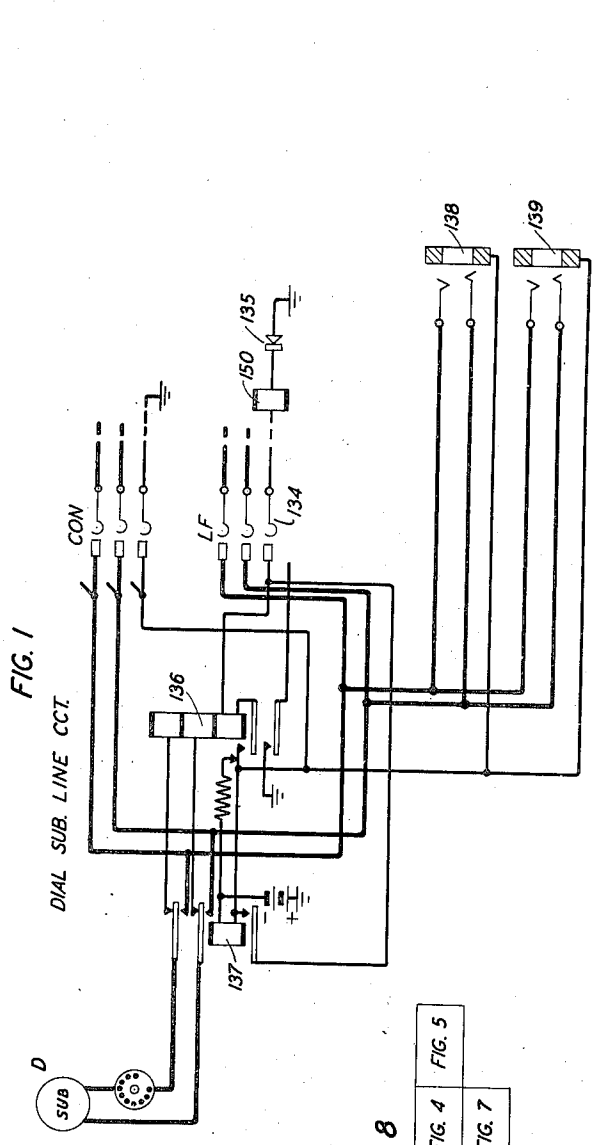
Aug. 24, 1943. H. M. BASCOM ET AL 2,327,851

