July 28, 1942. H. N. NEWSTEDT 2,291,496

TELEPHONE SYSTEM

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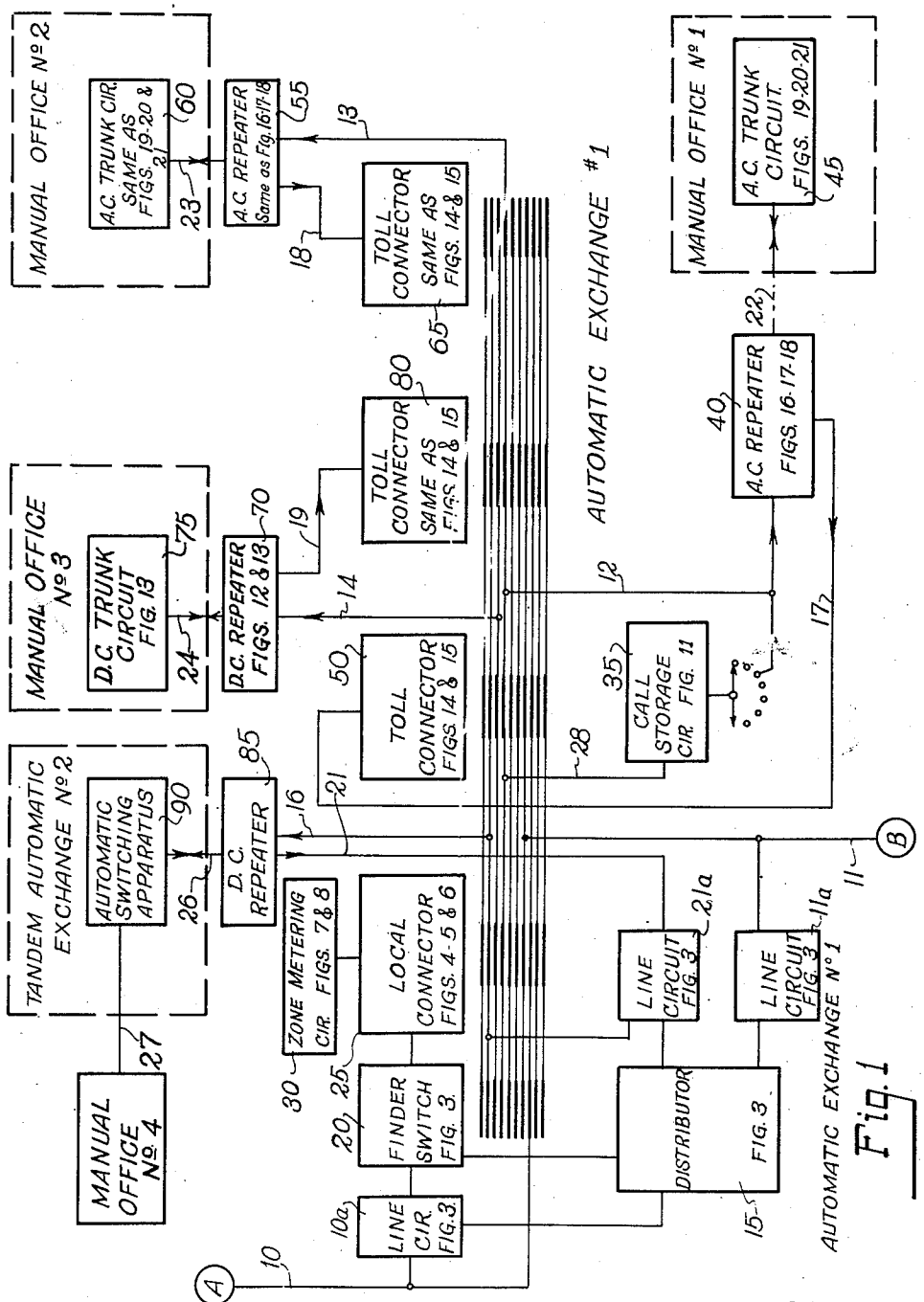


Fig. 1

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ATTORNEYS.

July 28, 1942. H. N. NEWSTEDT 2,291,496

TELEPHONE SYSTEM

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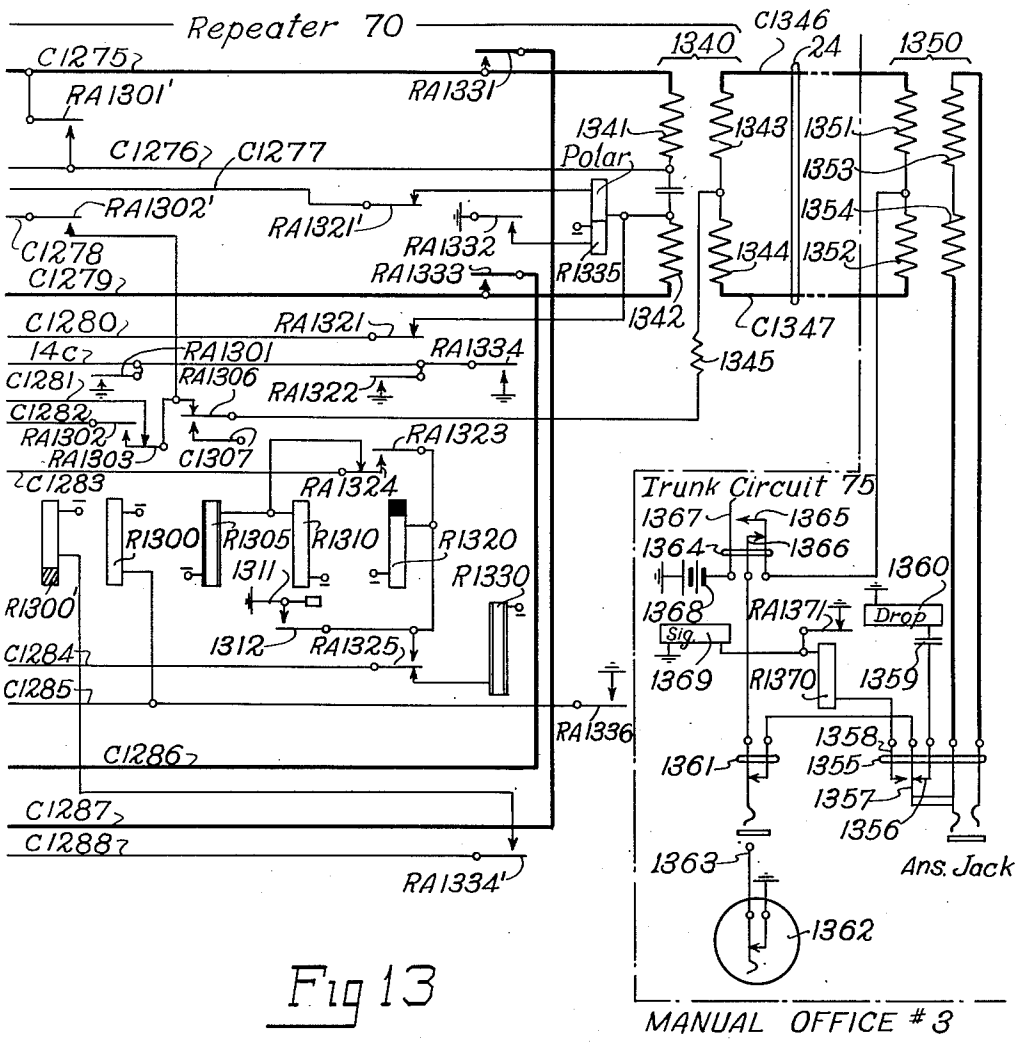


