battery. Relay 32 and magnet 30 are thus in mutually controlling circuits and their conventional interaction will result in the shaft of the line finder being stepped upward to find the group containing the calling line. On each such step the group brush 34 will test a group terminal. When terminal 35 is encountered the ground supplied thereto by relay 24 will be extended through the right-hand winding of relay 33, and while the vertical magnet is still in operated position, through back contact and armature 1 of rotary magnet 31, left-hand winding of relay 32, back contact and armature 1 of relay 25 to battery. This serves to momentarily prevent the release of the vertical magnet until the changeover takes place. Relay 33 is energized and this relay locks through its armature 2, front contact and its left-hand winding and the winding of vertical magnet. Relay 33 through its armature 1 now transfers the front contact of relay 32 from the vertical magnet 30 to the rotary magnet 31 so that relay 32 and rotary magnet 31 are placed in a mutually controlling circuit. The rotary magnet now rotates the brushes 36 and 43, inclusive, until brush 37 encounters terminal 44 to which the second branch 45 of the signaling circuit 17 is connected. Thereupon the alternating current from source 13 will be connected through resistance 46 to an anode of the tube 47 causing a discharge to the cathode and through the left-hand winding of relay 48 to battery. The alternating current which causes this discharge is insufficient to operate relay 48 but it does cause ionization of the tube whereupon a circuit is closed from a plus battery 49 through a resistance 50, armature 4 and front contact of relay 28, conductor 51, left winding of relay 52, the second anode of tube 47, the cathode of the said tube through the left winding of relay 48 to minus battery. Relays 48 and 52 become energized.

Prior to the closure of the circuit for relays 48 and 52 the potential of battery 49 is connected through resistance 50 and resistance 53 to conductor 54 to the grid of tube 47 to facilitate the closure of the said relay circuit. Thereafter the potential drop in resistance 50 lowers the potential on conductor 54 to block the remaining five tubes similar to tube 47 to prevent interference by another incoming call which might occur over brush 36 or brushes 38 to 41, inclusive.

Relay 48, through its armature 4, connects battery to conductor 55 so that now relay 52 locks through its right-hand winding, front contact and right-hand armature to grounded conductor 56. The right-hand winding of relay 48 is now connected through front contact and armature 3 of relay 48, front contact and armature 2 of rotary magnet 31, front contact and armature of relay 32, front contact and armature 2 of relay 28 to ground. Relay 32 is held operated in a circuit from ground, armature 3 and front contact of relay 28, right-hand winding of relay 32, armature 3 and back contact of relay 25, resistance 57, conductor 55, front contact and armature 4 of relay 48 to battery so that the rotary movement of the brushes 36 to 43 is stopped.

The alternating current from source 13 connected over the second branch 45 of the signaling circuit 17 and now connected by the left-hand armature of relay 52 to conductor 59 may be traced through resistance 60 to an anode of tube 58. This ionizes the tube 58 so that a current flow will now take place in a circuit from ground, source of alternating current 61, right-hand winding of relay 28, an anode of tube 58, the cathode thereof to battery. The average current in this circuit will oppose the energization of relay 28 through its left-hand winding whereupon relay 28 will release. This is followed by the establishment of a circuit from ground, the vertical off-normal springs 62, armature 1 and back contact of relay 28, right-hand winding of relay 25 to battery, whereupon the start wire is extended to the next line finder in the conventional manner.

Relay 48 will be maintained energized under control of a ground retuned from further switch facilities or from the sender 63 over the sleeve lead 29. Relays 32 and 33 and the rotary and vertical magnets 31 and 30 will be released in the conventional manner. The extension of the second branch of the signaling circuit to conductor 59 will so shunt the line diode 19 that this tube will be quenched and the first branch of the signaling circuit will be opened, causing the release of relay 24.

The single conductor line comprising the second branch of the signaling circuit will now be extended over conductor 59 toward the sender 63. The sleeve conductor 29, together with the class of service conductor 64 and the group conductor 65 now extend toward the sender. These four conductors are shown as dotted to indicate that they may extend in a conventional manner through other switching facilities on their way to the sender. In the sender the line wire 59 is eventually connected to a pulsing relay 66 and this relay will thereafter respond to the alternating current source 13.

Further operation of the line finder of Fig. 3 in its releasing and other functions is conventional and need not be further described.

The second branch of the signaling circuit is

now extended to the originating sender 63 where it terminates in the winding of a relay 66 which is responsive to the source of current 13. Otherwise the sender and the circuits controlled thereby are conventional. Detailed descriptions may be found in the following patents: 2,089,921, Carpenter, granted August 10, 1937; 2,093,117, Carpenter, granted September 14, 1937.

Dial tone may now be passed by the sender back over conductor 59 whence it passes by the sixth branch of the signaling circuit through condenser 67 to the ring of the line leading to the station 8. During the operation of relay 12 the source of current 13 is also connected over this sixth branch of the signaling circuit whereby the subscriber may know that the line relay has operated. The volume of this tone will be small so as not to be objectionable and it will be of a different quality so that it will not be confused with the dial tone.

