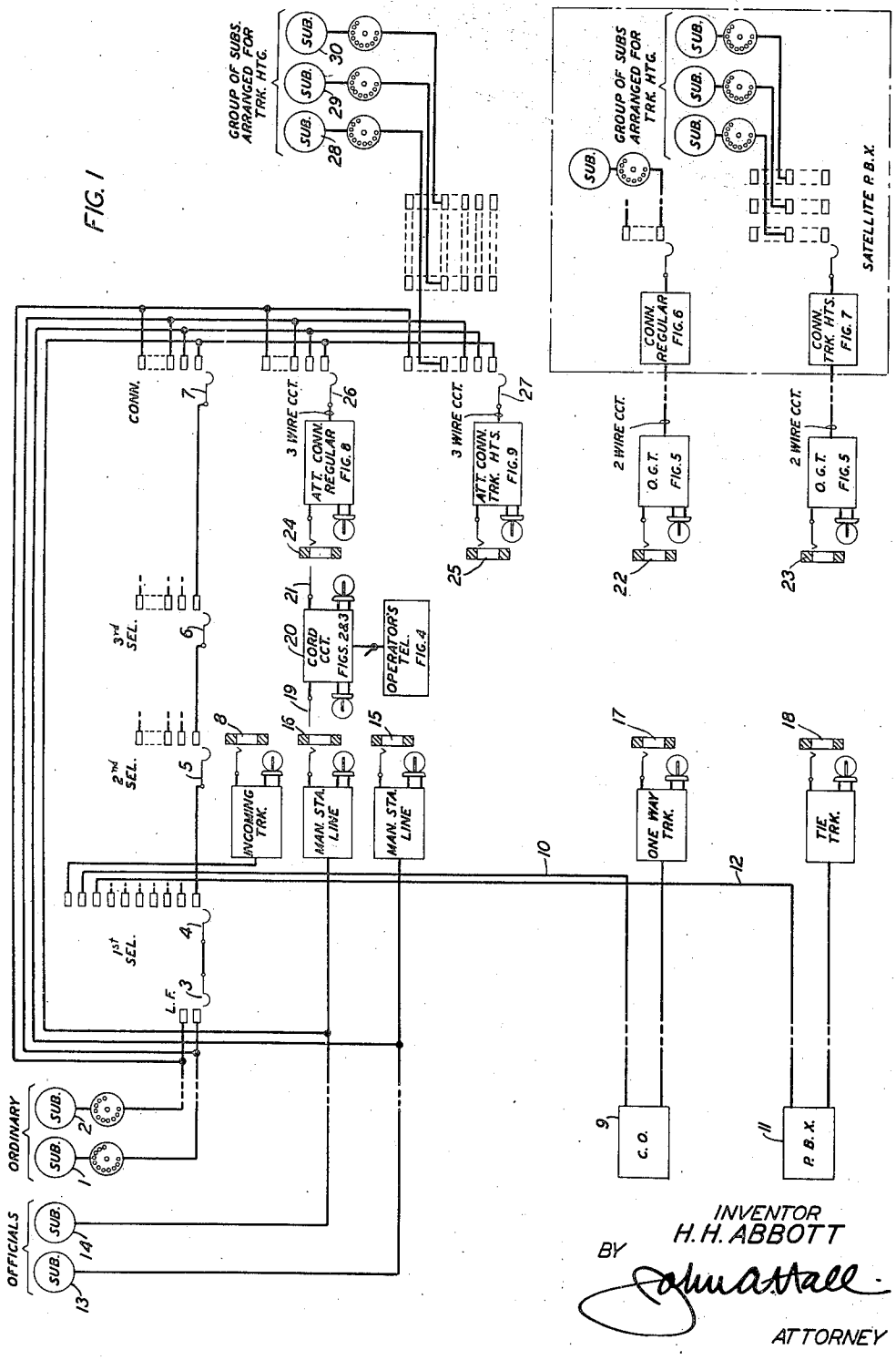
Aug. 24, 1943. H. H. ABBOTT 2,327,481

TELEPHONE SYSTEM

Filed July 22, 1942 9 Sheets-Sheet 1

FIG. 1



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TELEPHONE SYSTEM

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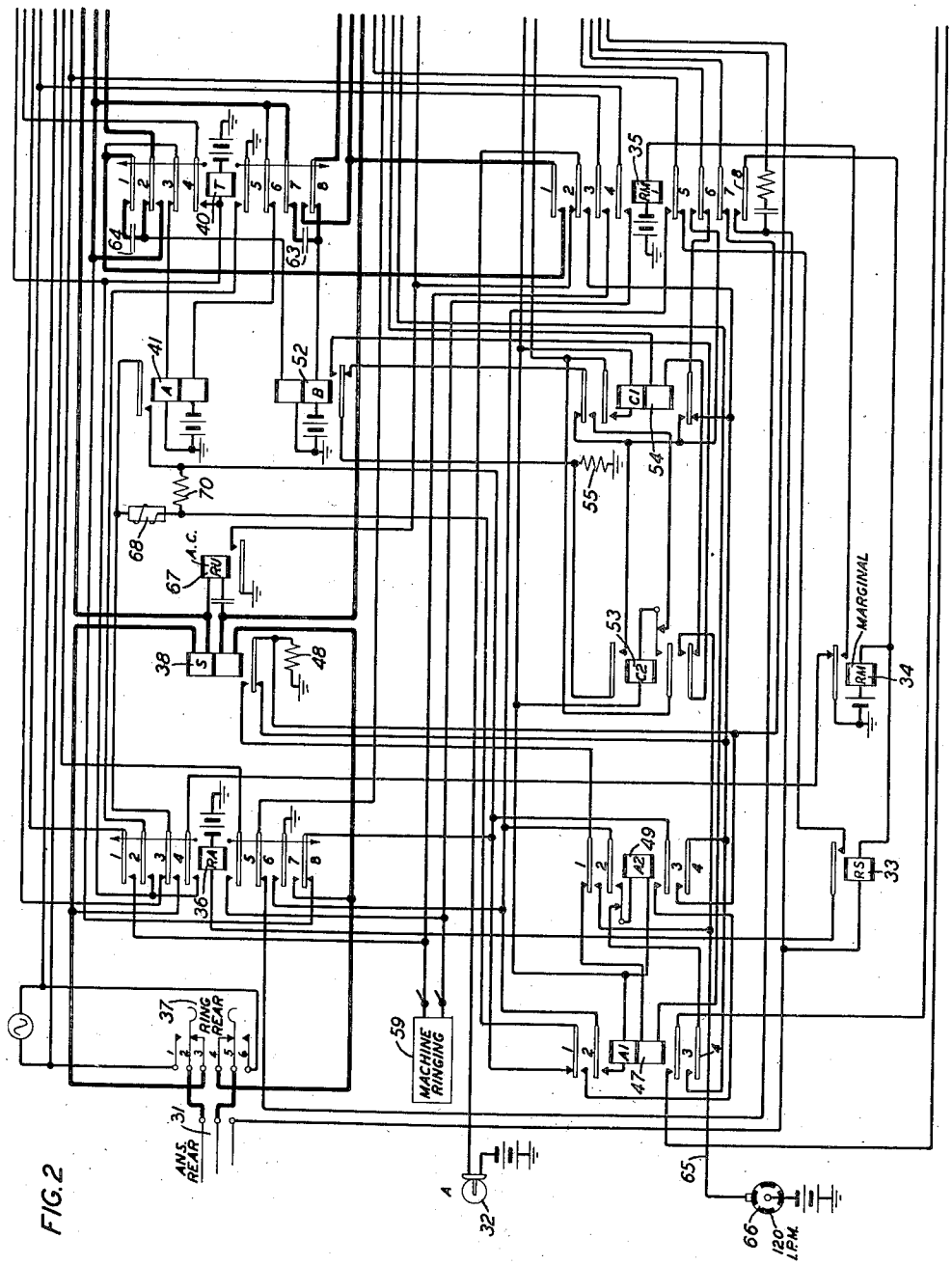

FIG. 2

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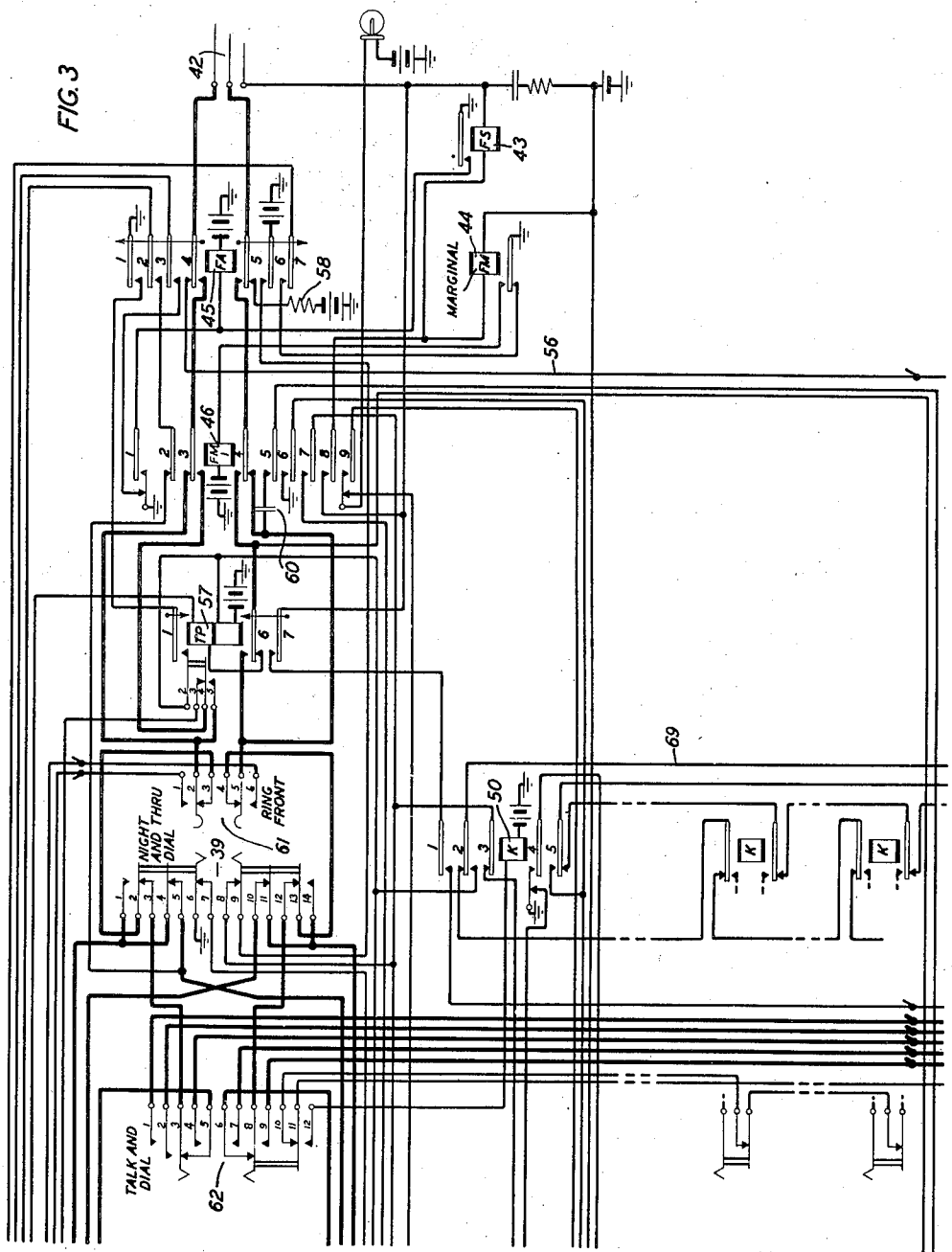
FIG. 3