Fig 13

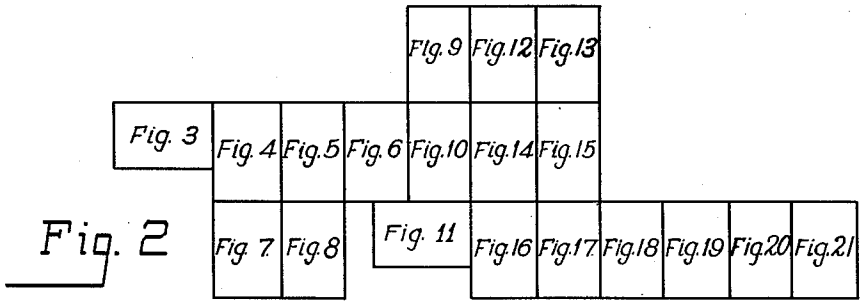


Fig. 2

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TELEPHONE SYSTEM

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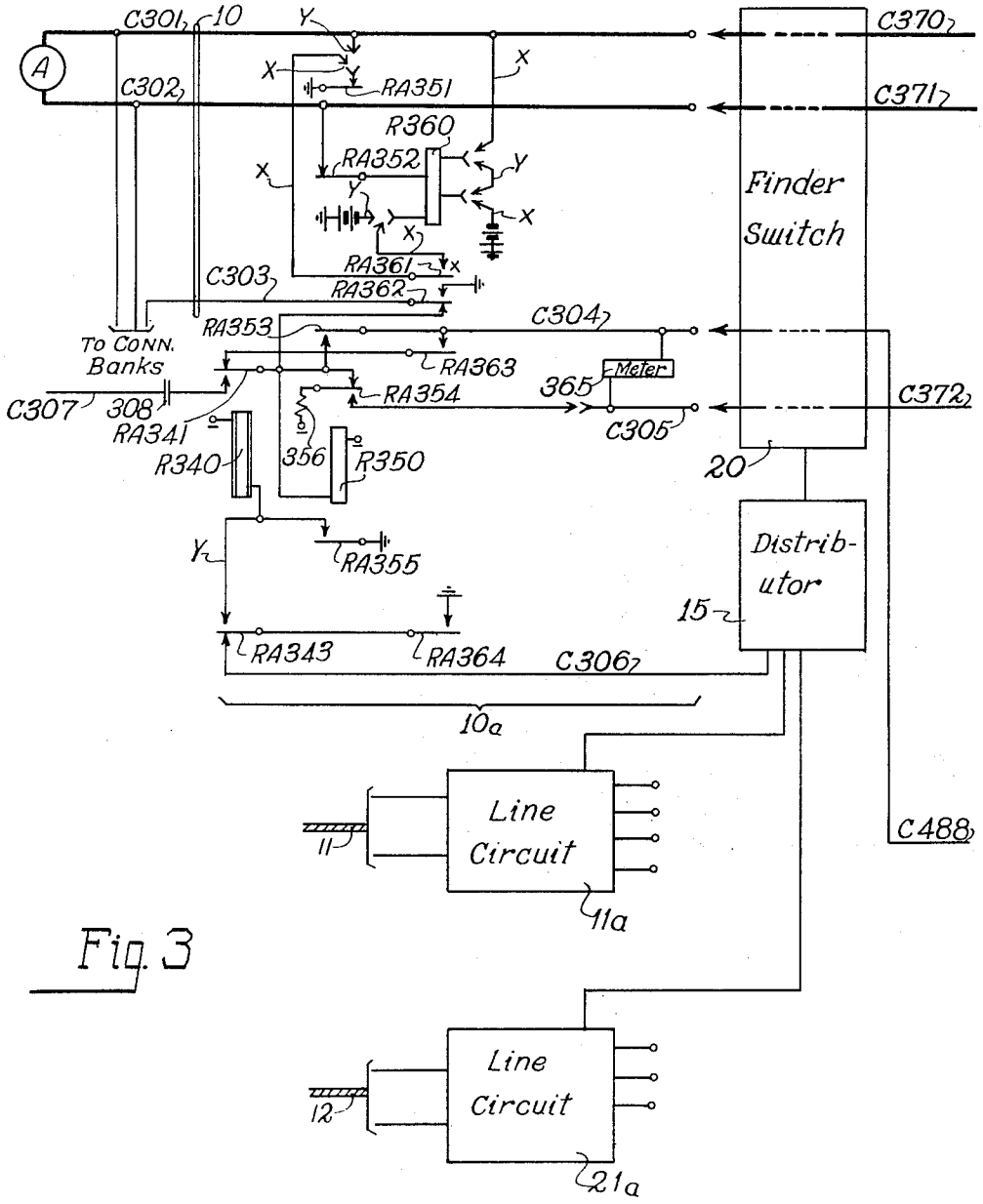


Fig. 3

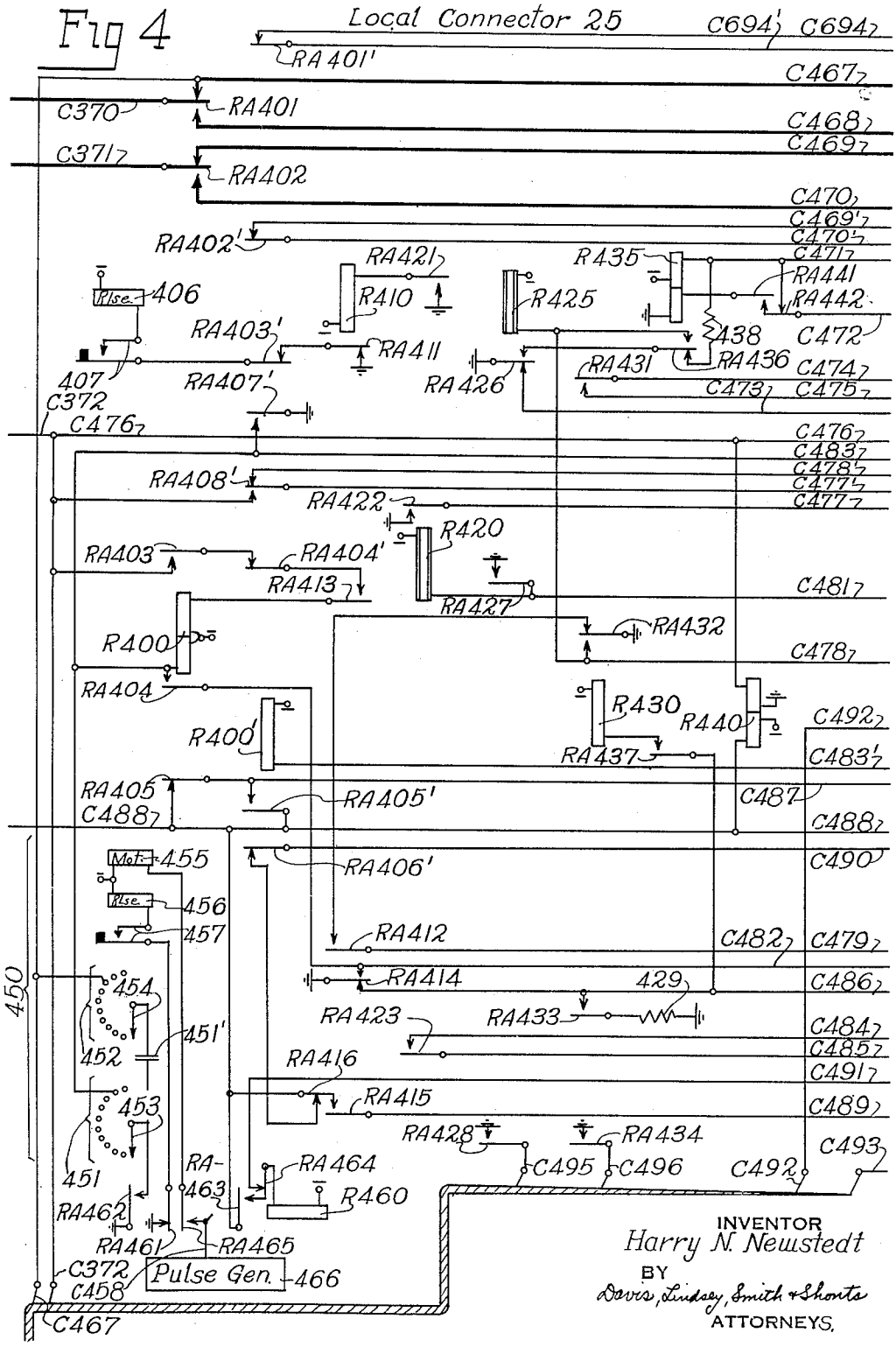
INVENTOR
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July 28, 1942. H. N. NEWSTEDT 2,291,496