PRIVATE BRANCH EXCHANGE SYSTEM

Filed April 11, 1942 6 Sheets-Sheet 1



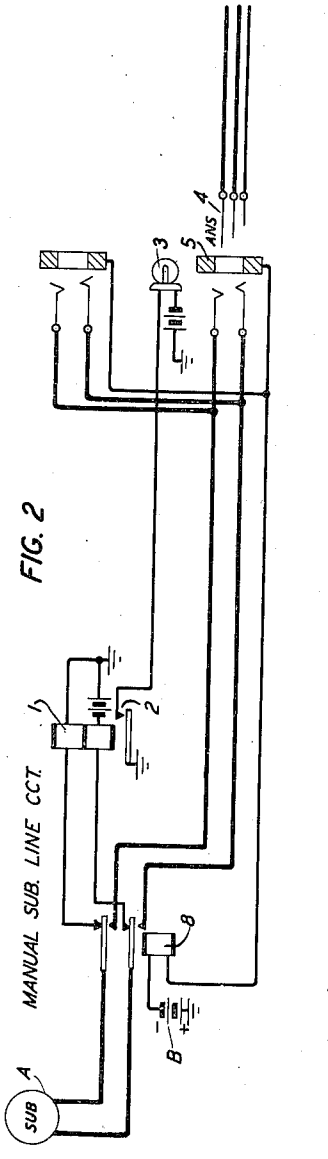


FIG. 8

FIG. 1 & FIG. 2	FIG. 3	FIG. 6
	FIG. 4	FIG. 7
	FIG. 5	

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FIG. 3

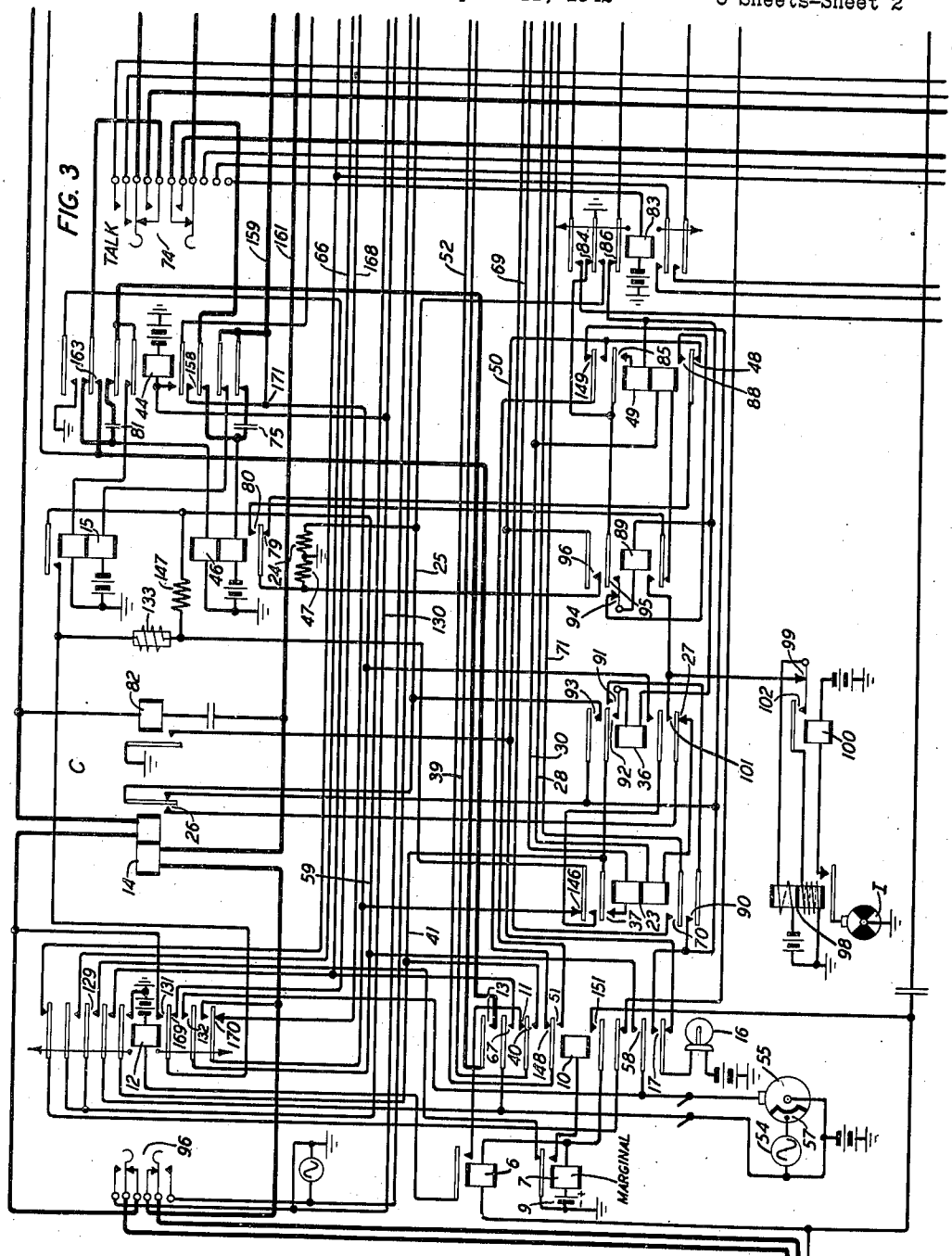

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FIG. 4

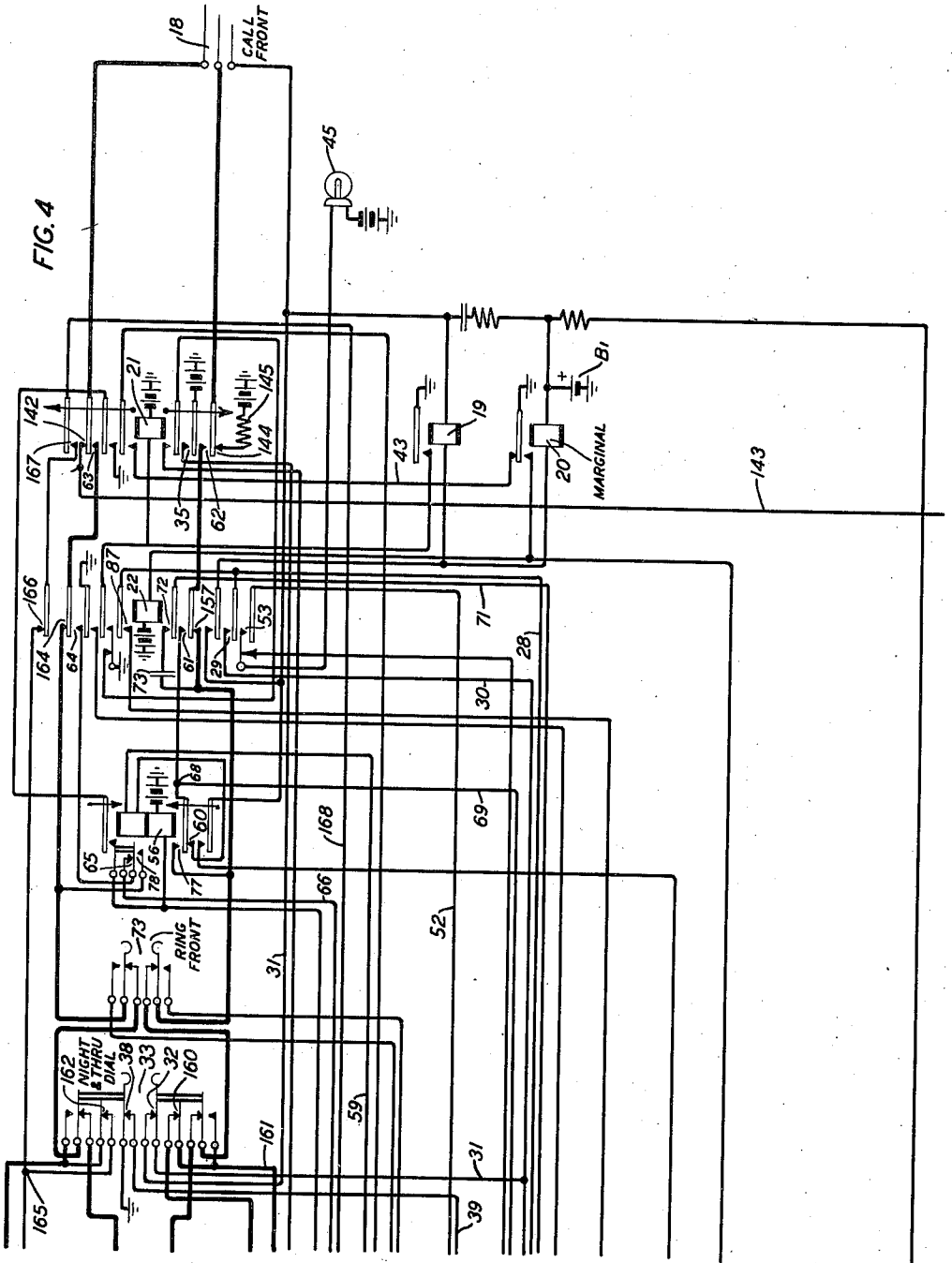

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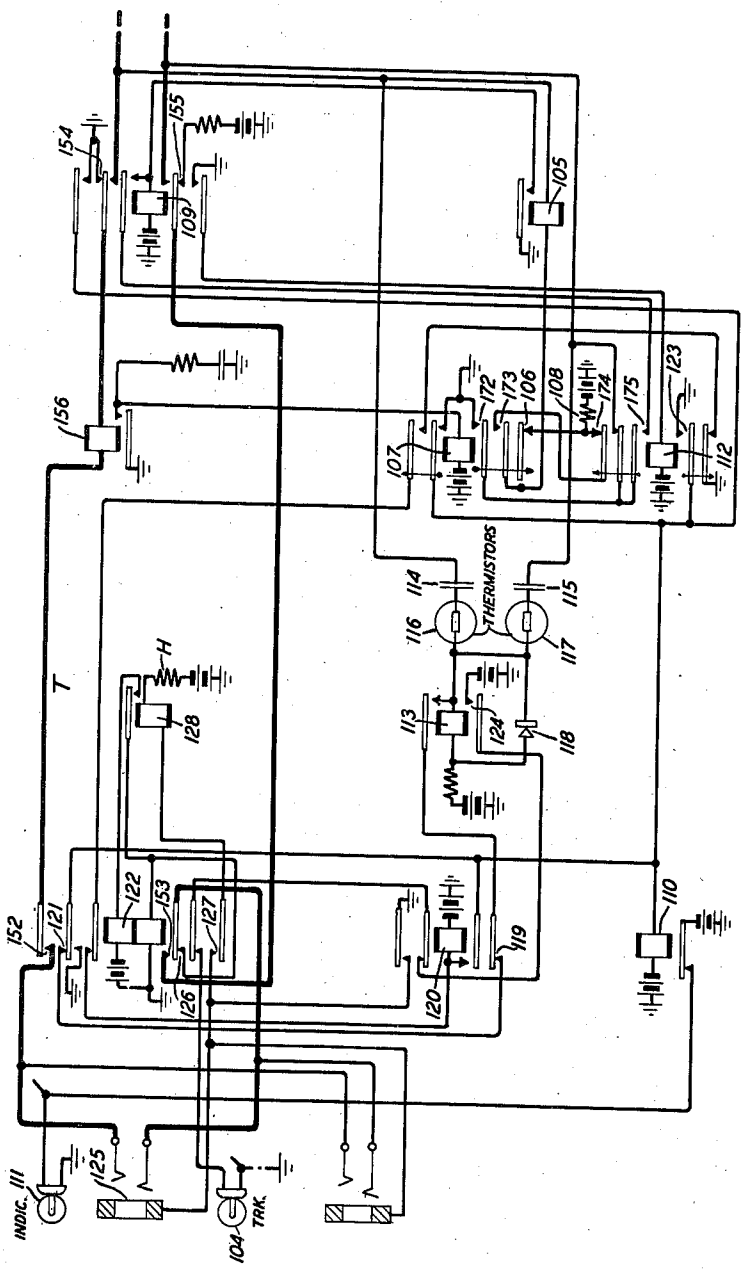
FIG. 5



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PRIVATE BRANCH EXCHANGE SYSTEM