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TELEPHONE SYSTEM

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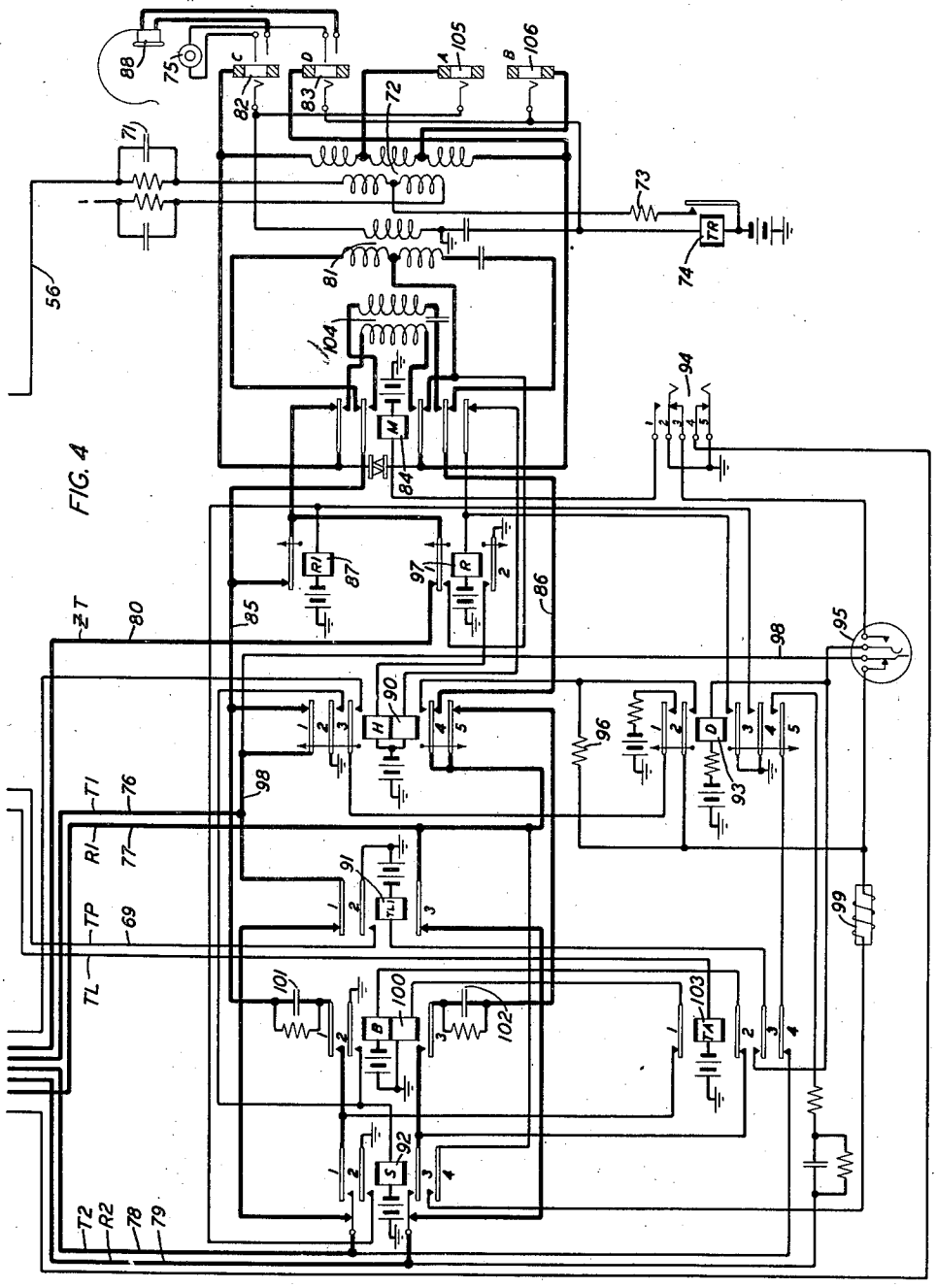

FIG. 4

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TELEPHONE SYSTEM

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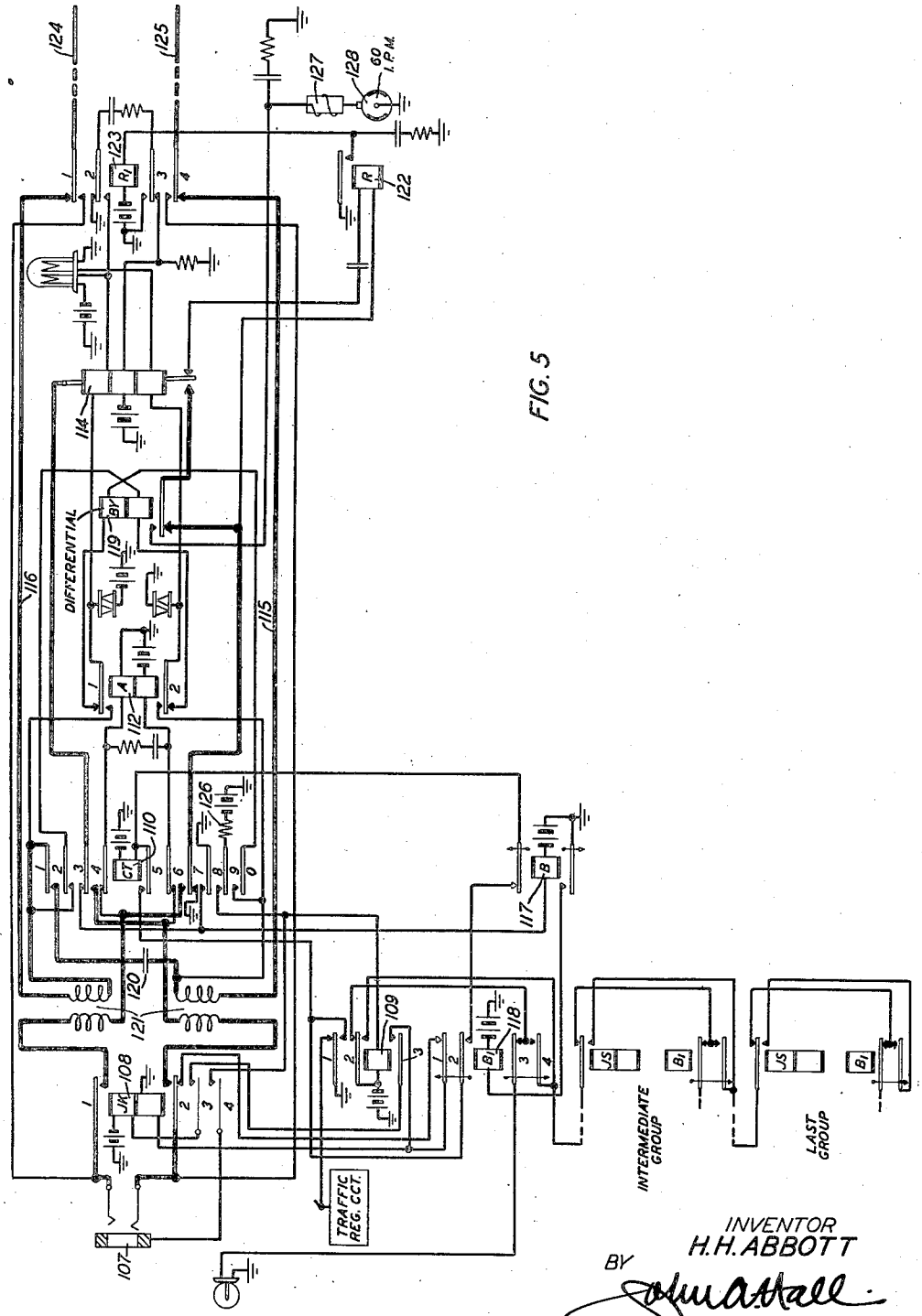

FIG. 5

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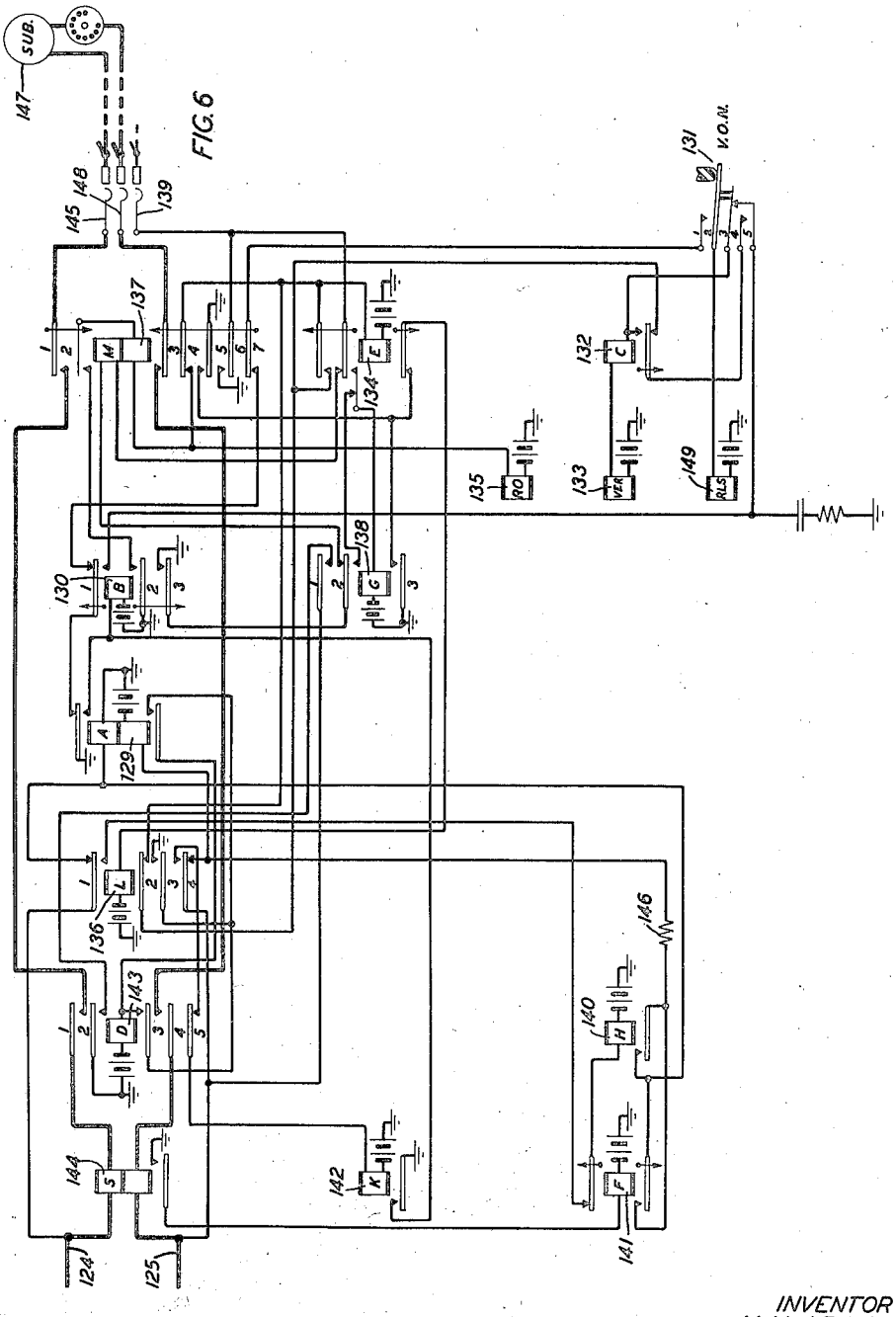