TELEPHONE SYSTEM

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Fig 4



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TELEPHONE SYSTEM

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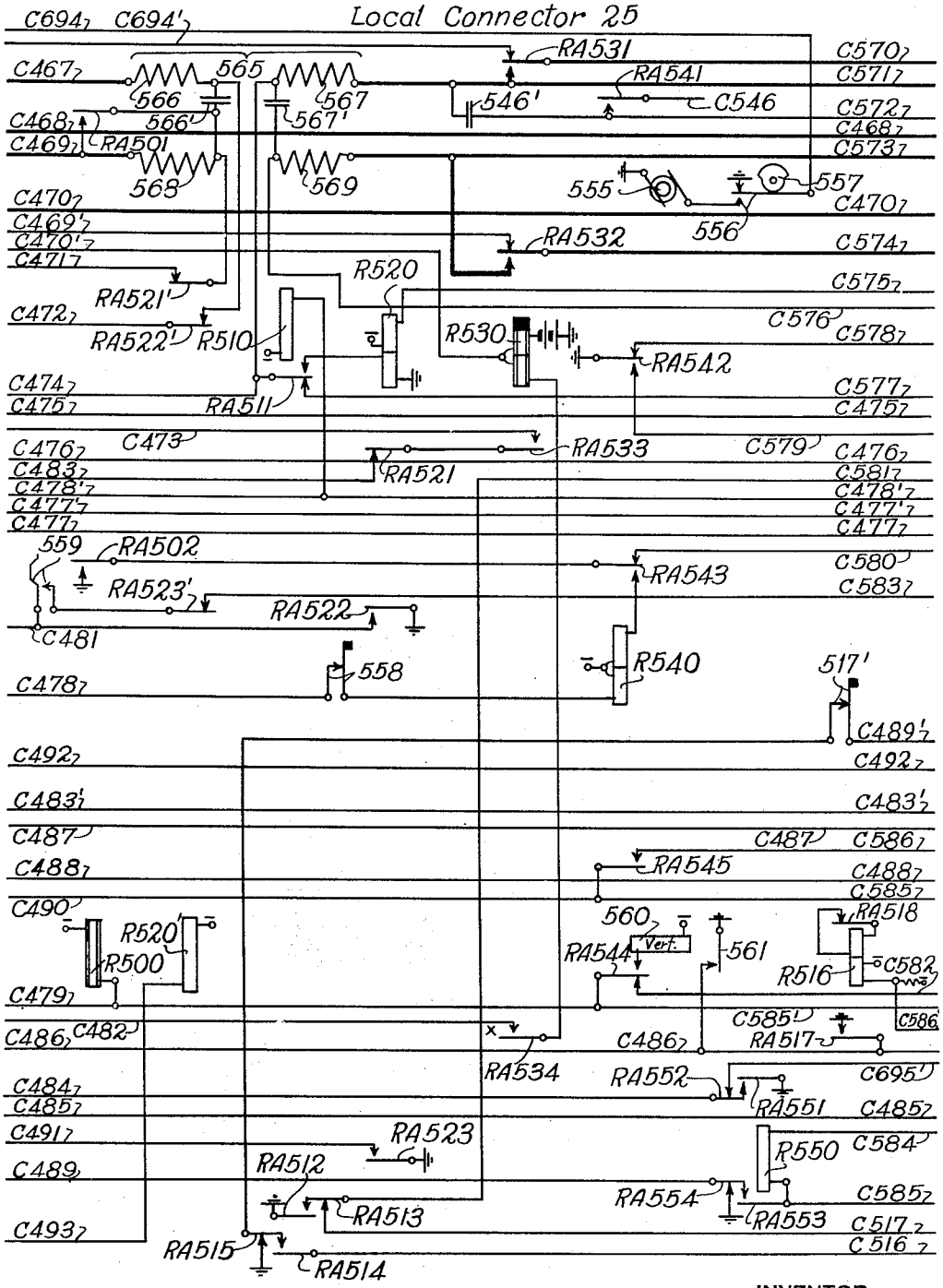


Fig. 5

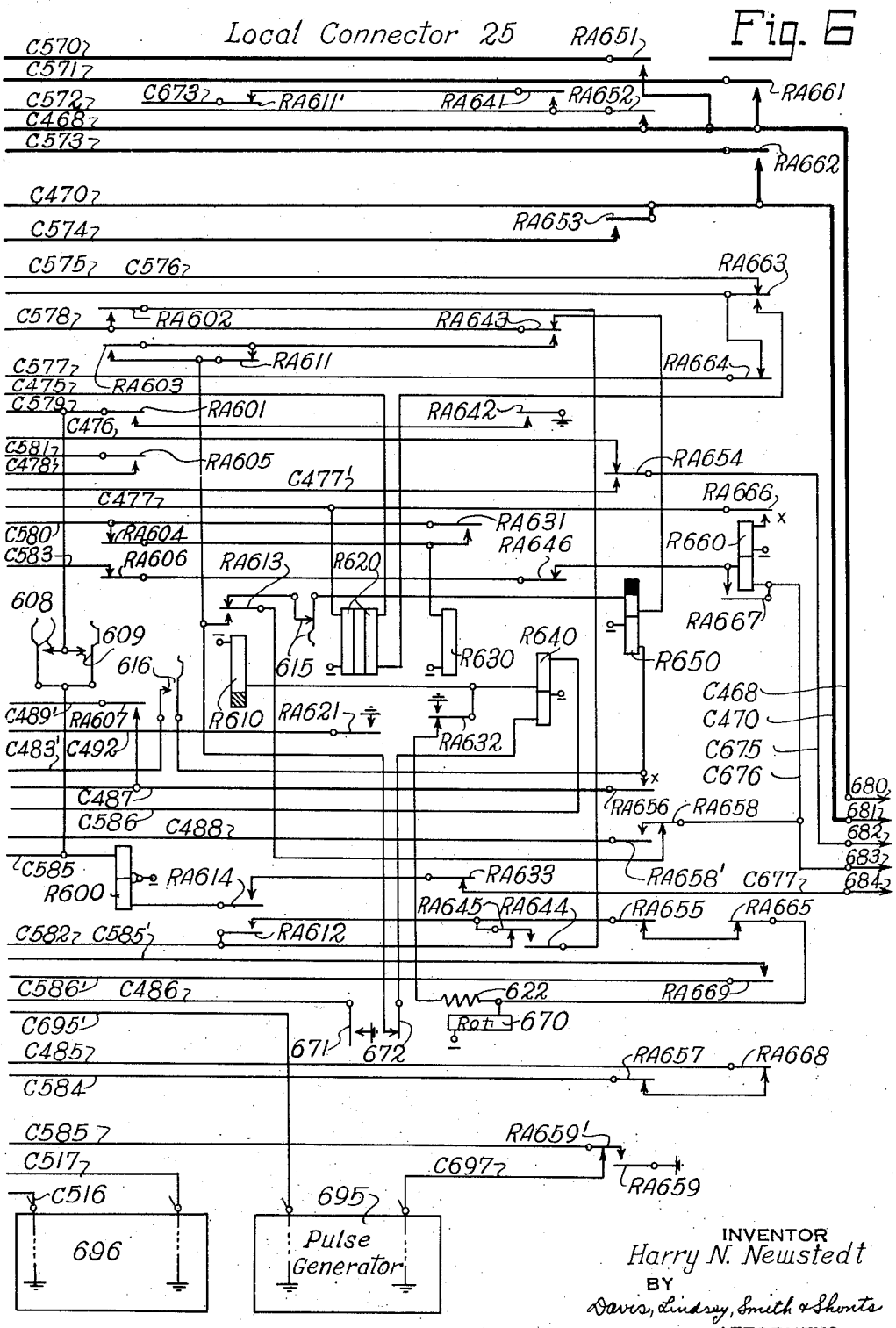
INVENTOR
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July 28, 1942. H. N. NEWSTEDT 2,291,496