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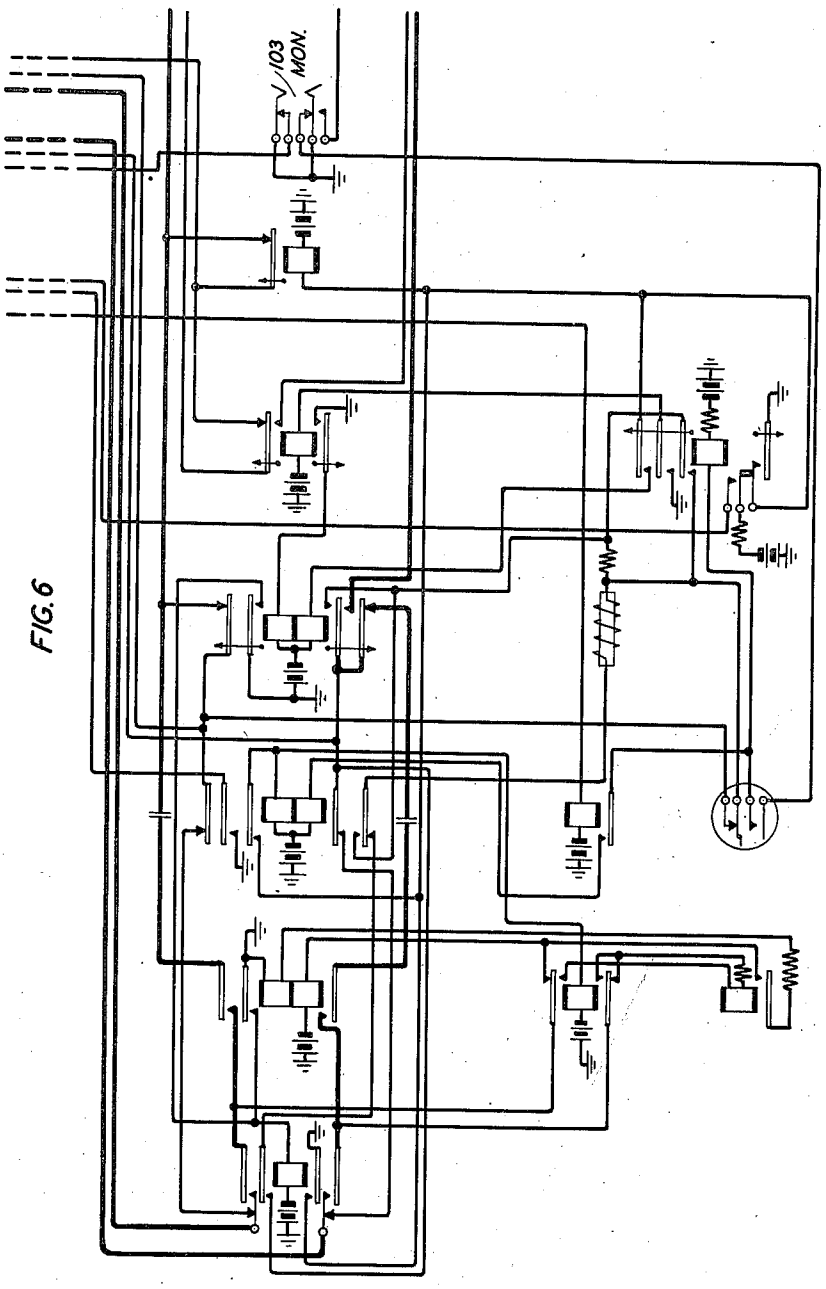

FIG. 6

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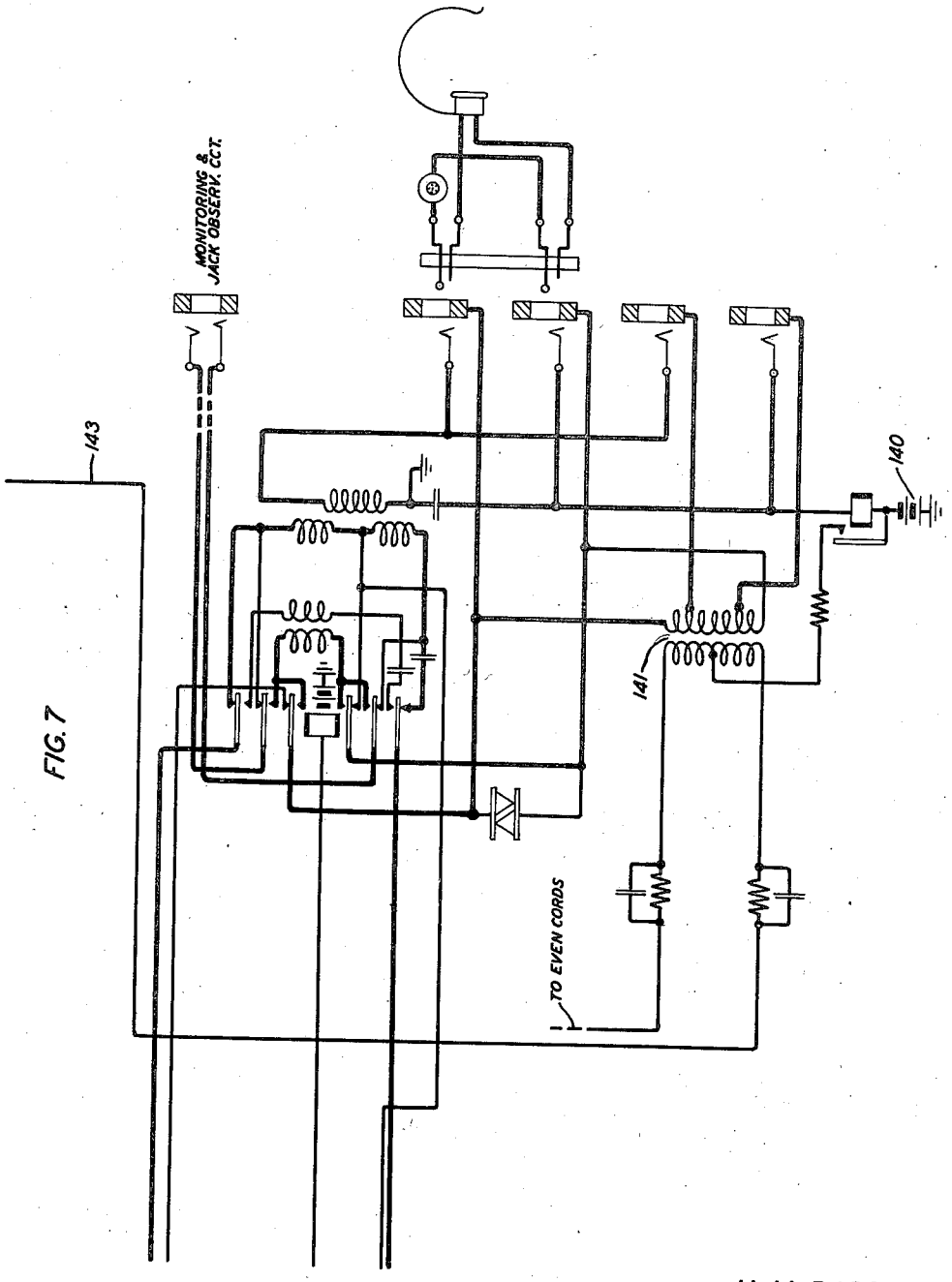

FIG. 7

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Patented Aug. 24, 1943 2,327,851

UNITED STATES PATENT OFFICE

2,327,851

PRIVATE BRANCH EXCHANGE SYSTEM

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Application April 11, 1942, Serial No. 438,580

9 Claims. (Cl. 179—27)

This invention relates to telephone systems and more particularly to automatic private branch exchanges of large capacity employing a manual switchboard for (*a*) answering and extending incoming calls from a central office to a local subscriber's line, either dial or manual, or to a tie-line to another private branch exchange, (*b*) for extending calls from a local manual subscriber's line, or a tie-line, to a central office, (*c*) for completing calls between a local station and a tie-line in either direction, or (*d*) for completing calls in either direction between two local manual stations or between a manual station and a dial station.