FIG. 6

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TELEPHONE SYSTEM

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FIG. 7

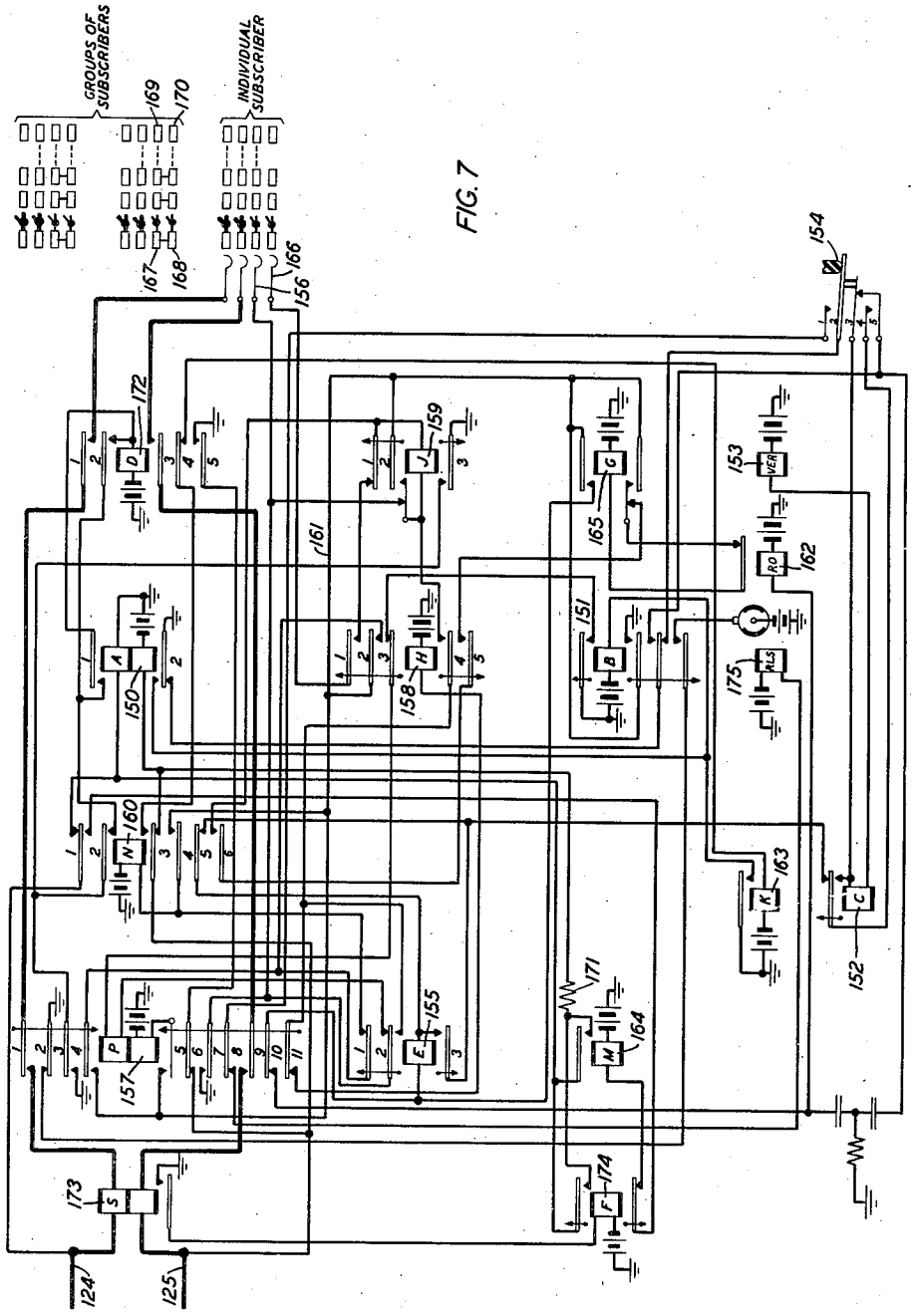

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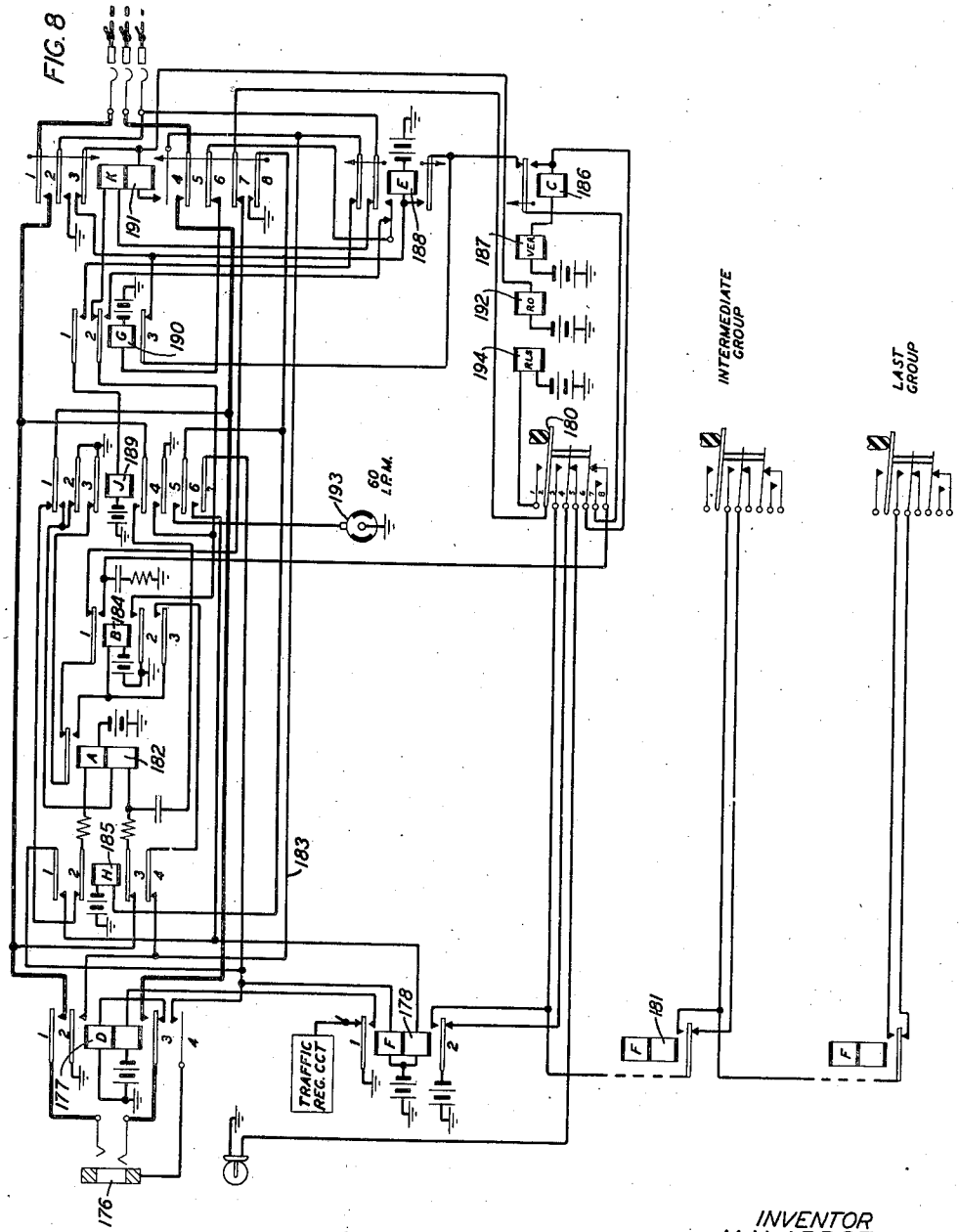
FIG. 8



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TELEPHONE SYSTEM

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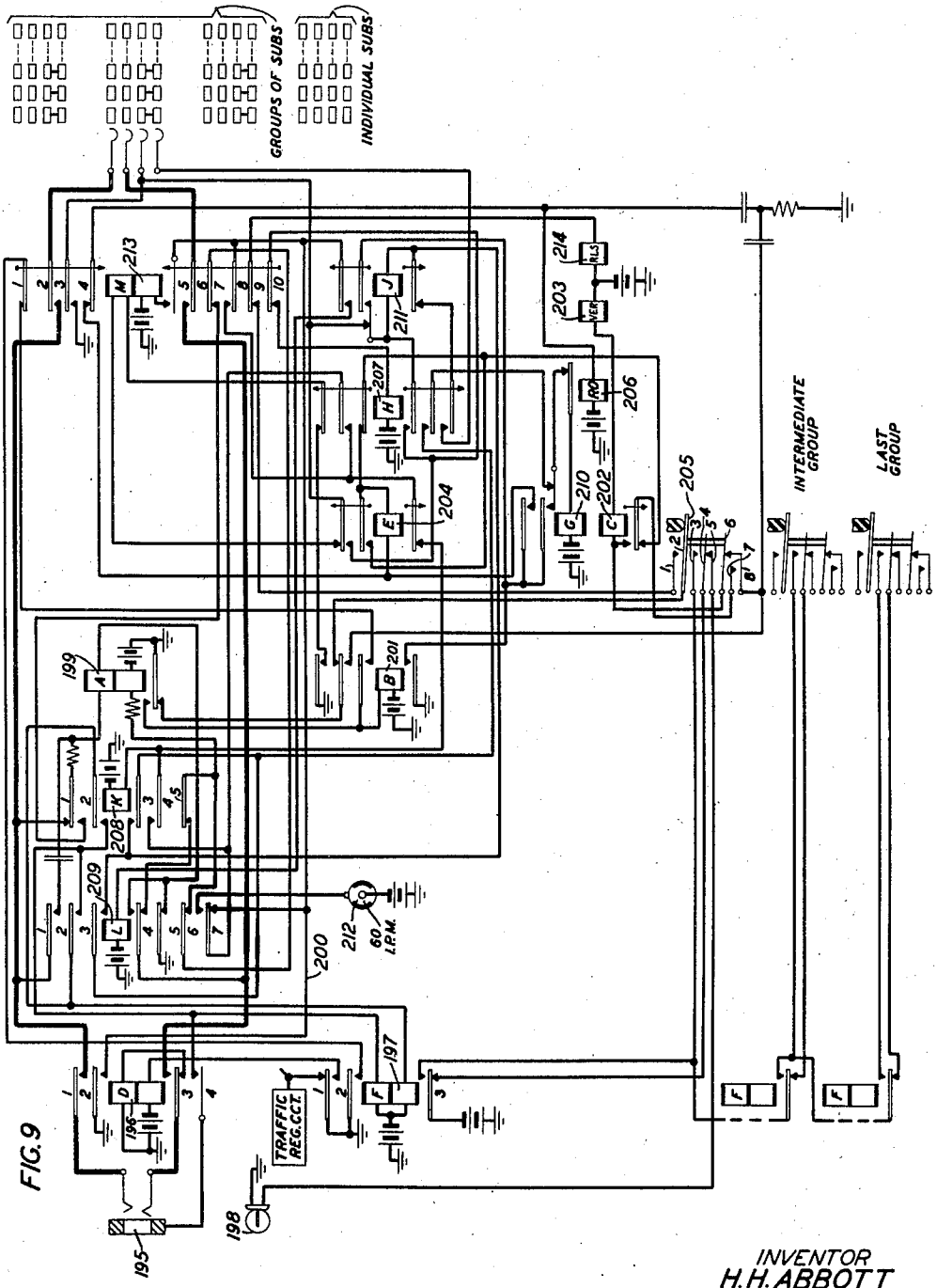

FIG. 9

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Patented Aug. 24, 1943

2,327,481

UNITED STATES PATENT OFFICE

2,327,481

TELEPHONE SYSTEM

Henry H. Abbott, Yonkers, N. Y., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application July 22, 1942, Serial No. 451,862

2 Claims. (Cl. 179—27)

This invention relates to telephone systems and particularly to private branch exchange systems wherein the lines are interconnected by automatic switches.

In large capacity private branch exchanges it is common practice to have an accompanying manual board by means of which incoming central office calls can be properly extended to the wanted subscriber. It is also common practice to have certain lines serving important offices answered by the operators. Furthermore, means are commonly provided so that any subscriber by dialing a special number may gain the services of an operator.

Where the capacity of a private branch exchange of this nature becomes large the limit of the capacity of the accompanying board is approached. This limit is fixed by the capabilities of the operators and the size of the line appearances which she may reach. The present invention provides a means for increasing the capacity of a private branch exchange very much beyond the ordinary capacity of the accompanying manual board. In accordance therewith the operators only partially complete a connection manually. Instead of having a line multiple before the operators a connector multiple is provided so that in completing a connection the operator plugs into a line designated by a portion of the digits of the wanted line and then dials the remaining digits.

It is generally conceded that a four-digit system is about the limit to the capacity of a manually operated switchboard. Hence, where the capacity of a private branch exchange requires more than four digits, other means must be employed. According to the present invention, the manual board is provided with a plurality of outlets to each hundred group of subscribers' lines so that in a five-digit system the first three digits are manually selected and the last two are dialed. The system, therefore, embraces connectors reached by switch trains and other connectors known as attendants' connectors and the latter differ from the former in many respects. Since the operators use certain standard cord circuits, the attendants' connectors must be made to produce the signals therein that are usually given when the cord is used for its ordinary purposes. Thus, the battery feed and ringing arrangements for the called subscriber are still in the cord circuit and must, therefore, be eliminated from the connector and the connector must be further modified to allow the passage of these currents freely from the cord circuit to the called subscriber. The connector must signal the cord circuit to the effect that the line terminals of the called line have been reached and thereafter signal the idle or busy condition of the line and later the fact that the called subscriber has answered.

Heretofore a so-called universal cord circuit has been used having a marginal relay in the sleeve circuit thereof. By this means the cord circuit is able to distinguish between different kinds of lines. For instance, on central office lines where dialing arrangements in the cord are required, a high resistance sleeve in the outgoing line is used and through the non-operation of a marginal relay such dialing arrangements are rendered effective. On other lines, such as subscriber's lines no dialing is necessary but ringing current is needed. In this case the sleeve of the tie line is made of low resistance and so through the operation of the said marginal relay the cord circuit is so affected that the dialing circuit is rendered ineffective and the ringing circuit in its place is rendered effective. Such prior art arrangements merely distinguished between different types of outgoing lines and made suitable arrangements in the cord circuit to cooperate therewith. In this connection reference is made to Patent 1,866,260 granted July 5, 1932, to King et al. and Patent 1,881,669 granted October 11, 1932, to King et al.

Other prior art arrangements used other methods of discrimination between the types of outgoing lines but used what is termed sleeve supervision. By way of example, Patent 1,675,956 granted July 3, 1928, to L. F. Porter shows the use of a marginal relay in the sleeve of the cord circuit which responds to a supervisory signal in the form of a change in the resistance of the sleeve of the cooperatively associated circuit.

In accordance with the present arrangement, the marginal relay in the sleeve of the cord circuit is used for both purposes, that of discriminating between types of outgoing lines and that of passing supervisory signals. Thus, the attendant's connector jack circuit is provided with a normally high resistance sleeve circuit whereby the dialing circuit of the cord is rendered effective. When the connector is thereby driven to the line terminals of the wanted line the sleeve resistance is lowered so that the marginal relay of the cord circuit operates and now renders the ringing circuit of the cord effective in place of the dialing circuit. Thus, the normal arrangements of the cord circuit are used advantageously to perform an additional function.

Reference is made to the copending applications Serial No. 451,863 filed in the name of C. D. Koechling and Serial No. 451,918 filed in the name of A. S. Martins on even date herewith, both of which applications cover inventions based mainly on the same disclosure as that herein set forth.

Other features will appear hereinafter.

The drawings consist of nine sheets of circuit diagram.