TELEPHONE SYSTEM

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Fig. 6



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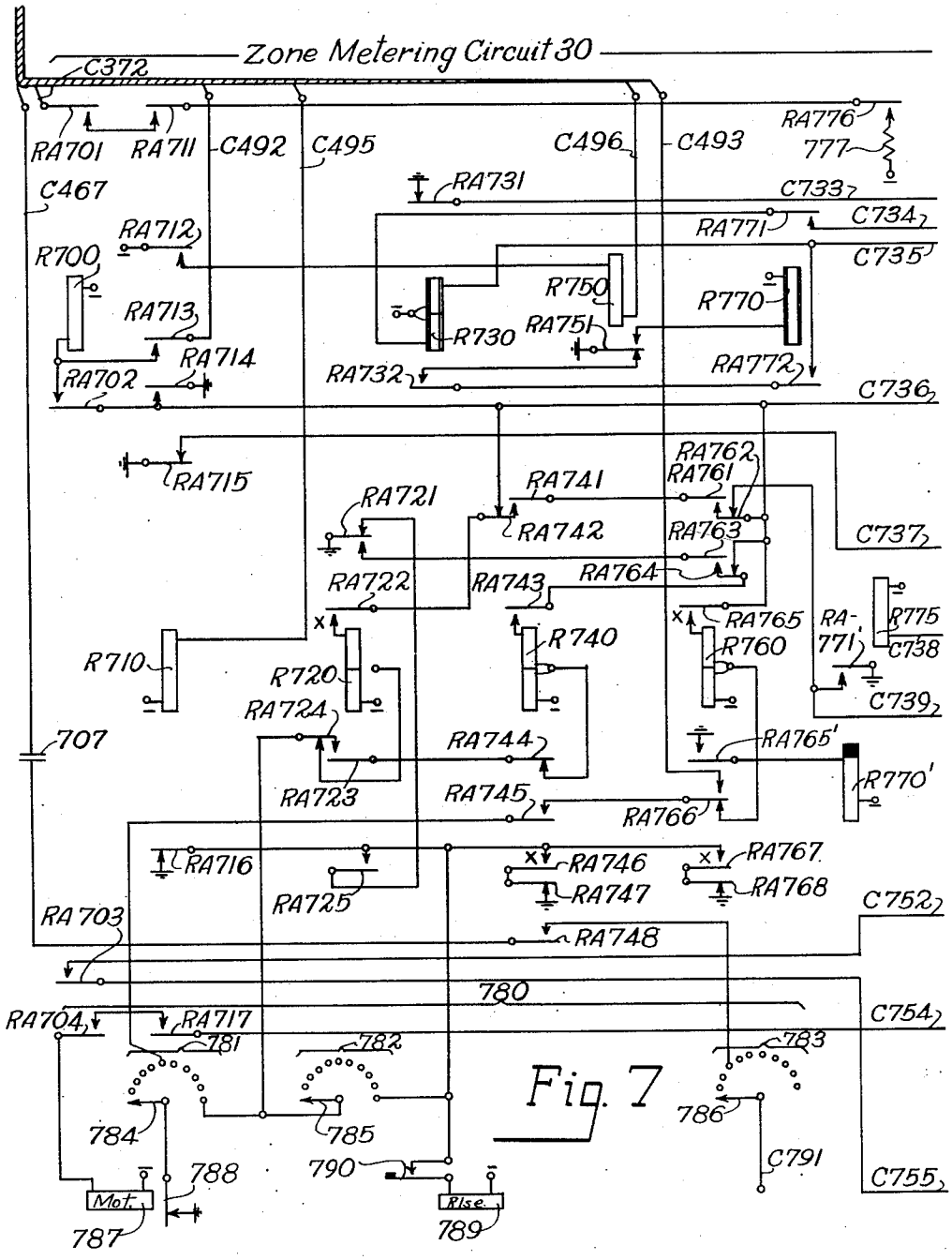


Fig. 7

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TELEPHONE SYSTEM

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Zone Metering Circuit 30

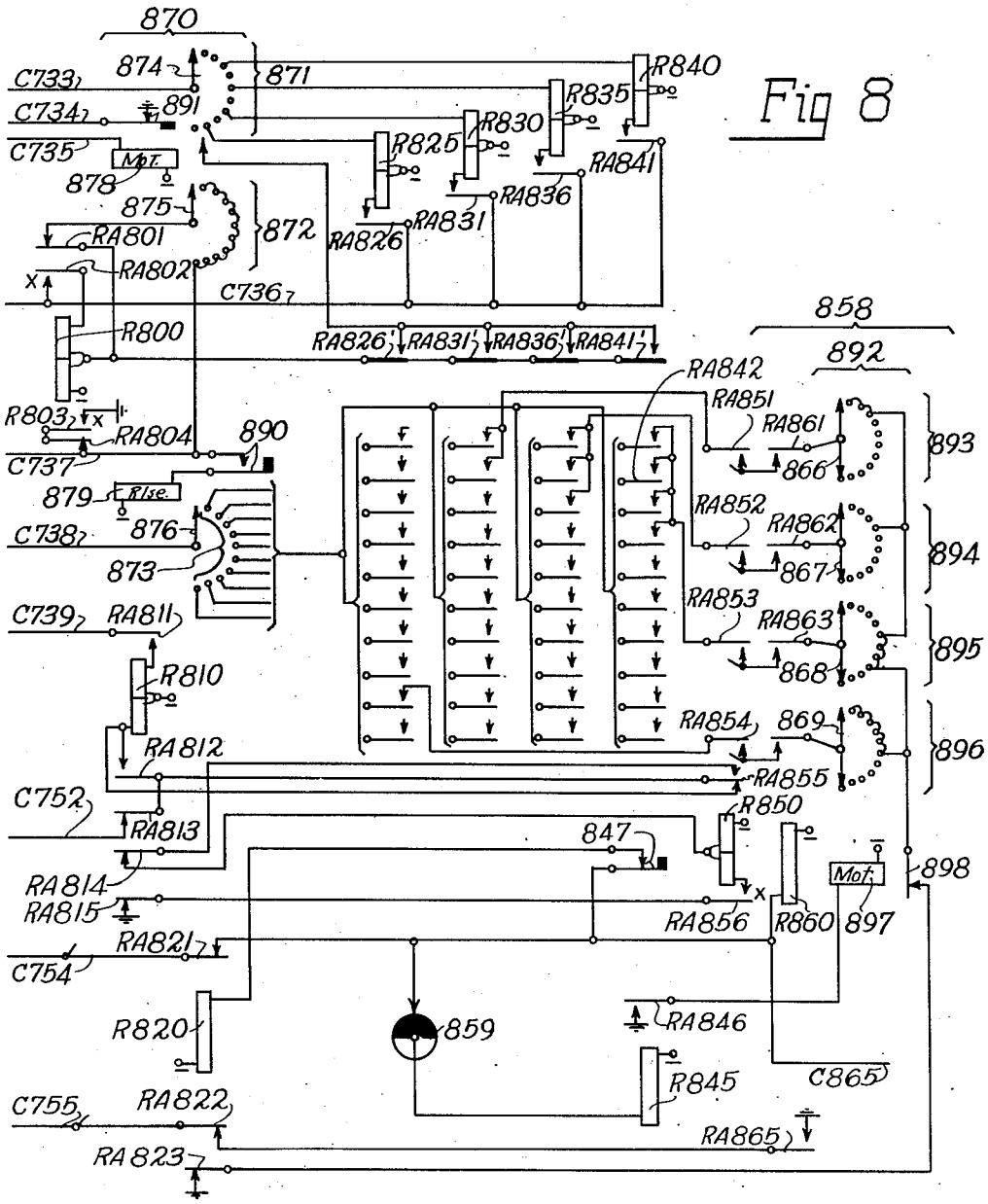


Fig 8

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July 28, 1942. H. N. NEWSTEDT 2,291,496