In some cases where an existing private branch exchange equipment has a definite maximum capacity and whose line circuit arrangements are of a certain type, it may become necessary to greatly increase the number of lines to be served beyond the maximum capacity of the present equipment and, to avoid the necessity of adding extra equipment to the present line circuits of the exchange in order to function in the desired manner, the present circuits have been developed. More specifically, United States Patent 1,747,849 shows a subscriber's line circuit terminating in a jack in a manually operated switchboard which jack is provided with a set of auxiliary springs which close upon the insertion of a plug to, thereby, connect ground to operate the cut-off relay. In this arrangement, the jack sleeve is normally "dry," i. e., has no connection to either battery or ground. When the cut-off relay operates, the sleeve of the jack is grounded to control sleeve relays in the cord and provides a busy test in the case of a multiple switchboard. The jacks employed in this switchboard necessarily occupy a greater space in the face of the board than jacks having only tip and ring springs and switchboards so equipped have, in the past, been limited to exchanges having a capacity of the order of less than 2,000 lines.

Larger private branch exchanges have been developed having a capacity of the order of 5,000 lines and the switchboards, used therewith, have been arranged with circuits in accordance with United States Patent 1,866,260, the lines of which terminate at the manual board in smaller jacks having only tip and ring springs as shown in Fig. 1 of the patent. In this arrangement it will be noted that the jack sleeves of the station lines are connected to ground in series with a sleeve relay which operates, when a plug is inserted, from battery on the sleeve of the cord to connect ground to operate the cut-off relay in the line circuit. Such an arrangement while employing smaller jacks than the board first mentioned, requires an extra relay per line.

In case it is desired to substantially increase the number of lines in existing exchanges of the type first mentioned, i. e., a much larger manual board would be required due to the fact that jacks having auxiliary ground springs are required which auxiliary springs occupy a relatively large space in the face of the board, and such large capacity boards are not available and further would be impractical.

On the other hand if a manual board of the second type is used, as described in Patent 1,866,260 in order to serve the increased lines, which board employs the smaller type of jack having only tip and ring springs, then the existing line circuits of the exchange must be rewired and a sleeve relay, such as 194 of Fig. 1 of the patent, must be added and a more expensive line circuit used for the additional new lines.

The present invention therefore provides circuit arrangements for a new manual switchboard of the desired large capacity which employs the smaller type jack, together with certain relatively inexpensive modifications in the automatic exchange circuits whereby all present operating features are retained and additional features made available without any extensive additions to the present line circuit equipment or in any material increase in the cost of the additional line equipment required.

An object of the present invention is to simplify and reduce the cost of private branch exchange systems of the type described.

A further object is to enable an operator to connect to a subscriber's line which is busy, due to the connection of an automatic switch thereto, in order to talk with subscriber, in an emergency.

The principal feature of the invention whereby all operating features of existing switchboards are retained, the foregoing objects obtained, and jacks having only tip, ring and sleeve terminals are required, resides in connecting the line cut-off relay, in series with the central office battery, directly to the sleeves of the multiple switchboard jacks and in the connection of an independent low voltage (six volt) battery in the sleeve circuit of the switchboard cord circuit so poled that the positive terminal is toward the sleeve of the plug, i. e., a low voltage positive battery is connected in both the answering and calling sleeves of the cord

in place of the usual negative central battery of the order of 48 volts.

Other features reside in further modifications of certain arrangements of the cord, and of the line, trunk, and automatic switching equipment in which the cord is to be used, which provide the necessary operating functions of the system, which features will appear from the following description when read in connection with the accompanying drawings:

Fig. 1 of which shows a dial subscriber's line appearing in the banks of step-by-step line finders and connectors and also in multiple jacks located in the face of an operator's switchboard.

Fig. 2 shows a manual subscriber's line circuit also appearing in jacks at the switchboard.

Fig. 5 shows the line circuit of a central office trunk; and,

Figs. 3, 4, 6 and 7, when arranged in accordance with Fig. 8 show a cord, position, and operator's telephone circuit, the answering or rear plug of which is shown, for convenience, opposite Fig. 2.

Station to station connection

In describing the operation of the system of the present invention it will be first assumed that a manual station A (Fig. 2) calls and desires to be connected to a similar manual station (not shown), whereupon the line relay 1 operates in a well-known manner thereby closing its contacts 2 to light the line lamp 3 at the switchboard. When the operator answers by inserting the answering plug 4, of her cord circuit C (Fig. 2), in jack 5, relays 6 and 7 in the cord sleeve operate in series with cut-off relay 8 of the line which circuit can be traced from the negative pole of central office battery B (usually 48 volts) through winding of relay 8, over the sleeve contacts of jack 5 and plug 4 and windings of relays 6 and 7 to the positive side of the independent battery 9 whose negative pole is connected to ground. The battery 9 is of relatively low potential with respect to central office battery B (in practice of the order of 6 volts) and is in series-aiding relation thereto, and relays 6, 7 and 8 operate.

Relay 8 in operating disconnects the line relay 1 which in releasing extinguishes the line lamp 3. Relay 8 also connects the line through to the tip and ring of the answering plug 4 of the cord circuit. Operation of relay 6 performs no useful function at this time but relay 7, in operating, closes the circuit for relay 10 which opens its contact 11 thereby preventing relay 12 from operating and at its contact 13 closes the tip conductor of the cord through to ground in series with the right winding of answering supervisory relay 14 and the upper winding of relay 15. Relay 10 in operating also closes at its contacts 151 to short circuit relay 6 thereby reducing the resistance of the sleeve circuit to a low value.

Relays 14 and 15 operate in series with the subscriber's line. Operation of the supervisory relay 14 opens at another point the circuit for the answering supervisory lamp 16 which circuit was partially closed at contact 17 of relay 10 when that relay operated.

The operator after receiving the required information from the calling station makes the usual busy test with the tip of calling plug 13 and, assuming the called line is idle and similar to the line of station A inserts calling plug 18 (Fig.4) in the jack whereupon the cut-off relay, corresponding to relay 8 of Fig. 2 and relays 19 and 20 in the calling end of the cord (Fig. 4) operate in series in a circuit extending from negative central office battery, winding of the line cut-off relay, winding of relays 19 and 20, and positive battery B1 to ground. In this connection it is assumed that the resistance of the cut-off relay of the subscribers' lines is of the order of 1200 ohms, relays 6 and 19 are 100 ohms each and relays 7 and 20 are 31 ohms each. Operation of the cut-off relay in the called line performs the usual function of disconnecting the line relay from the line and connecting the line through to the tip and ring springs of the jack. Operation of relay 19 closes an obvious circuit to operate relay 21, and relay 20 operates relay 22 which latter relay in operating, in conjunction with the previous operation of the answering supervisory relay 14 and relay 21, closes a circuit to operate relay 23 which circuit can be traced from ground, resistance 24, conductor 25, contact 26 of relay 14, contacts 27 of relay 36, lower winding of relay 23, conductor 28, contact 29 of relay 22, conductors 30 and 31, contacts 32 of the night and through dial key 33, conductor 34, and contact 35 of relay 21 to battery. Relay 23 in operating locks, through its upper winding and contacts 37, under control of relays 10 and 21 in the following circuits: Ground, contacts 38 of key 33, conductor 39, contacts 40 of relay 10, conductor 41, contacts 37 and upper winding of relay 23, conductors 30 and 31, contacts 32 of key 33, conductor 34, and contacts 35 of relay 21 to battery.