Fig. 1 is a schematic circuit diagram showing the general plan of operation and indicating the arrangement of the remaining figures;

Figs. 2 and 3 placed with Fig. 3 to the right of Fig. 2 show a cord circuit and Fig. 4 placed below Fig. 3 shows the operator's telephone and dial circuit all used at the manual switchboard used in connection with a dial private branch exchange;

Fig. 5 shows an outgoing trunk circuit cooperating with the cord circuit of Figs. 2 and 3 by means of which the operator may control the distant connectors of Figs. 6 and 7;

Fig. 6 shows a distant connector over which an operator may reach any one of a group of individual lines;

Fig. 7 shows a similar circuit arranged for trunk hunting over which an operator may reach a group of lines arranged in subgroups;

Fig. 8 shows an operator's connector cooperating with the cord circuit of Figs. 2 and 3 over which an operator may reach any one of a group of individual lines; and

Fig. 9 shows a similar circuit arranged for trunk hunting over which an operator may reach a group of lines arranged in subgroups.

The system herein disclosed is a dial private branch exchange system so large that it is beyond the capacity of the manual attendant's board. It is common practice to supplement a dial private branch exchange system with a manual attendant's board where incoming calls are answered and certain other special service is given. Generally speaking, a manual board has a capacity of about ten thousand lines or can handle only four digit numbers. But it is possible to employ a system of much greater capacity for private branch exchange service. The present system is shown as a five-digit system, though it may be of even greater capacity.

Since the number of lines to be served is beyond the capacity of a manually operated switchboard the operator is not given direct access to any of the lines but selects an outlet bearing the first three digits of the number of the wanted line and then dials the last two digits thereof. Thus, by way of example, if the operator wishes to establish a connection to line numbered 12345 she will insert her calling plug into a jack designated 123 and then dial 45. By thus setting up a connection partly by a manual operation and partly by an automatic or dialing operation the operator at such a switchboard may reach any one of a number of subscribers more numerous than could be reached by conventional methods.

In Fig. 1 there are shown two ordinary private branch exchange lines terminating in stations 1 and 2, each equipped with a dial. These station lines appear in a line finder 3 and by dial control may operate a first selector 4, a second selector 5, a third selector 6 and a connector 7 all in conventional manner. Thus these stations may be interconnected by ordinary and well-known means. As indicated in this schematic any one of such ordinary stations may dial 0 and reach an operator through an answering jack appearance 8. Such a station by dialing the digit 9 may reach a central office 9 over an outgoing trunk 10. In the same manner any one of these stations by dialing 8 may reach a distant private branch exchange 11 over a tie line 12.

There may be provided certain special lines for high ranking officials such as those terminating in stations 13 and 14 which do not appear in line finders, but, on the other hand, have special switchboard appearances 15 and 16, respectively, so that outgoing service is on a manual basis. These lines have appearances in the bank of the connectors so that they may be reached automatically.

Incoming central office lines and tie lines have manual appearances such as 17 and 18.

The operator may answer a call at any one of the appearances 8, 15, 16, 17 or 18 by means of the answering plug 19 of the cord circuit 20 and by means of the calling plug 21 may establish connections to any one of the stations of the private branch exchange. It is understood, of course, that the operator may also extend connections to the central office 9 and the distant private branch exchange 11, but these arrangements are well known and do not form any essential part of the present invention. It may also be noted that the distant private branch exchange 11 may be the same as the distant private branch exchange indicated in the broken line rectangle in the lower right corner of this figure. In the one case the tie line 12 leading to the private branch exchange is answered by the operator thereat and in the other case a connection may be extended from jacks 22 or 23 directly to a subscriber in such distant private branch exchange.

Locally the calling jack 24 leads to a connector 26 by means of which the operator may extend a connection to any one of one hundred subscriber's lines in the group designated by the three-digit number distinguishing the jack 24. In the same manner the operator may employ the jack 25 to reach any one of one hundred lines characterized by the same first three digits which distinguishes the jack 25. However, this connector 27 is arranged for trunk hunting and if driven to the proper level will automatically pick out the first idle one of stations 28, 29 and 30 by way of example.

Cord circuit

It will appear hereinafter that the cord circuit shown in Figs. 2 and 3 is arranged to cooperate with various lines provided with a connection to battery on the sleeves thereof. When the plug of the rear cord 31 is inserted in the jack associated with a lighted line lamp, such as that associated with jack 15 for instance, a circuit will be established from battery on the sleeve of the associated line circuit through the sleeve of plug 31 and thence in series through the windings of relays 33 and 34 through a small positive battery to ground. Both relays 33 and 34 operate in this circuit through the relay 33 performs no useful function at this time. Relay 34 operated closes a circuit from ground through its armature and front contact and the winding of relay 35 to battery whereupon relay 35 operates and at its armature 5 and back contact opens a circuit for relay 36. Through the operation of relay 35 a circuit is closed from the tip

of the plug 31, springs 2 and 3 of the ringing key 37, upper winding of relay 38, springs 4 and 5 of the key 39, armature 6 and front contact of relay 35, armature 3 and back contact of relay 40, upper winding of relay 41 to ground. At the same time a circuit may be traced from the ring of plug 31 through springs 5 and 4 of the ringing key 37, lower winding of relay 38, springs 11 and 10 of key 39, armature 3 and back contact of relay 40, the lower winding of relay 41 to battery. Relays 38 and 41 both operate due to current flowing through the circuit just described and over the bridge provided by the calling line circuit. For a clear understanding of the nature of such calling line circuit reference may be had to the application filed by Bascom and Lamberty, Serial No. 438,580, April 11, 1942.

Relay 38 operated prevents the rear cord supervisory lamp 32 from lighting while the relay 41 operated performs no useful function at this time.

The attendant, after receiving the required information from the calling station, makes the usual busy test with the tip of the front cord 42 and if the wanted line is idle, inserts the plug of the front cord in the jack of the called line operating relays 43 and 44 in series.

Relay 43 operated establishes a circuit from ground, its armature and front contact through the winding of relay 45 to battery, causing the operation of relay 45. Relay 44 in operating establishes a circuit from ground, its armature and front contact, through the winding of relay 46 to battery whereupon relay 46 becomes operated. A circuit may now be traced from ground, resistance 48, armature and front contact of relay 38, armature 1 and back contact of relay 49, the lower winding of relay 47, springs 8 and 9 of key 39, front contact and armature 6 of relay 45 to battery. Relay 47 operates and locks in a circuit from ground, springs 6 and 7 of key 39, armature 5 and front contact of relay 35, armature 2 and front contact of relay 47, the upper winding of relay 47, back contact and armature 3 of relay 50, springs 8 and 9 of key 39, front contact and armature 6 of relay 45 to battery.

The operation of relay 44 prevents the operation of relay 40 when relay 45 is operated by relay 43. The purpose of this will appear hereinafter. Relay 46 operated causes the front cord supervisory lamp 51 to light under control of relays 46, 52 and 53. A circuit may be traced from battery, lamp 51, front contact and armature 9 of relay 45, armature 6 and front contact of relay 35, back contact and armature 1 of relay 54, back contact and armature of relay 52, resistance 55 to ground. The operation of relay 46 also opens a retardation coil bridge circuit across the tip and ring of the rear cord 31 which, up to this time has been open at the contacts of relay 45. With relay 45 operated and relay 46 unoperated a bridge circuit may be treated from the tip of plug 31, springs 2 and 3 of key 37, upper winding of relay 38, springs 4 and 5 of key 39, back contact and armature 2 of relay 46, front contact and armature 2 of relay 45, back contact and armature 3 of relay 36, retardation coil 68, armature 1 and back contact of relay 47, armature 3 and back contact of relay 36, springs 10 and 11 of key 39, lower winding of relay 38, springs 4 and 5 of key 37 to the ring of plug 31. This circuit, though closed by armature 2 of relay 45, is opened by armature 2 of relay 46. Relay 45 operated removes the busy test lead 56 from the tip of the front cord, connects the tip and ring of the cord through the contacts of relay 57 and disconnects battery through resistance 58 from the ring of the front cord plug. Relay 46 operated connects the windings of relay 52 to the front contacts of relay 57. A circuit may be traced from the tip of plug 42 through armature 4 and front contact of relay 45, armature 3 and front contact of relay 46, springs 4 and 3 of relay 57, armature 4 and front contact of relay 35 to one side of the source of ringing current 59. The ring conductor may be traced from the ring of plug 42 through armature 5 and front contact of relay 45, armature 4 and front contact of relay 46, armature 6 and back contact of relay 57 through the upper winding of relay 57, armature 3 and front contact of relay 35 to the other side of the source of ringing current 59 so that ringing current is now supplied to the tip and ring of the plug 42 with the upper winding of tripping relay 57 in series therewith. The source of ringing current 59 represents the usual machine-ringing source and may be applied at intervals through an interrupter. During ringing part of the ringing current flows through condenser 60 in a circuit which may be traced from armature 6 of relay 57 through armature 3 and front contact of relay 47, armature 5 and front contact of relay 46, condenser 60, springs 5 and 4 of front cord ringing key 61, springs 13 and 12 of key 39, springs 8 and 6 of talking key 62, armature 8 and back contact of relay 49, lower winding of relay 52 to battery and in parallel therewith through condenser 63, back contact and armature 7 of relay 40, armature 6 and back contact of relay 40 and thence through the lower winding of relay 41 to battery. Through the connection of ringing current to the lower winding of relay 41, a ringing tone is transmitted back to the calling station as an indication that ringing current is being connected to the called station line.

When the receiver called station is removed from the switchhook the tripping relay 57 operates. The relay 57 thereupon substitutes the winding of relay 52 to the tip and ring of the called line in place of the source of ringing current 59 and locks through its lower winding, its contact 2 and armature 1 to the front contact and armature 1 of relay 45. Relay 52, now in circuit with the called station, operates and causes the front cord supervisory lamp to be extinguished and the relay 54 to operate through its lower winding. The circuit for relay 54 may be traced from ground, resistance 55, armature and front contact of relay 52, armature 3 and back contact of relay 53, lower winding of relay 54, front contact and armature 7 of relay 46 to springs 8 and 9 of key 39, front contact and armature 6 of relay 45 to battery. Relay 54 locks in a circuit from ground, normal contacts of armature 4 of relay 50, armature 2 and front contact of relay 54, upper winding of relay 54 through back contact and armature 3 of relay 50 to battery over the circuit hereinbefore described. Relay 54 therefore locks under control of relays 50, 45, and 46 and partly provides an operating path for relay 53.

From the foregoing we can summarize as follows: (A) Battery and ground for the calling station are furnished by the cord circuit through the windings of relays 41 and 38. (B) Battery and ground for the called station are furnished by the cord circuit through windings of relay 52. (C) The front and rear cords are coupled

through condensers 63 and 64. (D) No bridge is connected across the tip and ring of the cord, except the ringing relay 67 which has no useful purpose at this time.

When the receiver is replaced on the switchhook at the calling station, relays 41 and 38 release causing relay 49 to operate under control of relays 50 and 33. The circuit for relay 49 may be traced from battery, armature 6 and front contact of relay 45, springs 9 and 8 of key 39, armature 3 and back contact of relay 50, winding of relay 49 through the normal contacts of armature 2 of relay 49, armature 4 and front contact of relay 47, back contact and armature of relay 33, through resistance 48 to ground. Relay 49 operated locks through its front contact and armature 2, front contact and armature 5 of relay 35, springs 7 and 6 of key 39 to ground. The rear cord supervisory lamp 32 is now energized in a circuit from battery, lamp 32, armature 2 and front contact of relay 35, armature 4 and front contact of relay 49, resistance 48 to ground. The lighting of lamp 32 operates as a disconnect signal.

When the receiver at the called station is replaced on the switchhook relay 52 releases causing relay 53 to operate under control of relays 50, 46 and 45. A circuit for relay 53 may be traced from battery, armature 6 and front contact of relay 45, springs 9 and 8 of key 39, armature 3 and back contact of relay 50, winding of relay 53 through the normal contacts of armature 2 of relay 53, front contact and armature 1 of relay 54, back contact and armature of relay 52 through resistance 55 to ground. Relay 53 locks through its front contact and armature 2 to the normal contacts of armature 4 of relay 50 to ground. The operation of relay 53 now lights the front cord supervisory lamp in a circuit which may be traced from battery, lamp 51, front contact and armature 9 of relay 46, armature 6 and front contact of relay 45, front contact and armature 1 of relay 53, resistance 55 to battery. This lighting of lamp 51 operates as a disconnect signal. The operation of relay 53 in opening the path of the lower winding of relay 54 at its back contact and armature 3 thereupon opens the original operating circuit of relay 54 but this relay remains operated through its upper winding. When the plugs of the front and rear cords are withdrawn from the associated jacks all operated relays release and the circuit is restored to normal.