TELEPHONE SYSTEM

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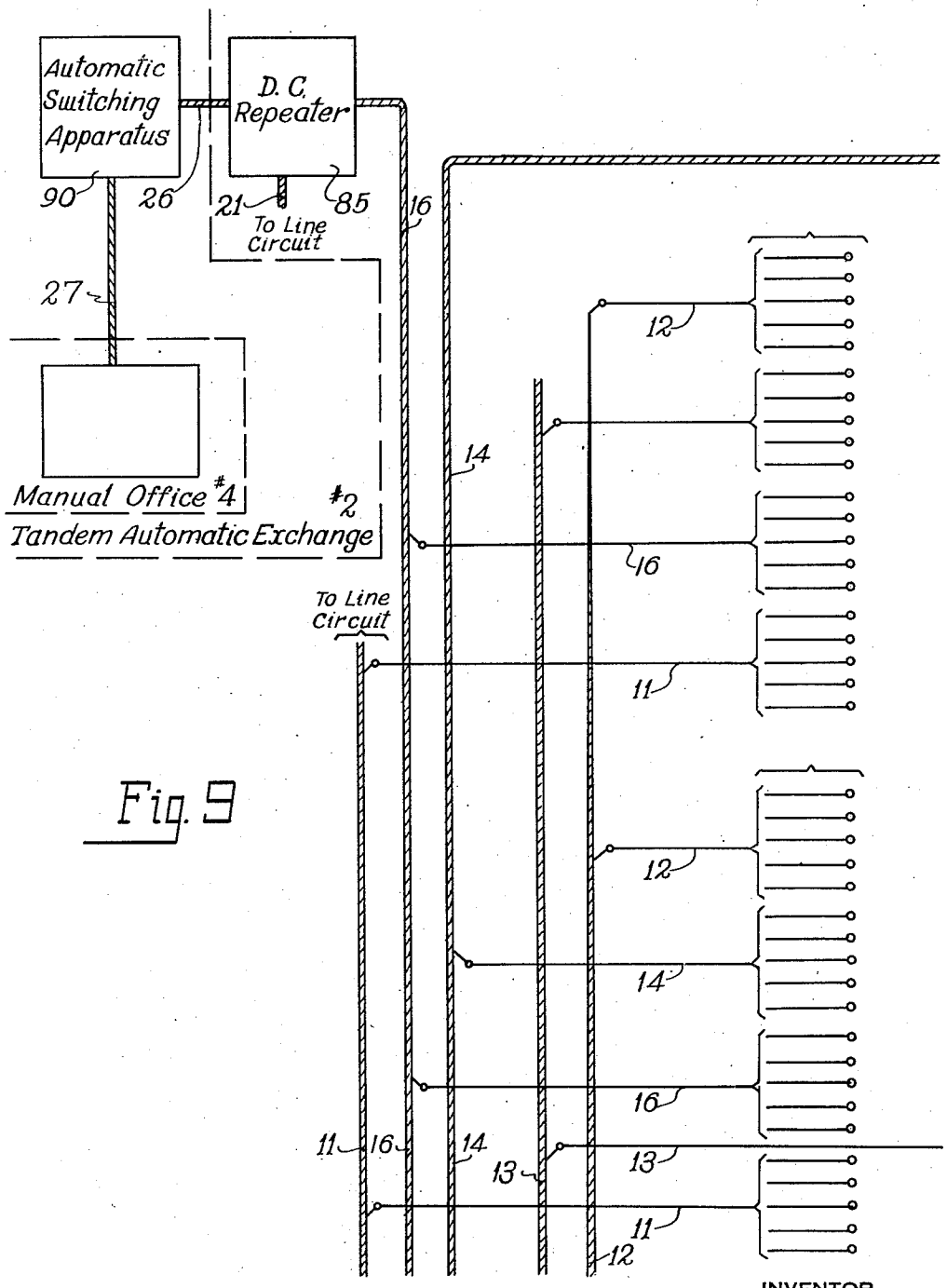


Fig. 9

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TELEPHONE SYSTEM

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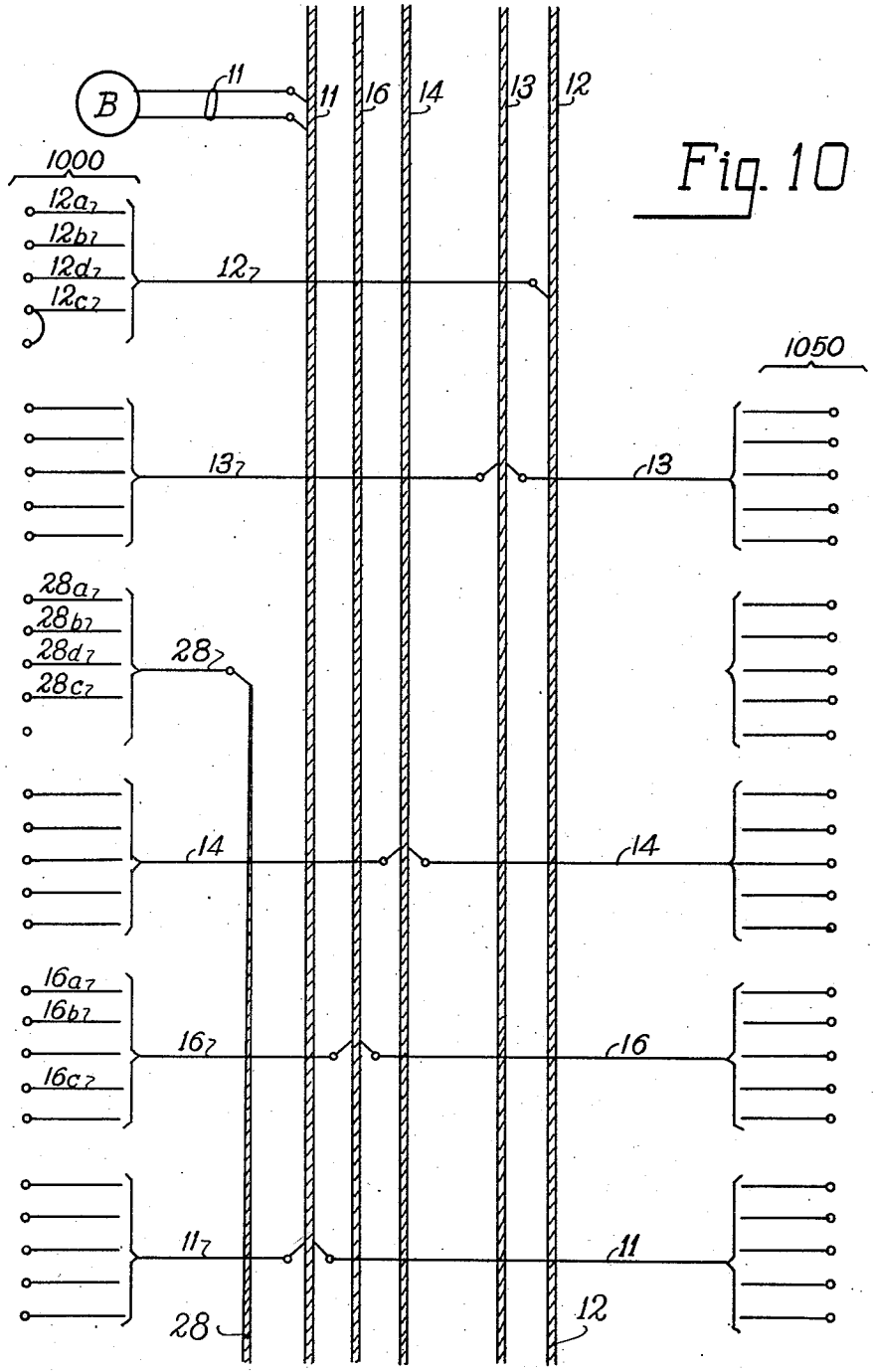