The operation of relay 20 opens its uppermost contact thereby disconnecting ground from conductor 43 and preventing the operation of relay 44 when relay 21 operates. Operation of relay 22 lights the calling supervisory lamp under control of relays 46 and 10, the circuit for which can be traced from ground, resistance 47, back contacts of relay 46, contacts 48 of relay 49, conductor 50, contacts 51 of relay 10, conductor 52, contacts 53 of relay 22, and lamp 45 to battery. With the foregoing relays in the cord circuit operated, i. e., relays 6, 7, 10, 14, 15, 19, 20, 21, 22 and 23, alternating current from the source 54, in series with a battery and interrupter 55, is applied to the called line in series with the upper winding of tripping relay 56, the circuit for which can be traced from grounded battery, ringing generator 54, brush of interrupter 55 when it is in contact with the ringing segment 57, contacts 58 of relay 10, conductor 59, upper winding and contacts 60 of relay 56, contacts 61 of relay 22, contacts 62 of relay 21, ring of the plug 18, ring conductor of the called line, through the ringer at the called station, back over the tip of the line and plug 18, contacts 63 of relay 21, contacts 64 of relay 22, contacts 65 of of relay 56, conductor 66, contacts 67 of relay 10 to the grounded terminals of battery in series with the ringing generator. Connected at a point 68 between the inner lower armature of relay 56 and contacts 61 of relay 22 a circuit in series with a condenser 73 extends to the ring conductor of the answering end of the cord and thence to the calling station as an audible ringing signal. This circuit can be traced from the point 68, conductor 69, contacts 70 of relay 23, conductor 71, contacts 72 of relay 22, condenser 73, and thence over contacts of the ringing key 73, the night key 33, talk key 74, relay 44, condenser 75, winding of supervisory relay 14, and rear ringing key 76 to the calling line and thence

back over the tip of the line and eventually to ground in series with the upper winding of relay 15.

When the called station answers, the tripping relay, which is in series with the previously traced ringing circuit operates in the usual manner to disconnect, at its contacts 60, the ringing current from the called line, and short-circuits at its contact 77, the condenser 73, in a circuit including contacts 77 of relay 22, conductor 71, contacts 76 of relay 37 and conductor 69. Closure of contacts 77 and 78 of the tripping relay also connects the calling end of the cord to the battery and ground in series with relay 46 which operates in series with the called station whose receiver is now off the hook. Operation of relay 46 opens its contact 79 thereby extinguishing the calling supervisory lamp 44 and by closing its contacts 80 causes relay 49 to operate from battery at contacts 35 of relay 21. Relay 49 in operating locks under control of relays 83, 21 and 22 in a circuit which can be traced from ground, contacts 84 of relay 83, contacts 85 and upper winding of relay 49, contacts 86 of relay 83, contacts 87 and 29 of relay 22, conductors 30 and 31, contacts 32 of talk key 33, conductor 34, and contacts 35 of relay 21 to battery. Operation of relay 49 closes its contacts 88 which prepares a circuit to operate relay 89 when relay 46 releases due to the called subscriber replacing his receiver on the hook.

At this point when the calling and called stations are interconnected for conversation, we can summarise as follows: (*a*) battery and ground for the calling station is supplied in series with relays 14 and 15; (*b*) battery and ground for the called station is supplied in series with relay 46; (*c*) the answering and calling ends of the cord are connected by condensers 75 and 81; (*d*) no bridge exists across the tip and ring conductors of the cord other than the ringing relay 82 which has no useful function at this time.

Disconnect

When the calling subscriber replaces his receiver on the switchhook, relays 14 and 15 release. Relay 14 in releasing closes its back contacts thereby completing a circuit to operate relay 36 which can be traced from ground, resistance 24, conductor 25, back contact of relay 14, contact 90 of relay 23, contact 91 and winding of relay 36, contact 86 of relay 83, contacts 87 and 29 of relay 22, conductors 30 and 31, contacts 32 of key 33, conductor 34 and contacts 35 of relay 21 to battery. Relay 36 in operating locks over its contacts 92 in a circuit which can be traced from battery, contact 35 of relay 21, conductor 54, contact 32 of key 33, conductors 31 and 30, contacts 29 and 87 of relay 22, contact 86 of relay 83, winding and contacts 92 of relay 36, conductor 41, contact 40 of relay 10, conductor 39 and contacts 38 of key 33 to ground.

When relay 14 released, the supervisory lamp 16 was lighted over contacts 17 of relay 10 and closure of contacts 93 of relay 36 shunted the back contacts of relay 14 thereby holding the lamp lighted under control of relays 10 and 36.

When the receiver at the called station is replaced on the switchhook relay 46 releases causing relay 89 to operate under control of relays 83, 22 and 49 in a manner similar to the operation of relay 36, i. e., from ground, resistance 47, contact 79 of relay 46, contacts 88 of relay 49, contacts 94 and winding of relay 89, contacts 86 of relay 83 and thence to battery over contacts 87 and 29 of relay 22, conductors 30 and 31, contacts 32 of key 33 and conductor 34 and contact 35 of relay 21 to battery. Relay 89 in operating locks over its contacts 95 to ground at contacts 84 of relay 83 and at contacts 96 closes the circuit to relight supervisory lamp 45 in the calling end of the cord; this circuit can be traced from ground, resistance 47, contacts 95 of relay 89, conductor 50, contacts 51 of relay 10, conductor 52, contacts 53 of relay 22 and lamp 45 to battery.

Flashing recall

If before the answering and calling plugs are removed the calling station again removes his receiver to recall the operator, supervisory relay 14 reoperates thereby opening its back contact and closing its front contact 26 thereby causing supervisory lamp 16 to flash as a recall signal. This arrangement is well known and described in United States Patent 1,866,260, see Fig. 4, but can be briefly described as follows: closure of contacts 26 of relay 14 completes the following circuit: battery, low resistance upper winding of relay 98, contacts 99 of relay 100, contacts 101 of relay 36, contacts 26 of relay 14, contacts 93 of relay 36 and contacts 17 of relay 10 to one terminal of lamp 16, the other terminal of which is also connected to battery thereby establishing a low resistance (2 ohm) shunt around the lamp causing it to be extinguished. Relay 98 operates in this circuit thereby closing its contacts to connect ground, interrupted at a predetermined rate by interrupter I, to relay 100 which, when operated, opens its contacts 99 thereby removing the shunt from lamp 16 and permitting it to relight. Relay 100 also closes its contacts 102 thereby completing a holding circuit for relay 98 including its lower and high resistance winding. When the interrupter removes ground from relay 100 this relay releases and recloses contacts 99 and replaces the shunt around lamp 16 which lamp is again extinguished. This operation continues until the operator actuates the talk key 74 which operates relay 83 in an obvious circuit to ground at contacts of the monitoring key 103 (Fig. 6). Release of relay 83 opens, at its contacts 84 and 86 the holding circuit for relay 36 which releases and extinguishes the lamp.

A recall by the called subscriber is effected in the same manner as previously described by the calling subscriber and will not be repeated.

Connection of the operator's telephone with the cord under control of the talk key 74 forms no part of the invention claimed and as it follows well known practice will not be described.