Flashing recall

If before the plugs of the front and rear cords are withdrawn from the jacks the switchhook at the calling station is operated and released to recall the attendant, the relays 41 and 38 will release and reoperate. The relay 38 in releasing causes the operation of relay 49 in the manner hereinbefore described. Upon the reoperation of relay 38 the rear cord supervisory lamp is now connected in a circuit which may be traced from battery, lamp 32, armature 2 and front contact of relay 35, armature 4 and front contact of relay 49, through the resistance 48 and in parallel therewith, the armature and front contact of relay 38, armature 1 and front contact of relay 49 to the flashing recall lead 65 which essentially supplies interrupted battery to periodically shunt the lamp 32. This causes the lamp to flash. The attendant then operates the talking and dialing key 62 causing relay 50 to operate which releases relay 49. Relay 49 released, stops the flashing of the lamp 32.

If the switchhook at the called station is operated and released, relay 52 releases and reoperates. Upon the release of relay 52 relay 53 is operated, as hereinbefore described. With relay 52 reoperated the front cord supervisory lamp 51 is connected in parallel with the flashing recall circuit 65 in a manner similar to that hereinbefore described so that lamp 51 now flashes. The attendant then operates the talk and dial key 62 causing relay 50 to operate. Relay 50 operated releases relays 53 and 54. Relay 53 released stops the flashing of the lamp. When the talk and dial key 62 is restored to normal, relay 50 releases and relay 54 reoperates, as described hereinbefore.

The above description applies to the use of the cord circuit when a connection is being made between two local lines as, for instance, a connection between the stations 13 and 14. In the schematic shown in Fig. 1 it is not contemplated that the calling cord 21 will be used for directly calling a local substation though it is capable of this use in the manner above described.

It should be noted that both the answering and calling cords have two relays in their sleeve circuits, one of which is marginal. Thus, for instance, the sleeve of the answering cord has the two relays 33 and 34 in series, the relay 34 being marginal and only operating when a line sleeve of lower resistance is encountered. In the same manner the sleeve of the calling plug 42 has the relays 43 and 44 in series with it, the relay 44 being marginal.

It will be noted in the description to follow that the sleeve of the line leading to an attendant's connector as, for instance, from the jack appearances 22 to 25, inclusive, has a high resistance when it is selected and maintains this high resistance until certain operations are completed, after which the resistance is lowered. Therefore on a call from a station to another station via an attendant's connector the marginal relay of the calling cord will not be operated at first.

When completing a call from an attendant's trunk, such as that terminating in the jack 8, or from a manual station, such as those terminating in the jacks 15 and 16, to a station via an attendant's connector, the operation when the call is answered with the rear cord is the same as described hereinbefore. However, when the front cord is inserted in the jack associated with an attendant's connector relays 43, 45 and 40 operate since the sleeve resistance is high. Relay 40 operated disconnects the relay battery supply from the rear cord but the calling station receives battery from the connector in the manner which will be described hereinafter. When the operator's dial is moved off normal for the first digit the rear cord is fed battery and ground from the telephone and dial circuit and the front and rear cords are separated in the dial circuit. The attendant then dials the two digits required to bring the connector to the desired line.

The attendant's connector will cut through on the called line if it is idle and the battery and ground from the tip and ring of the connector will be removed. At this time the connector also changes the resistance on the jack sleeve from high to low. The change to a low sleeve resistance causes relays 44 and 46 to operate which in turn causes relay 40 to release. The release of relay 40 reconnects relay 41 to the rear cord and separates the rear and front cords by condensers

63 and 64. The connector is held off normal under control of the sleeve after cut through and the tip and ring of the front cord are connected to the back contacts of the tripping relay 57 to transmit machine-ringing current to the called subscriber. Audible ringing tone is transmitted toward the rear cord through condenser 60 as hereinbefore described. Relay 46 closes the windings of relay 52 to the front contacts of the tripping relay 57 to supply talking battery to the called line after tripping relay 57 operates upon the response of the called party.

When the called station answers, relay 57 operates and relays 52, 53 and 54 function as described hereinbefore. The talking, signaling, supervision, disconnect and flashing recall will be the same as described hereinbefore.

If the attendant's connector is dialed to a busy line the sleeve becomes low in resistance and the battery and ground on the tip and ring of the connector are removed and replaced by a bridge intermittently applied. The ringing from the cord is tripped through this bridge. If the attendant has restored the talk and dial key 62 the intermittent bridge across the tip and ring will operate and release relay 52 starting the flashing recall signal 51 on the front cord lamp. If the attendant has not restored the talk and dial key 62 she will receive an audible busy indication.

It is particularly to be noted that the interrupter in the attendant's connector circuit which intermittently applies the bridge to the tip and ring of the calling cord 42 is of one-half the rate of the interrupter 65. By way of example, the interrupter 66 applies battery to the lead 65 at the rate of 120 impulses per minute while the interrupter in the attendant's connector circuit runs at the rate of 60 interruptions per minute. Since the interrupter in the attendant's connector circuit operates the relay 52 it will therefore render the flashing recall circuit of this cord circuit effective on every other interruption thereof so that the effect is that the lamp 51 will be lit approximately three-tenths of a period and dark the other seven-tenths thereof. The signal for the recall is a steady flashing at the rate of 120 interruptions per minute, while the signal for the encounter of a busy condition is this so-called syncopated signal wherein every other flash of the signal in its ordinary working is rendered effective. Since the interrupter of the attendant's connector circuit and the interrupter 66 are both operated from the same power plant they may both be on the same shaft and the relation between them may be fixed.

The operation of the cord circuit on a connection between a central office call and a station is as follows: the incoming central office call is answered with the rear cord 31 in the usual manner and the operation is different from that described hereinbefore in that a high sleeve resistance is encountered which does not allow the marginal relay 34 to respond. Since the marginal relay does not respond, therefore relay 35 does not operate.

As a result a connection is established from ground, springs 6 and 7 of key 39, armature 5 and back contact of relay 35, front contact and armature of relay 33, winding of relay 36 to battery. As a result of the operation of relay 36 a connection may be traced from ground at the armature and back contact of relay 34, armature 4 and front contact of relay 36, winding of relay 40 to battery and ground whereupon relay 40 becomes operated. The operation of these relays connects a bridge across the cord which may be traced from the tip of plug 31, springs 2 and 3 of the ringing key 37, front contact and armature 3 of relay 36, retardation coil 68, armature 1 and back contact of relay 47, armature 8 and front contact of relay 36, springs 4 and 5 of ringing key 37 to the ring of plug 31. This bridge serves as a signal on the central office line that the call has been answered and will serve to trip ringing and perform the other usual functions required in a case of this kind.

When the front cord is inserted in the jack of an attendant's connector relay 38 operates and causes the operation of relay 47 on its lower winding.

A circuit may be traced from ground on the tip of cord 31, springs 2 and 3 of ringing key 37, upper winding of relay 38, springs 4 and 5 of key 39, front contact and armature 7 of relay 40, springs 6 and 8 of key 62, springs 12 and 13 of key 39, springs 4 and 5 of key 61, back contact and armature 4 of relay 46, front contact and armature 5 of relay 45, to the ring of plug 42 where it encounters battery in the circuit of the attendant's connector. Likewise, a circuit may be traced from battery on the ring of cord 31, springs 5 and 4 of key 37, lower winding of relay 38, springs 11 and 10 of key 39, front contact and armature 2 of relay 40, springs 5 and 3 of key 62, springs 3 and 2 of key 39, springs 3 and 2 of key 61, back contact and armature 3 of relay 46, front contact and armature 4 of relay 45 to the tip of plug 42 where it encounters ground in the circuit of the attendant's connector. Relay 38 responds and closes a circuit from ground, resistance 48, armature and front contact of relay 38, armature 1 and back contact of relay 49, lower winding of relay 47, springs 8 and 9 of key 39, front contact and armature 6 of relay 45 to cause the operation of relay 47.

Relay 38 will release when the dial is moved off normal but relay 49 will not operate and relay 47 will release since the talk and dial key 62 is operated. Moving the dial off normal separates the front and rear cords. The attendant then dials the two digits to direct the connector to the desired line.

The attendant's connector cuts through on the called line if it is idle, removing the battery and ground from the tip and ring and changing the jack sleeve resistance associated with the front cord to a lower value. Thus relays 44 and 46 will operate but relay 40 remains operated under control of relay 36. The tip and ring of the front cord are then connected to back contacts of tripping relay 57 for the transmission of ringing current. The calling lamp 51 will also light at this time.

When the called station answers the tripping relay 57 operates and closes through the tip and ring of the front cord. The ground that locks relay 57 operated also passes over lead 69 to the telephone circuit and causes a relay therein to operate and furnish talking battery to the called station until the talking key is restored by the attendant. When the talk and dial key 62 is restored to normal the battery and ground from the central office is fed through the windings of relay 38 to the called station. Relay 38 will operate and extinguish the calling line lamp 51 at this time and relay 47 will operate, opening the short circuit about resistance 70 whereby less current from the central office line is drained by the bridge and a greater amount allowed to flow

to the called station. The operations in this connection may now be summarized as follows: (A) Talking battery for the called station is furnished from the central office. (B) A high resistance bridge consisting of the winding of retardation coil 68 in series with the resistance 70 is bridged across the tip and ring of the rear cord. (C) The supervisory relay 38 is under control of the called station.

When the receiver is replaced on the switchhook at the called station the circuit functions, as described hereinbefore, except that relay 38 is under control of the called station and the operation of relay 49 causes the front supervisory lamp to light as a disconnect signal and short circuits the resistance 70, thereby decreasing the resistance of the bridge across the cord.

Flashing recall is controlled by relay 38 in conjunction with relays 47 and 49, as described hereinbefore. However, since relay 35 is not operated the supervisory lamp 51 of the calling cord is flashed rather than the answering cord lamp 32.

If the called station is busy the sleeve becomes low in resistance and the battery and ground are removed from the tip and ring in the connector and replaced by a bridge which is intermittently applied. If the talk and dial key 62 has been restored to normal the application of this bridge will cause the supervisory relay 38 to operate and release, thereby starting the flashing recall signal on the front cord lamp. If the attendant has not restored the talk and dial key on a busy connection she will receive an audible busy indication.

In the first case, where the busy indication comes in from the attendant's connector circuit the bridge will be applied to the tip and ring at the rate of 60 interruptions per minute and this will so effect the flashing of the lamp 51 at the rate of 120 interruptions per minute that every other flash will be eliminated, resulting in what is spoken of as a syncopated signal in which the lamp 51 is lighted for approximately three-tenths of a period and dark for the remaining seventh-tenths.

Telephone and Dialing Circuit Arranged for Use With Attendant's Connectors

Busy test

When the tip of an associated cord, for instance, plug 42, is touched to the sleeve of a busy station line, tie trunk, attendant's connector or trunk jack, ground or positive potential from the busy sleeve charges condenser 71 through a winding of the repeating coil 72 and resistance 73 to the front contact of relay 74, this relay being energized through the transmitter 75 of the telephone set. This induces a busy click through the winding of the repeating coil 72 at the attendant's telephone receiver.

Talking

When the tank and dial key 62 of an associated cord circuit is operated the leads 76 to 80, inclusive of the telephone and dial circuit are connected to the cord circuit, thereby closing the tip, ring and receiver leads and providing a talking circuit for the attendant. The attendant's transmitter circuit may be traced from ground, the right-hand winding of repeating coil 81, through the tip of jack 82, transmitter 75, the tip of jack 83, the winding of relay 74 to battery. Speech currents from the transmitter 75 are then transmitted by the left-hand windings of repeating coil 81, through the back contacts and armatures 2 and 4 of relay 84 to the talking conductors 85 and 86. The operator's telephone receiver circuit may be traced from conductor 85 through the back contact and armature of relay 87, back contact and armature 1 of relay 84, the sleeve of jack 82, the telephone receiver 88, the sleeve of jack 83, armature 3 and back contact of relay 84, the mid-point tap on the left-hand winding of repeating coil 81 through the condenser 89, back contact and armature 4 of relay 84 to conductor 86. Through the back contacts and armatures of relay 90 this talking circuit is connected to conductors 76 and 77, leading to the front cord 42. Through the armatures and contacts of relays 91 and 92 this talking circuit is connnected to conductors 78 and 79 leading to the tip and ring of the rear cord 31.