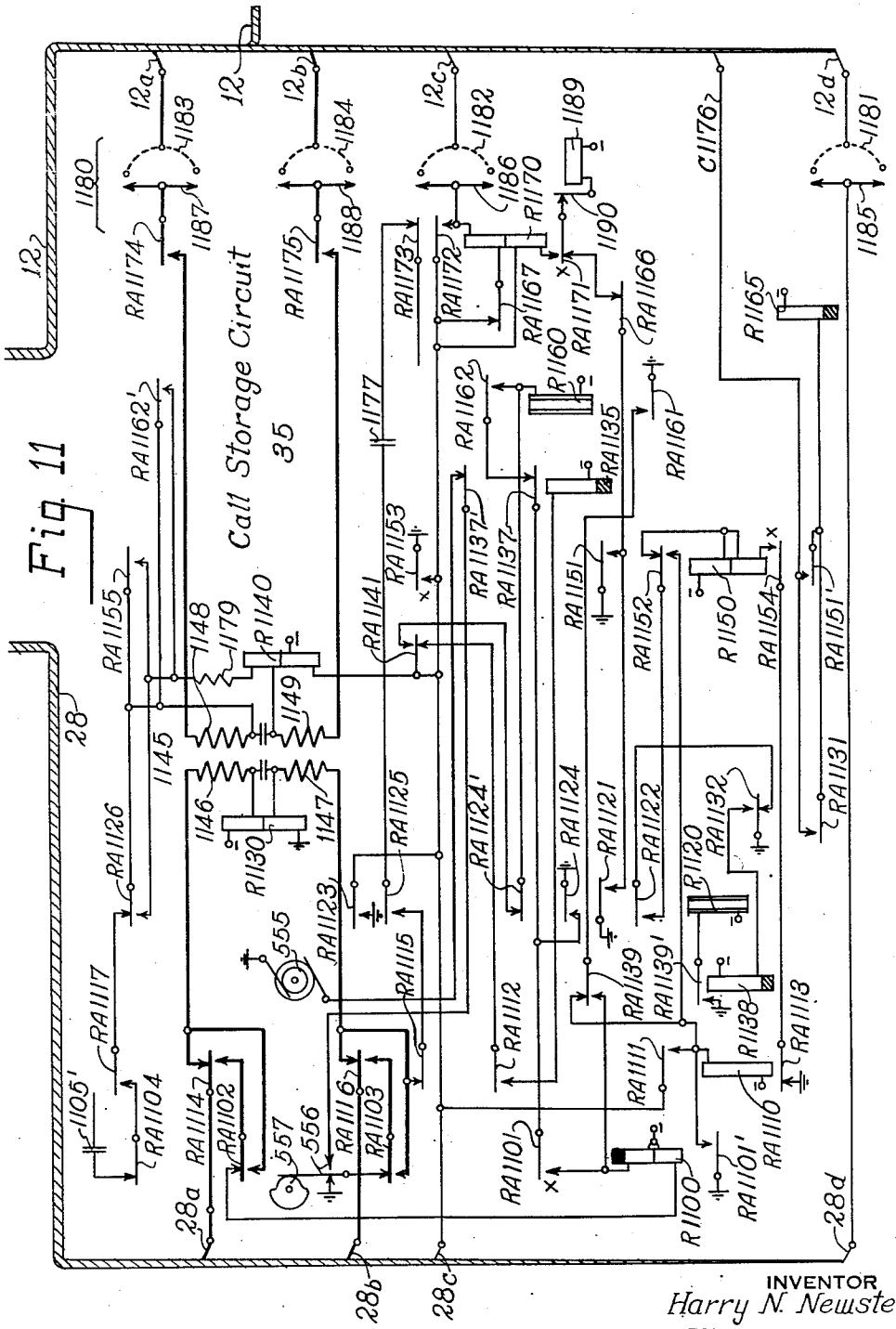
Fig. 10

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TELEPHONE SYSTEM

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INVENTOR
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TELEPHONE SYSTEM

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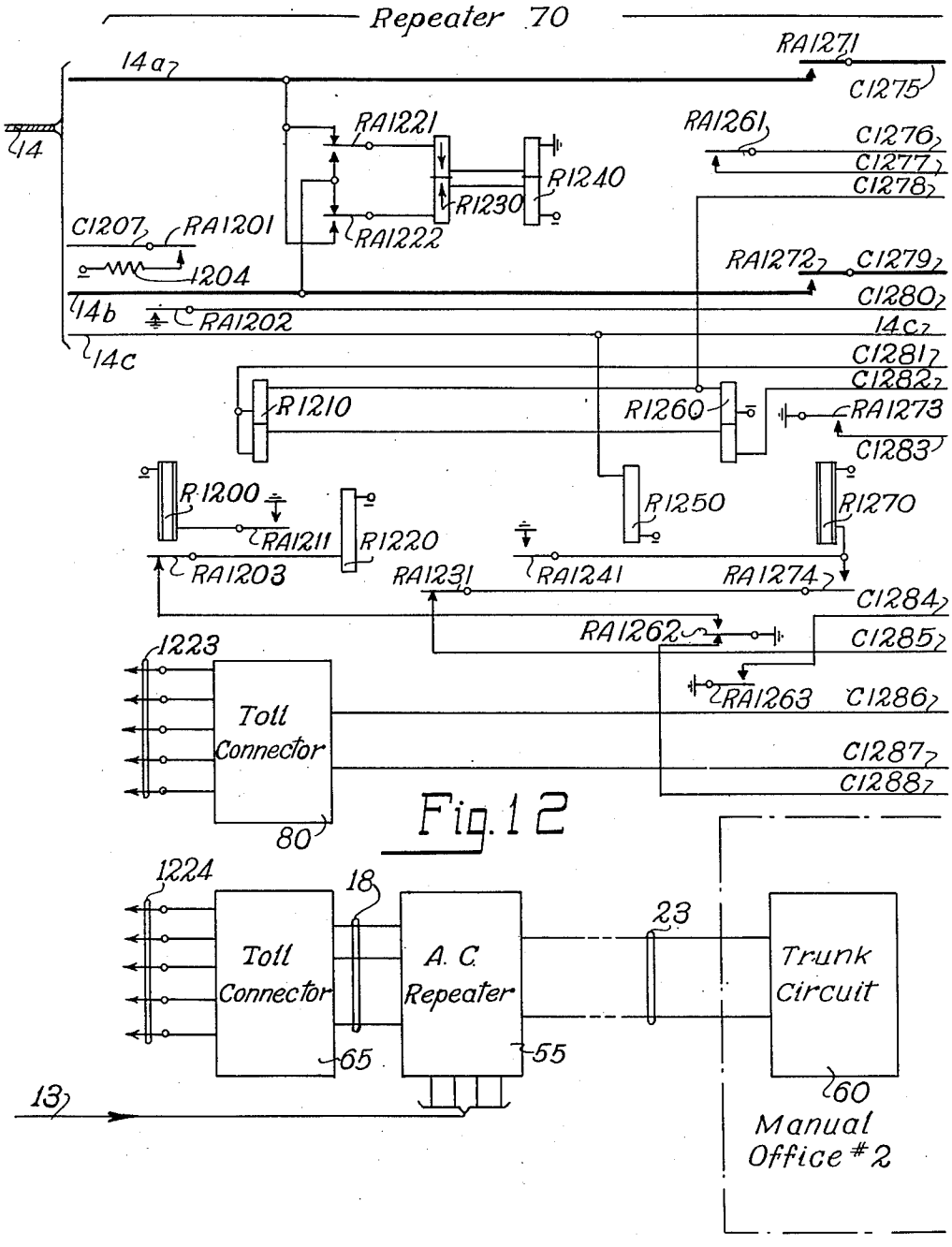