The subscriber will now dial the complete designation of the called subscriber's number. The line relay will follow these dial pulses and the pulsing relay 66 in the sender 53 will follow the line relay. When the sender is completely set a communication channel between the calling and the called subscribers will be established over a set of crossbar switches in the manner set forth in the above-noted Carpenter patents. The showing of these facilities here is purely schematic. The sender 63 controls a marker 68 which in turn controls switching facilities 69 to 74 to extend the calling line to outgoing trunks such as 75 and 76. The sender through the group wire 65 controls the group relays 77 and 78 and the marker through the operation of the proper group relay 77 controls the selecting magnets such as 79 and 80 and finally the sender over the second branch of the signaling circuit will ground such signaling circuit to cause the operation of the hold magnet 11 which is thereafter held operated by the sleeve wire over the third branch of the signaling circuit.

The operation of the hold magnet cuts off the line relay whereupon the sender is released and the line finder of Fig. 3 and other switching facilities between the line finder and the sender are released.

In the meantime at the distant end where the trunks 75 and 76 may represent incoming trunks a trunk finder 81 will appropriate a terminal sender 82 which through a number group connector 83 will test the called line and perform the usual operations of returning a busy signal or through a marker 68 will control the setting of switches 69 to 74 at the distant end to extend the connection to the called line.

The number group connector and the terminal sender will differ only slightly from conventional apparatus in that they will respond to alternating current as well as the usual ground as designating a busy condition. Since means of this nature are well-known the present disclosure makes no specific disclosure thereof. The marker 68 is here shown as operating both from the originating sender 63 and the terminating sender 82 but it will be understood that this showing is schematic and is merely intended to indicate in a general way the manner in which the communication channel is established by crossbar switches. Details will be found in the above-noted Carpenter patents.

What is claimed is:

1. In a communication system, a plurality of subscriber's lines, each said line having a relay connected thereto responsive to switchhook and dial operation on said line, a line finder, a source of alternating current, a signaling conductor individual to each said line, said relay operating to connect said source of alternating current to said individual signaling conductor, a first branch of said signaling conductor connected to means for starting said line finder, a second branch of said signaling conductor connected to a bank terminal of said line finder, an impulse receiving circuit connected to a brushing of said line finder, means responsive to alternating current connected to said brush of said line finder for stopping said line finder with said brush on said terminal and means in said impulse receiving circuit responsive to alternating current impulses created by the response of said line relay to dial operation on said line.

2. In a communication system, a plurality of subscriber's lines, each said line having terminals appearing in a switch for extending said line and a line relay connected to said line responsive to switchhook and dial operation on said line, a line finder, a source of alternating current, a signaling conductor individual to each said line, said relay operating to connect said source of alternating current to said individual signaling conductor, a branch of said signaling conductor extending to one of said terminals in said switch for marking said line as busy upon the operation of said line relay and another branch of said signaling conductor extending to said line finder for extension thereby to signal responsive means.

3. In a communication system, a plurality of subscriber's lines, each said line having terminals appearing in a switch for extending said line, and a relay connected to said line responsive to switchhook and dial operation on said line, a line finder, a source of alternating current, a signaling conductor individual to each said line, said relay operating to connect said source of alternating current to said individual signaling conductor, a first branch of said signaling conductor leading to a start circuit for said line finder, a second branch of said signaling conductor appearing in the bank of said line finder, a third branch of said signaling conductor extending to one of said terminals in said switch for marking said line as busy upon the operation of said line relay and a fourth branch of said signaling conductor leading to the winding of a cut-off relay for said line relay.

4. In a communication system, a plurality of subscriber's lines, each said line having a relay connected thereto responsive to switchhook and dial operation on said line, a switch for extending calls to and from said lines, each said line having a magnet of said switch individual thereto, said magnet having cut-off contacts for said line relay, a line finder, a source of alternating current, a signaling conductor individual to each said line; said relay operating to connect said source of alternating current to said individual signaling conductor, a first branch of said signaling conductor leading to a start circuit for said line finder, a second branch of said signaling conductor appearing in the bank of said line finder, a third branch of said signaling conductor extending to a terminal in said switch for extending calls to and from said line, a fourth branch of said signaling conductor leading to the said individual magnet, said magnet being responsive to direct current applied thereto and unresponsive to said alternating current applied to said signaling conductor, a fifth branch of said sig-

naling conductor leading to a control circuit for operating said magnet and means in said control circuit responsive to the application of alternating current to said signaling conductor or the application of a direct current magnet operating potential to said signaling conductor for preventing other connections being made to said line.

5. In a communication system, a plurality of subscribers' lines, each said line having a relay connected thereto responsive to switchhook and dial operation on said line, a switch for extending said line, a magnet of said switch individual to said line, a line finder, a control circuit for testing the idle or busy condition of said line appearance in said switch and for operating said magnet to extend said line through said switch, a source of alternating current, a signaling conductor individual to said line, said relay operating to connect said source of alternating current to said individual signaling conductor, a first branch of said signaling conductor leading to means for starting said line finder, a second branch of said signaling conductor leading to said line finder, a third branch of said signaling conductor appearing in said switch as a companion supervisory circuit for said line, a fourth branch of said signaling conductor leading to said magnet comprising an energizing path for said magnet, a fifth branch of said signaling conductor leading to said control circuit and comprising a path for testing for the idle or busy condition of said line and a sixth branch of said signaling conductor comprising an alternating current transmission path leading to the winding of said line relay.

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