Central office to station connection

We will now assume that a call is initiated at the central office, not shown, over trunk T (Fig. 5) which causes the trunk lamp 104 to light as follows: When the trunk is seized at the central office, which we will assume is arranged for machine ringing, ground is connected to the tip during the silent interval of the ringing cycle thereby causing relay 105 to operate in a circuit to battery including the winding of relay 105, contacts 106 of relay 107, and resistance 108. Relay 105 operates relay 109 which (*a*) connects the trunk through to the jack circuit, (*b*) connects ground to operate relay 110 which extinguishes the idle indicating lamp such as 111 which are normally lighted, and (*c*) operates relay 112. When ringing current is applied to the trunk at the central office relay 113, which is connected between battery and ground and both the tip and ring of the line by means of condensers 114 and

115, and "thermistors" 116 and 117, operates. A rectifier 118 is connected in shunt to the relay 113. The thermistors 116, 117 are devices which have the characteristic of rapidly decreasing in resistance with an increase in applied potential, i. e., at zero potential they have a normal high resistance of the order of 50,000 to 75,000 ohms and decrease in about one half second to about 1,000 ohms when normal ringing potential is applied. The impedance of relay 113, at ringing frequency (20 cycles), is so high that ringing current applied to either side of the line will not flow through the respective thermistor to operate the relay and therefore the rectifier 118 is connected in shunt to this relay so that one half of each cycle of the ringing current will by-pass the relay thereby causing the respective thermistors to reduce its resistance to a value such that it will pass sufficient current. When this occurs the other half cycle, which is not blocked by the rectifier, flows through the relay 113 causing its operation. The thermistor connected to the opposite side of the line, i. e., the side which is grounded at the central office during ringing, is so high in resistance compared with the resistance of relay 113, plus the resistance to battery, that sufficient ringing current will flow to ground through relay 113 to cause its operation. The reason for providing a connection between the relay 113 and each side of the line is due to the fact that under certain conditions ringing current at the central office may be applied to the ring and under certain other conditions to the tip. This arrangement which includes the thermistors 116 and 117 is for the purpose of preventing false operation of relay 113 on current reversals which may occur on the central office line and also to prevent this relay from operating when dial pulses are being transmitted to the central office.

While ringing current is being applied at the central office, relay 105 remains operated due to ground on the tip conductor of the trunk, assuming that ringing current is being applied to the ring. When relay 113 operates it locks over its upper contact in the following circuit: battery, winding and upper contact of relay 113, contact 119 of relay 120, contacts 121 of relay 122 and contacts 123 of relay 112 which relay was operated in response to seizure of the trunk at the central office. Closure of contacts 124 lights trunk lamp 104 in an obvious circuit.

When the operator answers by fully seating the answering plug 4 in jack 125 so that contact is made between the ring of the plug and the ring spring of the jack, battery on the ring of the answering plug causes partial operation of relay 122 over its contacts 126 and lower winding which causes its contacts 127 to close thereby operating relay 128 over the sleeve of the cord including relays 6, 7 and the low voltage positive battery 9. The combined resistance of resistance H which is in series with relay 128 and the winding of relay 123 is sufficiently high to prevent cord sleeve relay 7, which is marginal, from operating, and due to this fact relay 10 does not operate under this condition, i. e., connection of the cord to a central office trunk having a relatively higher resistance sleeve circuit than the sleeve circuit of a subscriber's line, as previously considered.

Sleeve relay 6, however, does operate in the foregoing circuit which closes a circuit, at its front contacts, to operate relay 12 which includes contact 11 of relay 10. Relay 12 in operating closes a circuit to operate relay 44 which can be traced to ground, back contact of relay 7, contacts 129 of relay 12, conductor 130 and winding of relay 44 to battery. Relay 12 also closes its contacts 131 and 132 thereby connecting the retardation coil 133 in bridge of the tip and ring of the answering end of the cord. Operation of relay 44 disconnects condensers 75 and 81 from the talking circuit of the cord, disconnects the battery feed relay 15 from the tip and ring of the answering cord, disconnects the battery feed relay 46 from the tip and ring conductors of the calling end of the cord, and connects the tip and ring conductor of the answering cord directly to the corresponding conductors of the calling cord.

When relay 128 of the central office trunk operated, it connected the upper and lower windings of relay 122 in series between battery and ground causing this relay to fully operate which thereupon disconnects its lower winding from the ring of the trunk, closes the tip and ring through from the jack to the central office line, provides a separate ground for holding relay 110 operated, releases relay 113, and opens the circuit of the trunk lamp 104 which is thereupon extinguished.

At this point the operator actuates the cord circuit talk key 74, thereby connecting her telephone set (Fig. 7) to the cord, and obtains the number of the wanted subscriber which we will assume to be subscriber D (Fig. 1) whose station is equipped with a dial and has access to, and is accessible from, an automatic exchange by means of line finders LF and connector CON, respectively. Subscriber D is also accessible from the manual switchboard by means of multiple jacks 138 and 139. Patent 1,799,654 (Fig. 1) shows a line finder of the type in question.

The line circuit for subscriber D employs a line relay 136 and cut-off relay 137 which perform the usual functions.

The operator upon ascertaining that subscriber D is wanted tests the sleeve of jack 138 or 139 with the tip of plug 18 in the usual manner. If the line is idle the jack sleeve will be at the full negative potential of the central office battery, i. e., 48 volts, which is the same potential source as the battery 140 connected to the busy test circuit (Fig. 7) and therefore the potential at both ends of the lower left winding of transformer 141, in the operator's telephone circuit, will be equal and no click will be heard in the operator's receiver. In case, however, the line is engaged by the connection of either a line finder or connector thereto, the sleeve circuit will be grounded and a click will be heard in the receiver, and further the connection of a plug such as 4 to jack 139, for example, connects the six volt positive battery 9 to one end of the lower left winding of coil 141, which will also produce a click in the operator's receiver.

In case the line is idle, the operator will insert plug 18 in one of the multiple jacks (138 or 139) of the line appearing at her position thereby operating cut-off relay 137 which disconnects line relay 136 from the line. Relay 137 operates in a circuit from negative 48 voltage battery, winding of relay 137, sleeve conductor of jack 138 or 139 and plug 18 and winding of relays 19 and 20 to the positive terminal of low voltage six volt battery, the negative terminal of which is connected to ground. Relay 19 operates relay 21 which in turn opens its contacts 142 thereby disconnecting the busy test lead 143 from the tip of plug 18. Relay 21 also opens its contacts 144 thereby disconnecting battery, through the resistance 145

from the ring conductor of the cord and at the same time closes its contacts 62 and 63 thereby connecting the tip and ring conductors of the calling cord through to relay 22. Operation of relay 20 caused relay 22 to operate at the same time as relay 19 and therefore with relays 21 and 22 operated ringing current is automatically applied to the called line in series with the upper winding of relay 56 in the following circuit. Ringing interrupter 55, contacts 58 of relay 10, conductor 59, upper winding of relay 56, contacts 60 thereof, contacts 61 of relay 22, contacts 62 of relay 21, ring conductor of the front or calling end of the cord, ring of the line, through the station telephone ringer, back over the tip of the line and cord, contacts 63 of relay 21, contacts 64 of relay 22, contacts 65 of relay 56, conductor 66 and contacts 67 of relay 10 to ground.