Fig. 12

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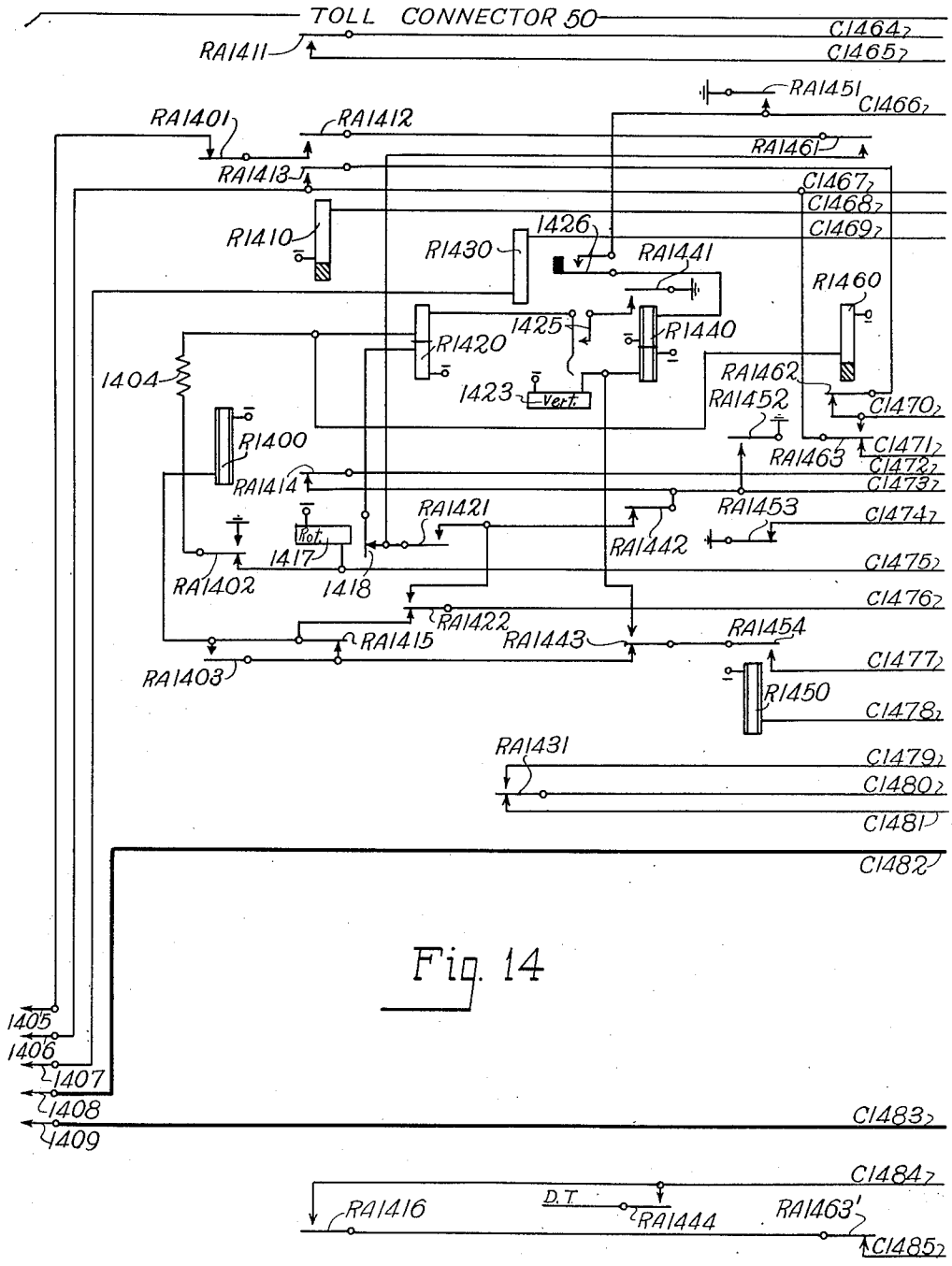


Fig. 14

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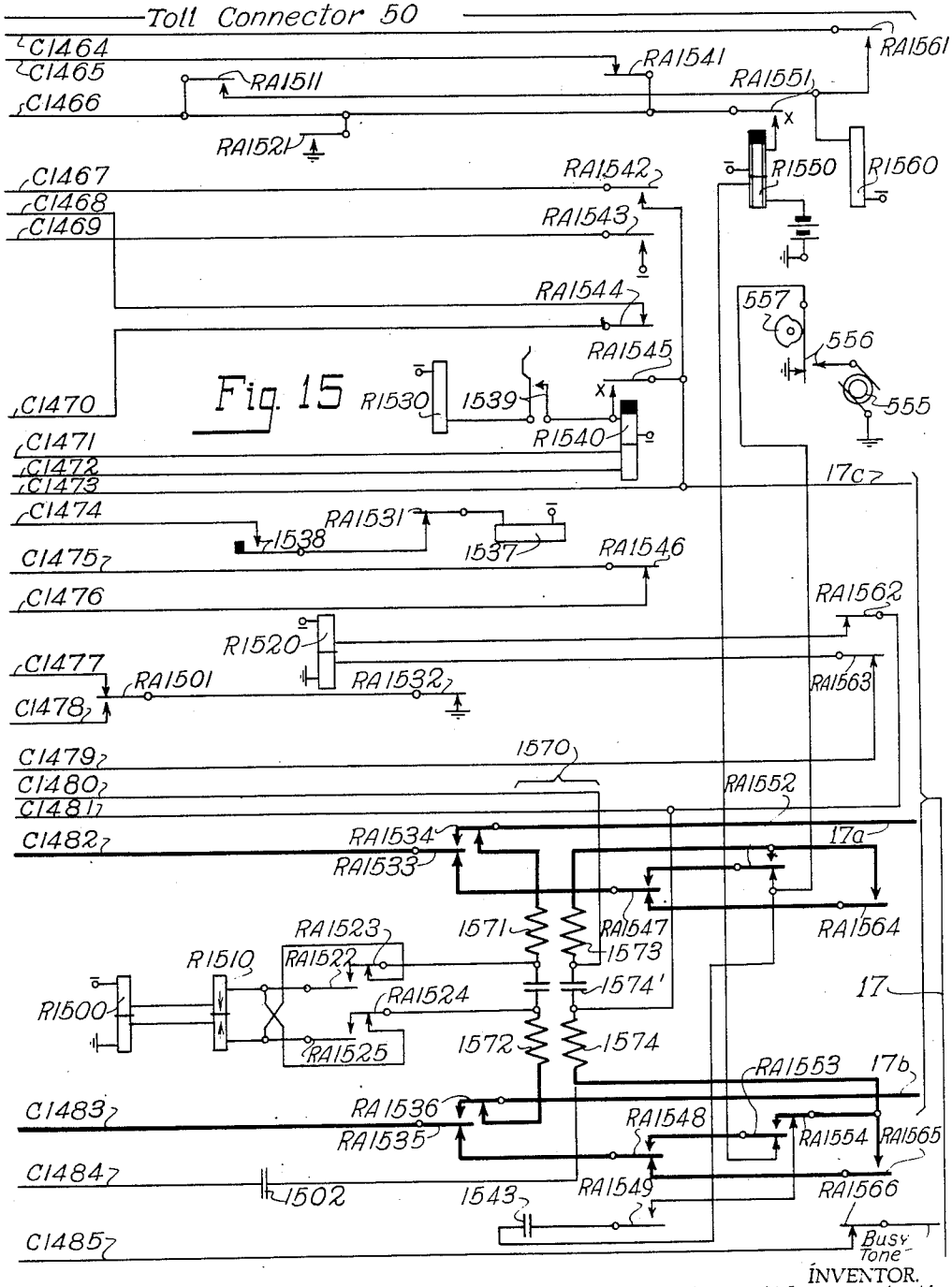