Dialing

In order to dial on a cord circuit the talk and dial key 62 of the cord circuit is operated. When the dial is moved off normal relay 93 operates in a circuit which may be traced from ground, springs 2 and 3 of key 94, the off-normal springs of the dial 95, winding of relay 93 to battery. Through its front contact and armature 2 relay 93 short circuits resistance 96. The operation of relay 93 also results in the operation of relays 97, 87 and 90. The circuit for relay 97 may be traced from battery, winding of relay 97, front contact and armature 3 of relay 93 to ground. The circuit for relay 87 may be traced from battery, winding of relay 87, front contact and armature 4 of relay 93 to ground. The ground for the operation of relay 97 may also be traced through the armature 5 and back contact of relay 84, the lower winding of relay 90 to battery. Upon the operation of relay 97 ground is extended from armature 2 of relay 97 and its front contact through the upper winding of relay 90 to battery. With relay 97 operated the attendant's receiver is short circuited at the armature 1 and front contact of relay 97 for a sufficient length of time to prevent an undesirable click when the dial restores after dialing the first digit. This also prevents the attendant from hearing transmission of the dial pulses. With relay 90 operated the attendant's telephone circuit is disconnected from conductors 76 to 79. Through its armature 2 and front contact relay 90 causes the operation of relay 92. At this time a short circuit across conductors 76 and 77 may be traced from conductor 76, conductor 98, the contacts of the dial 95, armature 2 and front contact of relay 93, front contact and armature 4 of relay 90 to conductor 77. The retardation coil 99 is short circuited through the front contact and armature 4 of relay 92. The operation of relay 92 splits the cord circuit leaving the impulse springs of the dials connected to the front cord over leads 76 and 77 and battery and ground through the windings of relay 100 connected to the rear cord over the leads 78 and 79. Relay 100 operates over the station loop or through the retardation coil bridge in the cord in case the receiver at the station has been replaced on the switchhook. Dial impulses are transmitted over the circuit to which plug 42 is connected in the usual manner. When the dial has completely restored relay 93 releases. With relay 93 released the short circuit is removed from the parallel combination of the resistance 96 and retardation coil 99 and relay 97 is released. The release of relay 97 removes the short circuit on the attend-

ant's receiver and releases the relay 90. Relay 90 released removes the shunt of the resistance 96 about the retardation coil 99 and closes the attendant's talking circuit. The retardation coil 99 now holds the connection, the circuit being traced from conductor 76 through the impulse springs of the dial 95, the retardation coil 99, front contact and armature 4 of relay 92 to conductor 77. The front and rear cords of the associated cord circuit are connected through condensers 101 and 102 to enable the station to talk on the connection in case the attendant fails to restore the talk and dial key of the cord after dialing. When the talk and dial key 62 is restored relays 100 and 92 release. With relay 92 released relay 87 is released. Relay 87 being slow in releasing will keep the receiver open long enough to prevent clicks to the attendant due to the release of the talk and dial key in the cord circuit.

Front cord inserted in attendant's connector jack

The circuit functions as described above. Relay 100 is connected to leads 78 and 79 after relay 92 operates and is held operated over the station loop if the rear cord is connected to a station. If the rear cord is connected to a central office trunk, battery and ground through the windings of relay 100 will be connected respectively to ground and battery from the central office due to a reversal in the cord circuit and relay 100 will therefore be operated. When the dial returns to normal relays 93, 97 and 90 release but relay 100 remains operated holding relay 92, which in turn holds relay 87 operated.

When the attendant has finished dialing the station number the attendant's connector cuts through in a manner which will be hereinafter described. This action results in a reduction of the sleeve resistance so that marginal relay 44 now becomes operated, in turn operating relay 46. During the operation of the talk and dial key 62 a circuit is established from ground, springs 4 and 5 of key 94, springs 11 and 12 of key 62 to the winding of relay 50 and thence to battery whereupon relay 50 becomes operated. Now upon the operation of relay 46 a circuit is established from ground, front contact and armature 5 of relay 46, front contact and armature 4 of relay 50 to the winding of relay 103 which now becomes operated. Relay 103 operated opens the circuit to relay 100 which releases and allows relays 92 and 87 to release. In this way all the relays in the dialing circuit restore to normal and leads 76 and 77 of the cord are connected to leads 78 and 79.

Monitoring

This telephone circuit is arranged with a position monitoring key. If the key 94 is operated and then the talk and dial key 62 of a cord circuit is operated the attendant can monitor on the particular cord whose key is operated. The operation of the position monitoring key 94 removes ground from spring 4 thus allowing relay 50 to become released and at the same time causes relay 84 to become energized. Relay 84 operated connects the attendant's telephone receiver across the cord through the repeating coil 104, the rest of the telephone circuit being disconnected from the receiver at this time. The release of the position monitoring key releases relay 84.

Jacks 82 and 83 are for the use of the operator and jacks 105 and 106 are for the use of the supervisor.

Outgoing attendant trunk circuit to attendant connector at distant private branch exchange—Fig. 5

A plug seating circuit is provided to insure against preliminary impulses during plug-in. This comprises a pair of relays 108 and 109, the first of which is a two-step relay. When relay 108 is energized through its lower winding it will move its armatures 3 and 4 but will not move its armatures 1 and 2. This is indicated by the fact that armatures 1 and 2 are shown heavy and armatures 3 and 4 are shown light. When a plug, such as plug 42, is inserted in jack 107 and the plug becomes fully seated, then a connection is made between the ring of the plug and the ring of the jack 107 which may be traced through armature 2 and back contact of relay 108, back contact and armature 1 of relay 118, the lower winding of relay 108 to ground. Since battery is supplied by the ring of the plug of the cord circuit, relay 109 moves its armatures 3 and 4. Thereupon a connection is made from positive battery, winding of relay 44, winding of relay 43 and the sleeve of the cord in cord circuit, Fig. 3, through the sleeve of jack 107, armature and front contact of relay 108, winding of relay 109 to battery. Relay 109 operates and establishes a connection from battery, upper winding of relay 108, armature 3 and front contact of relay 108, armature 3 and front contact of relay 109, the lower winding of relay 108 to ground. Thus the two windings of relay 108 are placed in series and this relay thereupon fully operates and attracts all of its armatures.

In its normal condition a circuit is established from battery, through armature 2 and back contact of relay 109, through the back contact and armature 3 of relay 118 to the idle indicating lamp 113. Therefore, upon the operation of relay 109 this idle indicating lamp is extinguished and the battery connection is extended by armature 2 of relay 109 to its front contact to cause the lighting of the next idle indicating lamp.

Upon the operation of relay 108 the tip conductor is extended over armature 1 and front contact of relay 108, the upper left-hand winding of repeating coil 121, back contact and armature 6 of relay 110, the upper winding of relay 112 to ground. In a similar manner the ring of jack 107 is extended from armature 2 and front contact of relay 108, the lower left-hand winding of repeating coil 121, back contact and armature 6 of relay 110, the lower winding of relay 112 to battery. Due to a reversal in the cord circuit hereinbefore explained, relay 112 becomes operated. The operation of line relay 112 connects the windings of the polarized relay 114 to the distant connector circuit which has a relay facing the line to this trunk circuit. This connection may be traced as follows: from ground, through the lower winding of relay 114, armature 2 and front contact of relay 112, the lower right-hand winding of repeating coil 121, conductor 115, back contact and armature 4 of relay 123 to conductor 125 and a similar circuit from battery, the upper winding of relay 114, armature 1 and front contact of relay 112, the upper right-hand winding of repeating coil 121, conductor 116, back contact and armature 1 of relay 123 to conductor 124. Relay 114 operates in this circuit and causes the operation of re-

lays 117 and 118. A circuit may be traced from battery, winding of relay 117, back contact and armature 3 of relay 119, armature and left-hand contact of relay 114, armature and back contact of relay 119, armature 7 and back contact of relay 110 to ground. Relay 117, in operating, connects ground through its armature 2 and front contact to the winding of relay 118.

When the attendant dials, relay 112 follows the dial pulses and opens the line to the distant connector each time it releases. The polarized relay 114 follows the dial pulses as repeated by relay 112 but the slow-release relay 117 holds operated.

When dialing is completed the distant connector circuit inserts a high resistance into the line causing relay 114 to release. The release of relay 114 causes the release of relay 117 which, due to the slow releasing characteristic of relay 118, results in the operation of the cut-through relay 119. A circuit for this relay may be traced from ground, armature 1 and front contact of relay 109, armature 2 and front contact of relay 118, back contact and armature 1 of relay 117, the winding of relay 110 to battery. Relay 110 locks through its armature 5 and front contact and the front contact and armature 1 of relay 109 to ground.

The operation of relay 110 causes the resistance in the sleeve lead to change from high to low. Up to this time the winding of relay 109 which has a high resistance is connected to the sleeve of jack 107 but upon the operation of relay 110 a lower resistance 126 is placed in parallel with the winding of relay 109 so that the marginal relay 44 in the cord circuit now becomes operated. The operation of relay 110 also connects a condenser 120 across the middle of the side of the repeating coil facing the distant connector and prepares a circuit for connecting the windings of relay 114 with polarity reversed to the leads of the distant connector through normally closed contacts of relay 112 and the windings of the differential relay 119. The operation of relay 110 opens the circuit of relay 112 so that this now releases. Relay 110 also prepares a circuit for giving a closure to the cord circuit through the contact of the polarized relay 114.

The change in the sleeve resistance to the cord circuit resulting in the operation of the marginal relay 44 causes the cord circuit to send out ringing to this trunk. The ringing current causes relay 122 to operate which results in the operation of relay 123, thus causing a clear path from the tip and ring of the jack 107 to the line conductors 124 and 125, respectively.

When the called party answers or when the distant connector connects a low resistance ground to the ring lead as a line-busy indication during the ringing interval, the tripping relay in the cord circuit operates and removes the ringing current, causing relays 122 and 123 to release. The release of relay 123 again places the polarized relay 114 in circuit to operate over the station loop if the line is idle. If, on the other hand, the line is busy and the operation just described has been caused by a low resistance ground to the ring lead, then the differential relay 119 will be unbalanced as a busy indication and instead of connecting a bridge across the tip and ring of jack 107, will now connect interrupted ground to the ring of jack 107, leaving the tip thereof open. In case only relay 114 operates as a signal that the called party has answered, a circuit may be traced from the tip of jack 107, armature 1 and front contact of relay 108, the upper left-hand winding of repeating coil 121, front contact and armature 7 of relay 110, back contact and armature of relay 119, left-hand contact and armature of relay 114, armature 3 and front contact of relay 110, the lower left-hand winding of repeating coil 121, front contact and armature 2 of relay 108 to the ring of jack 107. In case the signal coming from the distant connector is a low resistance ground on the ring, thereby causing the relay 119 also to operate, a connection may be traced from the ring of jack 107, through armature 2 and front contact of relay 108, the lower left-hand winding of repeating coil 121, front contact and armature 3 of relay 110, armature and left-hand contact of relay 114, armature and front contact of relay 119 through retardation coil 127 and interrupter 128 to ground. Upon the first open period of this circuit, the flashing recall circuit in the cord will be prepared for operation and then put into operation upon the next closure through the interrupter 128. Thereafter the signal displayed in the cord circuit will be modified by the interrupter 128. Since this is of one-half the rate of the interrupter causing the flashing recall signal, the result will be a totally different kind of visual signal in which the display is of approximately three-tenths of the period and the dark condition of the lamp is approximately seven-tenths of the period. In other words, every other flash of the lamp in the flashing recall circuit will be eliminated. As mentioned hereinbefore, the interrupter 128 is synchronized with the interrupter 66 of the cord circuit so that the relation between the two is fixed.

When the called line is idle and the ringing has been tripped, conversation may take place with the transmission battery for the called party furnished through the windings of relays 114, 119 and the repeating coil 121. The contacts of relay 114 maintain a closure toward the cord circuit and relay 114 will receive switchhook flashing from the called party to the cord circuit so that a flashing recall condition may be set up in the ordinary manner by the subscriber reached through the distant connector.

When the plug is removed from the jack, relay 109 releases causing the release of relays 108 and 110. The release of relay 110 causes the release of relay 117 and relay 114, except that this latter relay may have already released due to the called party hanging up. The release of relay 117 causes the release of relay 118 which causes the idle indicating lamps to light and restores the circuit from the lower winding of relay 108 to the ring of the jack 107 so that it can operate on the next call.

Connector circuit for completing calls from attendant at distant private branch exchange to station lines—Fig. 6

Upon the seizure of the circuit shown in Fig. 5 and the operation of the line relay 112 thereat, battery and ground are connected through the windings of relay 114 to the conductors 124 and 125 which extend to the upper and lower windings, respectively, of line relay 129. Relay 129 operates from battery on the tip and ground on the ring of the trunk circuit and causes the operation of the first slow relay 130 in preparation for pulsing.

On the first open period relay 129 releases and establishes a circuit from its armature 1 and back

contact, through armature 1 and front contact of relay 130, springs 6 and 3 of the vertical off-normal spring combination 131, through the windings of slow-release relay 132 and the vertical magnet 133 to battery. Relay 132 operates before the vertical magnet steps the switch, opens the circuit of relay 134 and closes its own locking circuit to spring 5 of the vertical off-normal springs 131. When the switch steps and the vertical off-normal springs operate, the original operating circuit for relay 132 and magnet 133 will be opened but a substitute circuit through the armature of relay 132 will be closed in its place without interrupting the stepping circuit. When the line relay 129 reoperates the vertical magnet releases, but relay 132 being slow to release holds until the end of the train of impulses comprising the first digit.

The switch thus continues to step vertical until the end of the train of impulses when the operation of relay 129 releases relay 132.

On the second digit, when relay 129 releases, relay 134 and the rotary magnet 135 operate. The circuit may be traced from armature 1 and back contact of relay 129, armature 1 and front contact of relay 130, springs 6 and 5 of the vertical off-normal spring combination 131, armature and back contact of relay 132, armature 4 and back contact of relay 135, through the winding of relay 134 to battery and in parallel therewith through armature 4 and back contact of relay 137 and the winding of rotary magnet 135 to battery. The rotary magnet and relay 134 are in multiple and the latter relay being slow to release remains operated during pulsing while the rotary magnet steps the switch to the desired terminal.