When the called station answers the tripping relay 56 operates as previously described, but instead of operating relay 46, relay 14 is operated due to the present operated condition of relay 44 which relay (14) operates in series with the central office battery and the called station telephone circuit. Operation of relay 14 causes relay 23 to operate, the circuit for which can be traced from ground, resistance 24, conductor 25, contacts 26 of relay 14, contacts 27 of relay 36, lower winding of relay 23, conductor 28, contacts 29 of relay 22, conductors 30 and 31, contacts 32 of key 33, conductor 34 and contacts 35 of relay 21 to battery. Relay 23 locks under control of relays 21 and 12 and opens its contact 146 thereby removing a short circuit which had previously been connected around the 850 ohm resistance 147. By removing this short circuit the resistance 147 is added to the resistance of the retard coil 133 which is connected across the tip and ring conductors of the cord when contacts 131 and 132 of relay 12 are closed. This increase in resistance of the bridge allows more current to flow through the transmitter of the called subscriber D.

We may now summarize the conditions of the above connection as follows (*a*) talking battery for the called station D is supplied over the trunk T and cord circuit C from the central office; (*b*) a relatively high resistance (1200 ohms) consisting of resistance 147 and retard coil 133, in series, is bridged across the tip and ring conductor of the cord C; and (*c*) the supervisory relay 14 is under control of the called station D.

When the receiver at station D is replaced on the hook relay 14 releases and operates relay 36 which lights the supervisory lamp 45 associated with the trunk or calling cord which is connected to the line of subscriber D. This circuit can be traced from battery, lamp 45, contact 53 of relay 22, conductor 52, contacts 148 of relay 19, contacts 149 of relay 49, contacts 93 of relay 36, conductor 25 and resistance 24 to ground.

It will be noted that when plug 18 is connected to either jack 138 or 139 of the called line, the jack sleeves instead of being at ground potential are six volts positive with respect to ground due to the low voltage battery B1 in series with relay 20 in the sleeve circuit of the calling end of the cord. In case a dial subscriber, not shown, whose line appears in a higher numbered terminal of the same line finder bank level as subscriber D, should originate a call, the line finder hunting for this calling line will, when it reaches the sleeve terminal of the line of subscriber D, encounter the low positive voltage applied by the plug 18 to the jack sleeve and this low voltage positive potential may be sufficient to operate the so-called B relay 150 identified as relay 55 in the before-mentioned Stokely Patent 1,799,654, and cause the switch to stop on the busy line. To avoid this false operation under the conditions described, a rectifying device 135 is connected in series with relay 150 in a direction which will prevent current of a positive potential on the brush 134 from flowing through the relay 150 thus insuring that it will not operate under the busy condition.

Emergency connection

The fact that the sleeve circuits of the cord C are connected to a positive 6 volt battery through low resistance sensitive and marginal relays such as 7 and 20 and that the cut-off relays in the station line circuits of Figs. 1 and 2 are connected to the sleeves of the jacks, such as 138, 139, and 5 in the manual board, the idle condition on these jacks is of the order of 1200 ohms to negative 48 volt central office battery and the busy condition is either a direct ground from the automatic switches in the case of the line of subscriber D or a slight positive potential when a cord is plugged into a jack. If the cord sleeve relays were connected to ground they would operate in series with the station cut-off relays such as 137 and 138 on regular connections but if the operator were to plug into a jack such as 138 or 139 which was busy due to a ground applied by the automatic switching equipment, the cord circuit sleeve relays would not operate thus preventing the operator from advising the subscriber D that an emergency call was waiting by preventing the closing through of the tip and ring conductors of the cord to the operator's telephone circuit. The failure of relay 19, for instance, to operate would prevent relay 21 from operating thus holding the tip and ring conductors of the cord open at contacts 63 and 62 of relay 21. Further, in case the operator disregarded the busy condition and inserted plug 18, into jack 138, for example, the tip of the line would be at ground potential and a steady current would flow through the busy test (lower left) winding of transformer 141, due to the fact that relay 21 did not operate and contacts 142 would therefore remain closed. Under this condition if a second cord should be used to test another line which was idle, due to the fact that the busy test lead 143, which is common to all the cord circuits at the position is grounded, a change in potential of the busy lead 143 would occur each time the tip of the second cord was brought into contact with an idle jack sleeve, thereby causing a false busy click in the operator's receiver.

By reason of the low voltage positive battery B1 in the sleeve circuit of the plug 18, the foregoing difficulties are obviated when this plug is inserted in the jack of a busy line, 138 for example, as relays 19 and 20 will operate to close a circuit to operate relay 21 which relay disconnects the busy test lead from the tip of the plug 18 and closes its contacts 62 and 63 to connect the tip and ring of the cord through to the talk key 74 thereby enabling the operator in an emergency to break in on an established automatic connection.

Station to central office connection

We will now assume that a call is initiated by station A for a station reached through a central office over trunk T (Fig. 5), whereupon

the line relay 1 operates in a well-known manner, thereby closing its contacts 2 to light the line lamp 3 at the switchboard. The operator answers as previously described by inserting the answering plug 4 in jack 5 whereupon relays 6 and 7 of the cord sleeve operate in series with the cut-off relay 8 of the line. Relay 8 disconnects the line relay which relay extinguishes the line lamp.

Operation of relay 6 performs no useful function at this time but relay 7 closes the circuit of relay 10 which opens its contacts 11, thereby preventing relay 12 from operating and at its contacts 13 closes the tip conductor of the cord through to ground in series with the right-hand winding of answering supervisory relay 14 and the upper winding of relay 15. Relay 10 in operating also closes, at its contacts 151, a short circuit for relay 6 thereby releasing and reducing the resistance of the sleeve circuit. Relays 14 and 15 operate in series with the subscriber's line and station. Operation of relay 14 opens at another point the circuit of the answering supervisory lamp 16 which circuit was partially closed at contacts 17 of relay 10 when that relay operated.

After receiving the required information from the calling station, the operator makes the usual busy test of the trunk jack 125 by touching the tip of plug 18 to the sleeve of the jack and, assuming the trunk is idle, inserts plug 18 in the jack whereupon relay 122 partially operates from battery on the ring of the cord in a circuit from battery, resistance 145, contacts 144 of relay 21, ring conductor of the cord and trunk, contacts 126 and lower winding of relay 122, to ground. Relay 122 is partially energized in this circuit and closes its contacts 127 to complete the sleeve circuit and operate relay 128 which operates in series with relays 19 and 20 and the low voltage positive battery B1 of the cord. Relay 128, and resistance H in series therewith, are of such a high combined resistance, however, that relay 20, which is of relatively low resistance and hence marginal, does not operate in this circuit. Relay 19, however, operates to energize relay 21 which relay in operating, while relay 20 is released, closes a circuit to operate relay 44. Relay 128 closes its contacts thereby fully operating relay 122 by connecting its upper and lower windings in series between battery and ground. Complete operation of relay 122 closes its contacts 152 and 153 to connect the trunk through to ground and battery at contacts 154 and 155 of relay 109 whereupon relay 156, in series with the tip conductor, operates in series with the subscriber's station in parallel with impedance bridge 133 and the battery and ground at contacts 154 and 155 of relay 109.

Operation of relay 44 disconnects battery feed relays 15 and 46 from the cord but relay 14 remains operated.

The trunk circuit between the battery and ground at relay 109, and the subscriber's station, can now be traced from battery, contacts 155 of relay 109, contacts 153 of relay 122, ring spring of the jack 125 and ring conductor of the plug 18, contacts 62 of relay 21, contacts 157 of relay 22, contacts of keys 73, 33 and 74, contacts 158 of relay 44, conductor 159, contacts 160 of key 33, conductor 161, left winding of relay 14, and thence over the ring of the calling line, back over the tip of the line, through the right winding of relay 14, contacts 162 of key 33, contacts 163 of relay 44, contacts of keys 74, 33 and 73, contacts 164 of relay 22, contacts 63 of relay 21, tip of the plug and jack, tip of the trunk, contacts 152 of relay 122, winding of relay 156, and contacts 154 of relay 109 to ground.

Impedance coil 133 is now connected in bridge of the tip and ring of the cord between supervisory relay 14 at the battery in a circuit which can be traced from point 165 in the tip conductor, contacts 166 of relay 22, contacts 167 of relay 21, conductor 168, contacts 169 of relay 12, winding of coil 133, contacts 146 of relay 23, and contacts 170 of relay 12 to point 171 in the ring conductor of the cord. Relay 156 operates in the closed trunk circuit just traced thereby operating relay 107 which relay closes its contacts 172 to connect ground to the ring conductor of the trunk leading to the central office which conductor is connected in series with a line relay (not shown) to battery. At this time the tip conductor is open at the central office.

When the operator answers ground will be connected to the tip of the trunk thereby operating relay 105 in a circuit including contacts 173 of relay 107, contacts 174 of relay 112, and resistance 108. Relay 105 operates relay 109 which closes the trunk through to the central office and disconnects ground and battery at its contacts 154 and 155. Relay 109 also closes its lowermost contacts to operate relay 112 which in turn closes its contacts 175 to lock relay 109 operated under control of relay 156.

What is claimed is:

1. In a common battery telephone system, a manual switchboard, an automatic exchange, manual and dial subscribers' lines appearing in multiple jacks of the switchboard, a predetermined negative potential source connected to the sleeve terminals of said jacks, said dial lines also appearing in automatic switches at said exchange which switches connect ground to the associated multiple jack sleeve when a line is seized thereby, a cord circuit at said switchboard for connecting to said lines a sleeve circuit in each end of the cord including means for conditioning said cord to conversation responsive to connection of either end of the cord to any idle one of said lines, and other means in each cord sleeve to cause said cord to be conditioned for conversation when said cord is connected to a dial line whose sleeve circuit is at ground potential.

2. In a common battery telephone system, a manual switchboard, an automatic exchange, manual and dial subscribers' lines appearing in multiple jacks of the switchboard, a predetermined negative potential source connected to the sleeve terminals of said jacks, said dial lines also appearing in automatic switches at said exchange which switches connect ground to the associated multiple jack sleeves when a line is seized thereby, a cord circuit at said switchboard for connecting to said lines, a sleeve circuit in each end of the cord including means for conditioning said cord for conversation responsive to connection of either end of the cord to any idle one of said lines, and other means in each cord sleeve to cause said cord to be conditioned for conversation when said cord is connected to a busy one of said lines.

3. In a common battery telephone system, a manual switchboard, an automatic exchange, manual and dial subscribers' lines appearing in multiple jacks of the switchboard, a predetermined negative potential source connected to the sleeve terminals of said jacks, said dial lines also

appearing in automatic switches at said exchange which switches connect ground to the associated multiple jack sleeves when a line is seized thereby, a cord circuit at said switchboard for connecting to said lines, a sleeve circuit at each end of the cord including relay means for conditioning said cord for conversation responsive to connection of the cord to a jack whose sleeve is at said predetermined negative potential, and means comprising a source of direct current in series with said sleeve relay means, and in a series-aiding direction with respect to said negative potential source when the cord is connected to a line, to insure conditioning of said cord for conversation when it is connected to a jack whose sleeve is at ground potential.

4. In a common battery telephone system, a manual switchboard, manual and dial subscribers' lines, multiple jacks at said switchboard terminating said subscribers' lines, a source of predetermined negative potential connected to the sleeve terminals of said jack, cord circuits at said switchboard for connecting to said lines, a sleeve circuit in each end of each cord, and means in each sleeve circuit for conditioning any cord for conversation responsive to connection of either end to any one of said lines regardless of its busy condition.

5. In a common battery telephone system, a manual switchboard, manual and dial subscribers' lines, multiple jacks at said switchboard terminating said subscribers' lines, a source of predetermined negative potential connected to the sleeve terminals of said jacks, cord circuits at said switchboard for connecting to said lines, a sleeve circuit in each end of each cord, and means in each sleeve circuit for conditioning any cord for conversation responsive to connection of either end thereof to any one of said lines regardless of its busy or idle condition, said means including a source of direct current of predetermined low potential in series-aiding relation to said negative potential source connected to the sleeve of the jack to which the cord is connected.

6. In a telephone system, lines of two different characters, a cord circuit for interconnecting a calling with a called one of said lines, means associated with said cord circuit responsive to the interconnection of two lines of one character by the cord for converting said cord into a bridged impedance battery feed type of cord, and means associated with said cord circuit responsive to the interconnection of two lines of different character for converting said cord to receive its battery feed from one of said lines, and other means associated with the cord for effecting said conversion regardless of the busy condition of the called line.

7. In a telephone system, a manual switchboard, subscribers' lines terminating thereat in multiple jacks, a source of negative potential connected to all the sleeves of said jacks, lines of other types also appearing in jacks at said switchboard and having sleeve potential characteristics differing from said subscribers' lines, cord circuits at said switchboard for interconnecting any two subscribers' lines or a subscriber's line and a line of said other type, a sleeve circuit in each end of each of said cords, and means in said sleeve circuits for conditioning a cord for conversation in one manner if one subscriber's line is calling, and the called line if another subscriber's line, and in different manners depending on whether the calling line is of said other type and the called line is a subscriber, or whether a subscriber's line is calling and the called line is of said other type, said sleeve means being effective to condition said cord for conversation in the proper manner regardless of the busy condition of the called line.

8. In a common battery telephone system, a manual switchboard, an automatic exchange, manual and dial subscribers' lines appearing in multiple jacks at the switchboard whose sleeve terminals have a predetermined resistance connection to negative battery, said dial lines also appearing in automatic switches at said exchange which switches connect ground to the associated multiple jack sleeves when a line is seized thereby, other lines having jack appearances at said switchboard whose normal sleeve conditions differ from that of said subscribers' lines, a cord circuit at said switchboard for interconnecting said lines having answering and calling ends, a sleeve circuit in each end of said cord, relay means in each sleeve circuit responsive to the interconnection in either direction of any two idle subscribers' lines to condition said cord in one manner for conversation, in another manner for conversation responsive to connection of the answering cord to a calling one of said other lines and the calling cord to an idle one of said subscribers' lines, and in a third manner when the answering cord is connected to a calling subscriber's line and the calling cord to an idle one of said other lines, and means to enable said cord to condition itself for conversation in the proper manner when either end of the cord is connected to a dial line jack whose sleeve terminal is at ground potential, said latter means including an individual low voltage positive battery in series with each cord sleeve circuit.

9. In a telephone system, a switchboard, first and second groups of lines of different characters terminating thereat in multiple jacks the sleeve terminals of which are at a predetermined potential with respect to ground when the respective lines are idle, and at a different potential when busy, a cord circuit for interconnecting two lines of the first group, or a line of the first group with a line of the second group, means responsive to the interconnection of two lines in the first group to condition said cord circuit in one manner, responsive to connection of a line in the first group with a line in the second group in one direction through the cord in another manner, and in the opposite direction through the cord in a third manner, all regardless of the busy condition of the called line, said means comprising a sleeve circuit at each end of the cord serially including a sensitive and a marginal relay and an auxiliary source of direct current whose potential differs materially from the idle potential of the sleeve of the connected line.

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