Testing the line—Line busy

When the switch is on the line to which it has been dialed and before the slow-release relay 134 releases, the sleeve of the called line is connected to relay 138. A circuit may be traced from battery through the winding of relay 138, front contact and armature 2 of relay 134, sleeve brush 139 to the sleeve terminal of the called line. On a busy line the sleeve will be grounded, thereby operating relay 138. When relay 134 releases, relay 138 locks through the normal contacts of armature 2 of relay 134, front contact and armature 2 of relay 138, armature 3 and front contact of the first slow-releasing relay 139 to ground.

Relay 138, operated, opens the circuit of relay 137 and operates relay 136. This circuit may be traced from battery, winding of relay 136, armature 3 and back contact of relay 134, front contact and armature 3 of relay 138 to ground. Relay 136 operated, (1) opens the circuit of relay 134 and the circuit of rotary magnet 135, (2) removes the line relay 129 from the tip and ring, thereby causing the release of relay 129, and (3) connects high resistance relay 140 through the armature 1 and back contact of relay 141 and the front contact and armature 1 of relay 136 to the tip wire 124 and high resistance relay 142, through armature 5 and back contact of relay 143, the front contact and armature 4 of relay 136 to the ring conductor 125. Relay 142 operates to ground on the ring at the distant end of the trunk and holds the first slow relay 130 operated.

Removing the line relay 129 from the tip and ring is a signal to the trunk at the distant private branch exchange to prepare to ring or to receive busy flashes and when the trunk is thus prepared it reverses battery and ground to the connector circuit. Relay 142 then releases and relay 140 then operates. Relay 140 closes resistance 145 across the windings of relay 129 which thereupon operates and holds the first slow relay 130 operated. Relay 129 also completes the circuit to relay 143 through the armature 2 and front contact of relay 129, armature 3 and front contact of relay 136, to ground. Upon operating, relay 143 establishes a connection from ground, armature 2 and front contact of relay 143, front contact and armature 1 of relay 136 to the ring conductor 125 extending to the outgoing trunk circuit, Fig. 5, where it results in unbalancing the differential relay 119 for the purposes hereinbefore described.

When the called line is idle, the sleeve brush 139 will encounter a battery connection instead of ground and relay 134 in releasing at the end of the rotary stepping movement connects relay 137 to the sleeve brush. This circuit may be traced from sleeve brush 139 through armature 2 and back contact of relay 134, upper winding of relay 137, back contact and armature 2 of relay 138, armature 3 and front contact of the first slow relay 139. Relay 137 becomes sufficiently energized in this circuit to move its armature 2 which closes a circuit from ground, armature 2 and front contact of relay 139, front contact and armature 2 of relay 137, lower winding of relay 137, through rotary magnet 135 to battery. This causes the full energization of relay 137 and at the same time stops further action of the rotary magnet. Relay 137 connects direct ground forward to the line circuit sleeve through its front contact and armature 6 to hold the cut-off relay of the called line and to busy the terminal to other switches. Relay 137 also opens the original energizing circuit for the rotary magnet and opens the release path through its armature 7. Through its armatures 1 and 3 relay 137 partially closes the tip and ring conductors to the called station.

Upon the release of relay 134 and the operation of relay 137 a circuit is established from ground through the front contact and armature 5 of relay 137, back contact and armature 3 of relay 134 to the winding of relay 136. As hereinbefore described, relay 136, upon operating, removes the line relay 129 from the tip and ring and closes the two high resistance relays 140 and 142, respectively, to the tip and ring of the trunk. Relay 142 holds first slow relay 130 operated until battery is reversed by the trunk circuit at the private branch exchange. Relay 142 then releases and relay 140 operates. Relay 140 again causes the operation of the line relay 129 to complete the circuit to relay 143 which now operates. Relay 143 operated, connects the tip and ring of the trunk from the distant private branch exchange to the tip and ring of the called station. The tip conductor 124 may be traced through the upper winding of the supervisory relay 144, through armature 1 and front contact of relay 143, front contact and armature 1 of relay 137 to the tip brush 145 of the connector which is now in association with the tip of the called line 147. The ring conductor 125 may be traced through the lower winding of relay 144, armature 4 and front contact of relay 143, front contact and armature 3 of relay 137 to the ring brush 146 of the connector leading to the called subscriber's station 147. Relay 143, in operating, opens the circuit of relay 142 but relay 140 is still connected to the tip so that the line relay 129 remains operated.

During the ringing of the station from the distant private branch exchange, relay 140 holds to the ringing ground on the tip. Relay 144, whose lower winding is in series with the ring, may oper-

ate on the alternating current and operate relay 141. This will open the winding of relay 140 but its lower contacts perform the same function as the lower contacts of relay 140 so that the line relay 129 remains operated to hold the connection.

When the called station answers, ringing is tripped and relay 144 operates on the station loop to remove relay 140 from the connection and hold the connection through the operation of relay 141 as described. Upon disconnection by the called station relay 144 releases and causes relay 141 to release, but relay 140 then operates to ground on the tip to hold the switch.

When the cord is pulled down at the private branch exchange after the called station disconnects, relay 140 will release thus releasing the line relay 129 and the first slow relay 130. Relay 130, in releasing, opens the circuit for relay 137 and now a circuit may be traced from ground, armature 1 and back contact of relay 129, armature 1 and back contact of relay 130, back contact and armature 7 of relay 137, springs 1 and 2 of the vertical off-normal spring combination 131, to release magnet 149 and battery. Release magnet 149 is operated and causes the brushes 145, 148 and 139 to leave their position in connection with the terminals of the called line. Thus, the switch is returned to normal. The release of relay 137 causes the release of relay 136 and the release of relay 129 causes the release of relay 143.

On disconnection by the attendant from a busy connection, relay 149, in releasing, releases the line relay 129 and the first slow relay 130. Relay 130 then releases relay 133 which, in turn, releases both relays 136 and 143. With relay 130 released, the release magnet operates to restore the switch to normal.

Connector circuit—Rotary hunting—For completing from attendant at distant private branch exchange to station lines—Fig. 7

The operation of this connector is in many respects similar to the operation of the connector in Fig. 6. When the attendant at the distant private branch exchange selects this trunk, the line relay 150 operates from battery on the tip and ground on the ring of the trunk circuit at the distant private exchange. Relay 150, operated, operates the first slow relay 151 which prepares the circuit for pulsing.

On the first open period relay 150 releases operating the second slow relay 152 in series with the vertical magnet 153, through the springs of the vertical off-normal contact combination 154. Relay 151 being slow to release will remain operated during pulsing. Relay 152 operates before the vertical magnet steps the switch, opens the circuit of relay 155 and closes its own locking circuit to the vertical off-normal springs. When the switch steps and the vertical off-normal springs operate, the original operating circuit of relay 152 will be opened but the holding path will be completed without interrupting the stepping circuit. When the line relay 150 reoperates, the vertical magnet releases but relay 152 being slow to release holds until the end of the digit. The switch thus continues to step vertically until the end of the digit when the operation of relay 150 releases relay 152. On the second digit when the line relay 150 releases, relay 155 and the rotary magnet operate. Relay 155 being slow to release holds over pulsing while the rotary magnet steps the switch to the desired line terminal which may be either an individual line or the first of a group of lines.

Before relay 155 releases at the end of rotary stepping a path is closed from the sleeve wiper 156 of the connector switch through armature 2 and front contact of relay 155, armature 11 and back contact of relay 157 to the winding of relay 158 and thence to battery. A busy line will have ground on the sleeve which will operate relay 158. When relay 155 releases, relay 158 locks to the sleeve ground through its armature 4 and front contact and the normal contacts of armature 2 of relay 159 to the sleeve wiper 156. Relay 158 at this time causes the operation of relay 160 in a circuit from battery, winding of relay 160, back contact and armature 1 of relay 155, front contact and armature 2 of relay 158 to conductor 161 supplied with ground over armature 2 and front contact of the first slow relay 151. Relay 160 operated, (1) opens the circuit of relay 155 and the circuit of the rotary magnet 162; (2) removes the line relay 150 from the tip and ring which now releases; (3) connects high resistance relay 163 to the ring conductor 125 and high resistance relay 164 to the tip conductor 124; and (4) closes a circuit from relay 165 which may be traced from battery, the winding of relay 165, armature and back contact of the rotary magnet 162, normal contacts of armature 2 of relay 165, front contact and armature 5 of relay 153, armature 6 and front contact of relay 160, armature 1 and back contact of relay 159, front contact and armature 1 of relay 158, to wiper 166 of the connector. Relay 163 holds to ground on the ring at the distant end of the trunk and holds relay 151 operated.

If the busy line is the first terminal in a group of lines, the bank terminals cooperating with brushes 156 and 166 will be strapped together as indicated in the second group of bank terminals where direct connection is shown between bank terminals 167 and 168. Thus, the busy potential of terminal 167 will be connected to terminal 168 and thus communicated over the circuit just traced to operate relay 165. Relay 165, operated, causes the rotary magnet to operate in a circuit which may be traced from ground on conductor 161 through armature 1 and front contact of relay 165, armature 10 and back contact of relay 157, winding of rotary magnet 162 to battery. Since relay 165 and rotary magnet 162 now mutually control each other, the switch will step automatically until an idle terminal is found or the last line of the group is encountered. Relay 158 being slow to release holds during this stepping and will remain operated so long as busy lines are encountered.

The switch will not step beyond the last terminal in the group since the terminals 169 and 170, cooperating with wipers 156 and 166, respectively, are not strapped together and there will be no operating circuit for relay 165 as described above. Relay 158 remains operated from ground on terminal 169 and an operating path for relays 159 is found from battery, through the winding of relay 165 to ground on the sleeve. During rotary stepping on terminals other than the last, relay 159 does not operate since it is bridged across the leads which are strapped together on these bank terminals. Relay 159, operated, locks itself and relay 153 to ground on conductor 161 and opens the circuits leading to wipers 156 and 166. Relay 165 does not operate in series with relay 159.

The operation of an individual busy line is

the same as described for the last line of a group except that there is no rotary hunting.

Removing the line relay 150 from the tip and ring as described above is a signal to the trunk that the distant private branch exchange to prepare to ring or to receive a busy indication and when the trunk is thus prepared, it reverses battery and ground to the connector circuit. Relay 163 then releases and relay 164 operates. Relay 164 closes resistance 171 across the windings of the line relay 150 which operates and holds the first slow relay 151. Relay 150 completes the circuit for relay 172 which closes ground to the ring of the trunk to the distant private branch exchange as a busy indication. This last connection may be traced from ground, front contact and armature 5 of relay 172, armature 6 and back contact of relay 157 to the ring conductor 125. This, as described hereinbefore, operates the differential relay 119 in the outgoing trunk circuit and causes the so-called syncopated signal to be displayed in the cord circuit.

If the first line of the group or an individual line is idle, relays 158 and 165 will not operate. When relay 165 releases, the upper winding of relay 157 is closed to the sleeve wiper 156. Battery through the cut-off relay on the sleeve bank operates armature 5 of relay 157 which closes a circuit for the lower winding thereof to completely operate relay 157. Relay 157, operated, grounds the sleeve wiper 156 to busy the line and to hold the cut-off relay operated partially closes the tip and ring of the line to the trunk, opens the rotary magnet, release magnet and the circuit of relay 158 and prepares the circuit of relay 172 which will become effective upon the reoperation of the line relay 150.

When relay 164 operates on battery reversal from the trunk circuit at the distant private branch exchange, relay 150 operates to complete the circuit for relay 172. Relay 172, operating, removes relay 163 from the ring of the trunk, closes the tip and ring of the trunk to the tip and ring of the station, and locks independently of the contacts of relay 150. During ringing from the distant private branch exchange relay 164 holds to ringing ground on the tip. The supervisory relay 173, whose windings are in series with the line to the called station, may operate on ringing current and operate relay 174. Relay 174 opens the circuit of relay 164 but since its armature 1 and front contact perform the same operation as the armature and front contact of relay 164, relay 150 will be maintained operated to hold the connection.

When the called line answers and ringing is tripped, relay 173 operates on the station loop to remove relay 164 from the connection and to hold the connection through the operation of relay 174 as described. On disconnection by the called station, relays 173 and 174 release but relay 164 holds the switch.

When the switch in rotary hunting over busy lines as described above steps to an idle line, relay 158 releases because of absence of busy potential on the sleeve but relay 160 which had operated from relay 159 remains operated through locking contacts to insure that the battery and ground from the line relay 150 are not again connected to the tip and ring. Relay 157 operating on the idle line as described above cannot operate until relay 158 releases and it is, therefore, necessary to lock relay 160 operated.

When the cord is pulled down after the station disconnects, relay 164 releases releasing the line relay 150 and the first slow relay 151. Relay 151 releases relay 157 which operates the release magnet 175 to restore the switch to normal and releases relays 160 and 157. On disconnection by the attendant from a busy connection, relay 164 releases relay 151 which operates the release magnet to restore the switch to normal. Relays 152, 153, 150 and 172 also release.

Connector circuit for completing from attendant to station lines—Fig. 3

A plug seating circuit is provided to insure against preliminary impulses during plug-in. When the plug is fully seated battery on the ring of the cord operates relay 177 to operate its armature 4 only. This closes the sleeve of the jack to the upper winding of relay 178. Relay 178 operates and extinguishes the idle indicating lamp 179. Normally the circuit may be traced from ground through lamp 179, springs 5 and 4 of the vertical off-normal spring combination 180, back contact and armature 2 of relay 178. Upon the operation of relay 178 this circuit is opened and battery is extended through armature 2 and its front contact to the corresponding armature of the next corresponding relay 181 for operating the idle indicating lamp of the next idle circuit. The operation of relay 178 also closes a circuit through the lower winding of relay 177 to fully operate this relay. Relay 177, fully operated, opens its own upper winding and closes the tip and ring of jack 176 to ground and battery, respectively, through the windings of the line relay 182. Relay 177 also grounds lead 183 for purposes to be described hereinafter.

The line relay 182 operates from a bridge in the cord circuit and energizes relay 184 which locks to ground through its armature 3 and front contact, armature 4 and back contact of relay 185 to ground on conductor 186. The circuit is now ready for pulsing. On the first opening from the dial, relay 182 releases operating relay 186 in series with the vertical magnet 187. Relay 186 operates before the vertical magnet steps the switch, opens the circuit of relay 188 and closes its own locking circuit to the vertical off-normal springs. When the switch steps and the vertical off-normal springs 190 operate, the operating path of relay 186 will be opened but the holding path will be completed without interrupting the stepping circuit. When the line relay 182 reoperates the vertical magnet releases but relay 186 being slow to release holds until the end of the digit. The switch thus continues to step vertically until the end of the digit when the operation of relay 182 releases relay 186.

On the second digit the line relay 182 and the rotary magnet operate. The circuit for this operation may be traced from ground, armature 3 and back contact of relay 188, armature and back contact of relay 182, armature 1 and front contact of relay 184, springs 8 and 7 of the vertical off-normal spring combination 189, armature and back contact of relay 186, armature 3 and back contact of relay 190 through the winding of relay 188 and in parallel therewith, over back contact and armature 3 of relay 191, rotary magnet 192 to battery. The rotary magnet 192 and relay 188 are in multiple but relay 188 being slow to release remains operated during pulsing while the rotary magnet steps the switch to the desired line terminal.

When the switch is on the line to which it has been dialed and before the slow release relay

188 releases, the sleeve of the called line is connected through the contacts of relay 188 to the winding of relay 190. On a busy line the sleeve will be grounded or connected to positive battery to operate relay 190. When relay 188 releases, relay 190 locks to the front contact and armature 2 of relay 184.

Relay 190 operated opens the circuit of relay 191, opens the circuit of relay 183 and the rotary magnet 192 and closes a circuit to operate relay 189. This circuit may be traced from ground on conductor 183 to the armature 1 and back contact of relay 183, front contact and armature 1 of relay 190, winding of relay 189 to battery. Relay 189, operated, (1) removes ground from lower winding of the line relay 182; (2) disconnects the upper winding of the line relay 182 from its normal connection to the ring conductor toward the jack; (3) connects the lower winding of relay 182 across the tip and ring of the jack under control of relay 185; (4) connects relay 185 to interrupter 193; (5) opens the operating circuit of relay 184; and (6) connects the lower winding of relay 178 to the sleeve in multiple with the upper winding thereof to change the resistance of the sleeve from high to low.

Reducing the resistance of the sleeve toward the cord by connecting the upper and lower windings of relay 178 in parallel causes the cord circuit to connect machine-ringing current to the tip and ring. This ringing is tripped the first time that the line relay 182 is connected to the tip and ring. Relay 185 operates and releases from 60 interruptions per minute provided by the interrupter 193 to open and close the bridged winding of relay 182 to the tip and ring as a busy indication to the attendant. As hereinbefore described, this interrupted bridge operates at the rate of 60 interruptions per minute and so modifies the flashing recall signal in the cord circuit that a different type of signal is produced.

The sleeve of an idle line will have the cut-off relay to battery instead of ground connected to it and when relay 186 releases at the end of rotary stepping, relay 191 has its upper winding connected to the sleeve wiper of the switch. This will energize armature 4 of relay 191 which results in closing a circuit from ground on conductor 183 through armature 4 and front contact of relay 191, the lower winding thereof in series with the winding of the rotary magnet 192. Relay 191 fully operates on its lower winding and holds under control of relay 177. Relay 191 connects direct ground forward to the line circuit sleeve to hold the cut-off relay and to busy the terminal to other switches. Relay 191 also opens the circuit for relay 190 and the rotary and release magnets, closes the tip and ring of the jack through to the tip and ring of the station, and operates relay 185.

Relay 185 operates and removes the winding of relay 182 from the tip and ring, closes the lower winding of relay 178 to the sleeve in multiple with the upper winding, and releases relay 184. The circuit is now in its talking condition.

When the cord is pulled down, relay 178 releases, releasing relay 177. Relay 177 releases either relay 191 on a completed connection or relay 190 on a busy connection. With relay 191 released, relay 185 releases and the release magnet 194 operates to restore the switch to normal. The idle indicating circuit is not reclosed to the lines associated with this circuit until the vertical off-normal springs 130 have functioned when the switch has restored to normal.

Connector circuit—Rotary hunting—For completing from attendant to station lines—Fig. 9

A plug seating circuit is provided to insure against preliminary impulses during plug-in. When the plug is fully seated, battery on the ring of the cord operates relay 196 to move its armature 4 only. This closes a circuit from the sleeve of jack 195 to the upper winding of relay 197. Relay 197 operates from the sleeve of the cord, extinguishes the idle indicating lamp 198 and extends the circuit to the idle indicating lamp of the next idle circuit. Relay 197, in operating, also closes a circuit to the lower winding of relay 196 to fully operate it. Relay 198, fully operated, opens its own lower winding from the ring, closes the tip and ring of the jack to ground and battery, respectively, through the windings of the line relay 199 and connects a holding ground to conductor 200.

Relay 199 operates from a bridge in the cord circuit or telephone circuit operating relay 201 which locks to ground from relay 197.

On the first opening from the dial, relay 199 releases operating relay 202 and the vertical magnet 203 through the front contact of armature 2 of relay 201. Relay 202 operates before the vertical magnet steps the switch, opens the circuit of relay 204 and closes its own locking circuit to the vertical off-normal springs 205. When the switch steps and the vertical off-normal springs operate, relay 202 will have its original operating path opened but the holding path through its own contacts will be completed without interrupting the stepping circuit. When the line relay 199 reoperates, the vertical magnet 203 releases but relay 202 being slow to release holds until the end of the digit. The switch thus continues to step vertically until the end of the digit when the operation of the line relay 199 releases the second slow relay 202.

On the second digit when the line relay 199 releases, relay 204 and the rotary magnet 206 operate. Relay 204 being slow to release holds over pulsing while the rotary magnet steps the switch to the desired line terminal which may be either an individual line or the first of a group of lines.

Before relay 204 releases at the end of rotary stepping a path is closed from the sleeve wiper to relay 207. A busy line will have ground or positive battery on the sleeve which will operate relay 207. When relay 204 releases, relay 207 locks to the sleeve ground and operates relay 208. Relay 208, operated, connects the lower winding of relay 197 to the sleeve in multiple with the upper winding thereof as a low condition to the cord sleeve, opens the line relay 199 from the tip and ring of the jack and holds relay 199 operated. Relay 207 locks under control of relay 200 in its normal condition and relay 196 operated. Relay 208 also closes a circuit from battery through relay 210 to the H wiper of the connector switch.

If the busy line is the first terminal in a group of lines, the H and S banks will be strapped together and the busy potential on the H bank will operate relay 210. Relay 210, operated, operates the rotary magnet 206. Relay 210 locks under control of the armature and back contact of the rotary magnet. When the switch steps to the next terminal relay 210 releases and opens the

circuit of the rotary magnet. Relay 207 being slow to release holds until the next terminal is reached and will remain operated if this terminal is also busy. Relay 210 and the rotary magnet will again operate to step the switch.

The switch will not step beyond the last terminal in the group since the H and S banks are not strapped together on this terminal and there will be no operating circuit for relay 210 as described above. Relay 207 operated from ground on the S lead and an operating path for relay 211 is found from battery through relay 210 to ground on the sleeve. During rotary stepping on terminals other than the last, relay 211 does not operate since it is bridged across the H and S leads which are strapped together on these terminals. Relay 211, operated, locks itself and relay 207 to ground on the contacts of relay 201, opens the H and S leads toward the switch bank, and operates relay 209. Relay 210 does not operate in series with relay 211. Relay 209, operated, (1) removes ground from upper winding of relay 199; (2) removes the lower winding of relay 199 from the ring of the jack; (3) connects the upper winding of relay 199 across the tip and ring of the jack under control of relay 208; (4) transfers relay 203 to interrupter 212; and (5) connects the lower and upper windings of relay 197 together at another point. Relay 209 operates and releases from the 60 interruptions per minute ground to open and close the bridged winding of relay 199 to the tip and ring of the jack, first, to trip machine ringing, and then to flash the cord lamps as a busy indication to the attendant.

If the first line of the group is idle, relays 207 and 210 will not operate. Relay 204 releases, closes the upper winding of relay 213 to the cut-off relay battery in the line circuit. Relay 213 operates its armature 5 which closes the lower winding thereof. Relay 213 then completely operates on its lower winding, grounds the sleeve wiper to busy the line and to hold the cut-off relay operated, connects the tip and ring of the jack to the tip and ring of the line, and opens the rotary magnet, release magnet and the circuits of relays 207 and 201.

When the switch in rotary hunting over busy lines, as described, steps to an idle line, relay 207 releases because of absence of busy potential on the sleeve, but relay 208 which had operated from relay 207 remains operated through locking contacts to insure that the battery and ground from the line relay are not again connected to the ring and tip of the jack and that the sleeve circuit does not again become high in resistance. Relay 213 operating on the idle line, as described hereinbefore, cannot operate until relay 207 releases.

When the cord is pulled down, relay 197 releases relay 196. Relay 196 releases either relay 213 on a completed connection or relays 207 and 211 on a busy connection. Upon the release of relays 199, 201 and 213 a circuit is established for the operation of release magnet 214 which operates to restore the switch to normal. The idle indicating circuit is not reclosed to the lamp associated with this circuit until the vertical off-normal springs 205 have functioned on the release of the switch.

What is claimed is:

1. In a telephone system, a plurality of lines, each said line having a designation containing a plurality of digits, subscriber controlled selective switches for interconnecting said lines, a manual board for establishing connections to lines each designated by a portion of the designation of a wanted one of said lines, attendant selective switches controlled over said manually selected lines for selecting said lines by the remaining portion of the designation of a wanted one of said lines, cord circuits in said manual board each having a marginal relay in the sleeve thereof, a high resistance sleeve connection for each of said lines leading to one of said attendant's selective switches to differentiate said lines from other lines outgoing from said manual board, said other lines each having a low resistance sleeve connection, a dialing circuit in said cord circuit effective in response to the connection of said cord circuit to one of said lines having a high resistance sleeve, a ringing circuit in said cord circuit effective in response to the connection of said cord circuit to one of said lines having a low resistance sleeve, said ringing circuit being rendered effective by the response of said marginal relay to said low resistance sleeve connection, means in said attendant's selective switch responsive to the seizure thereby of a wanted one of said lines for changing the high resistance sleeve circuit of the line leading to said attendant's selective switch to a low resistance sleeve circuit for operating said marginal relay in said cord circuit to effectively substitute therein said ringing circuit for said dialing circuit.

2. In a telephone system, a plurality of lines, each said line having a designation containing a plurality of digits, subscriber controlled selectors and connectors for interconnecting said lines, a manual board for establishing connections to lines each having a designation containing a portion of the designation of a wanted one of said lines, attendant connectors controlled over said manually selected lines for selecting said lines by the remaining portion of the designation of a wanted one of said lines, cord circuits in said manual board each having a marginal relay in the sleeve thereof, a high resistance connection for each of said lines leading to one of said attendant connectors to differentiate said lines from other lines outgoing from said manual board, said other lines each having a low resistance sleeve connection, a dialing circuit in said cord circuit effective in response to the connection of said cord circuit to one of said lines having a high resistance sleeve, a ringing circuit in said cord circuit effective in response to the connection of said cord circuit to one of said lines having a low resistance sleeve, said ringing circuit being rendered effective by the response of said marginal relay to said low resistance sleeve connection, means in said attendant's connector responsive to the seizure thereby of a wanted one of said lines for changing the said high resistance sleeve circuit of the line leading to the said attendant's connector to a low resistance sleeve circuit for operating said marginal relay in said cord circuit to effectively substitute therein said ringing circuit for said dialing circuit.

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