Fig. 15

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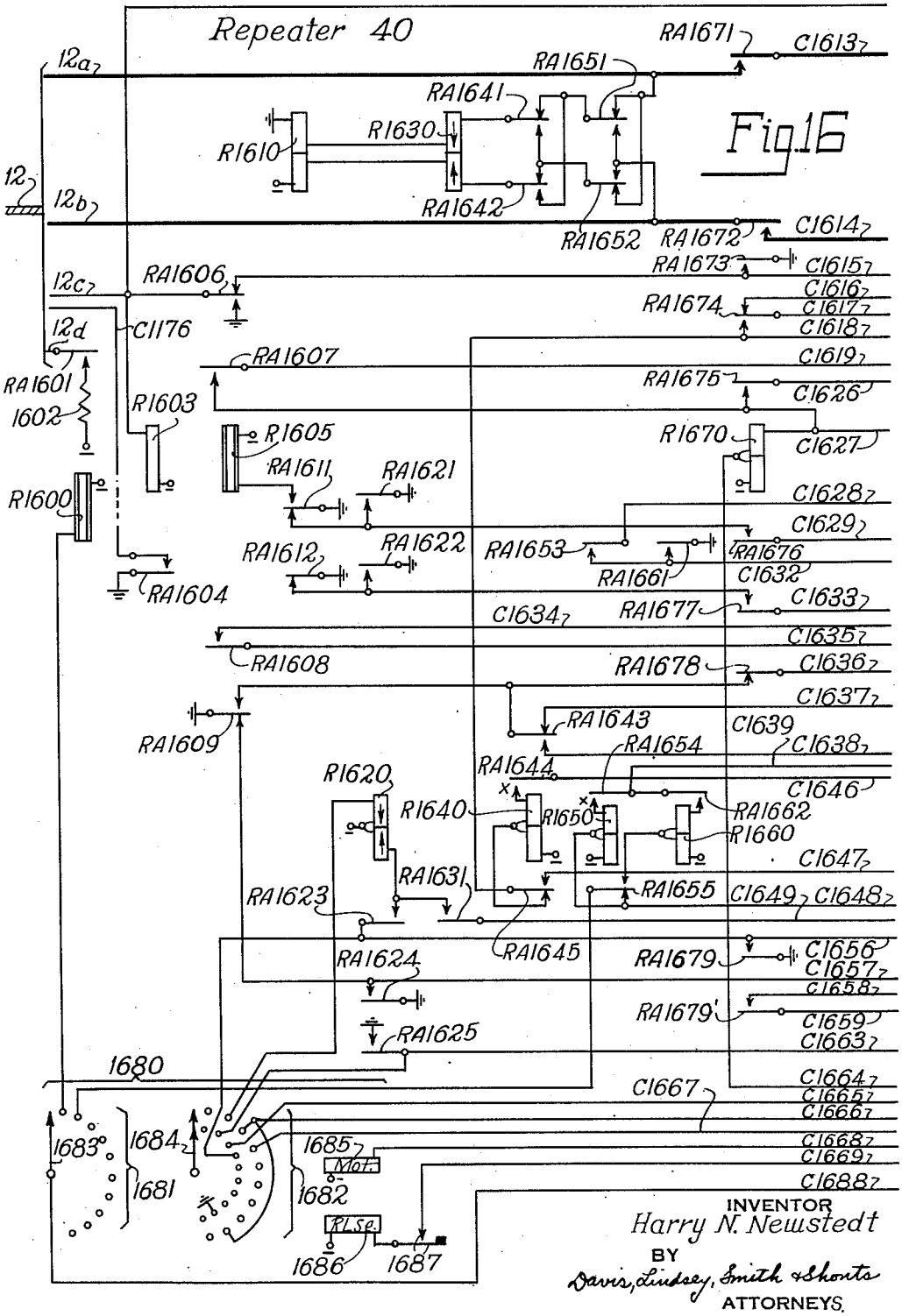


Fig. 16

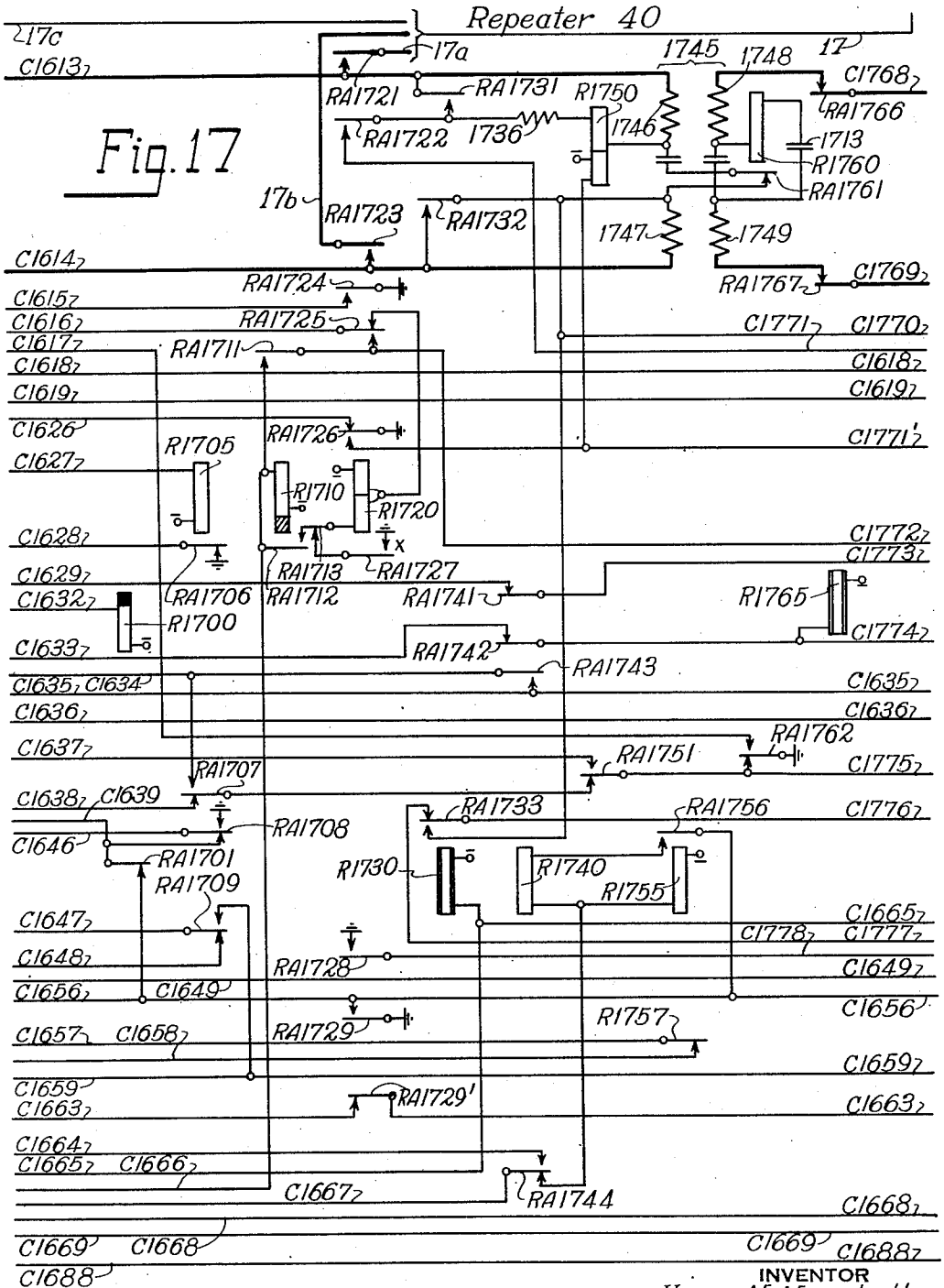
INVENTOR
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July 28, 1942. H. N. NEWSTEDT 2,291,496

TELEPHONE SYSTEM

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Fig. 17



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TELEPHONE SYSTEM

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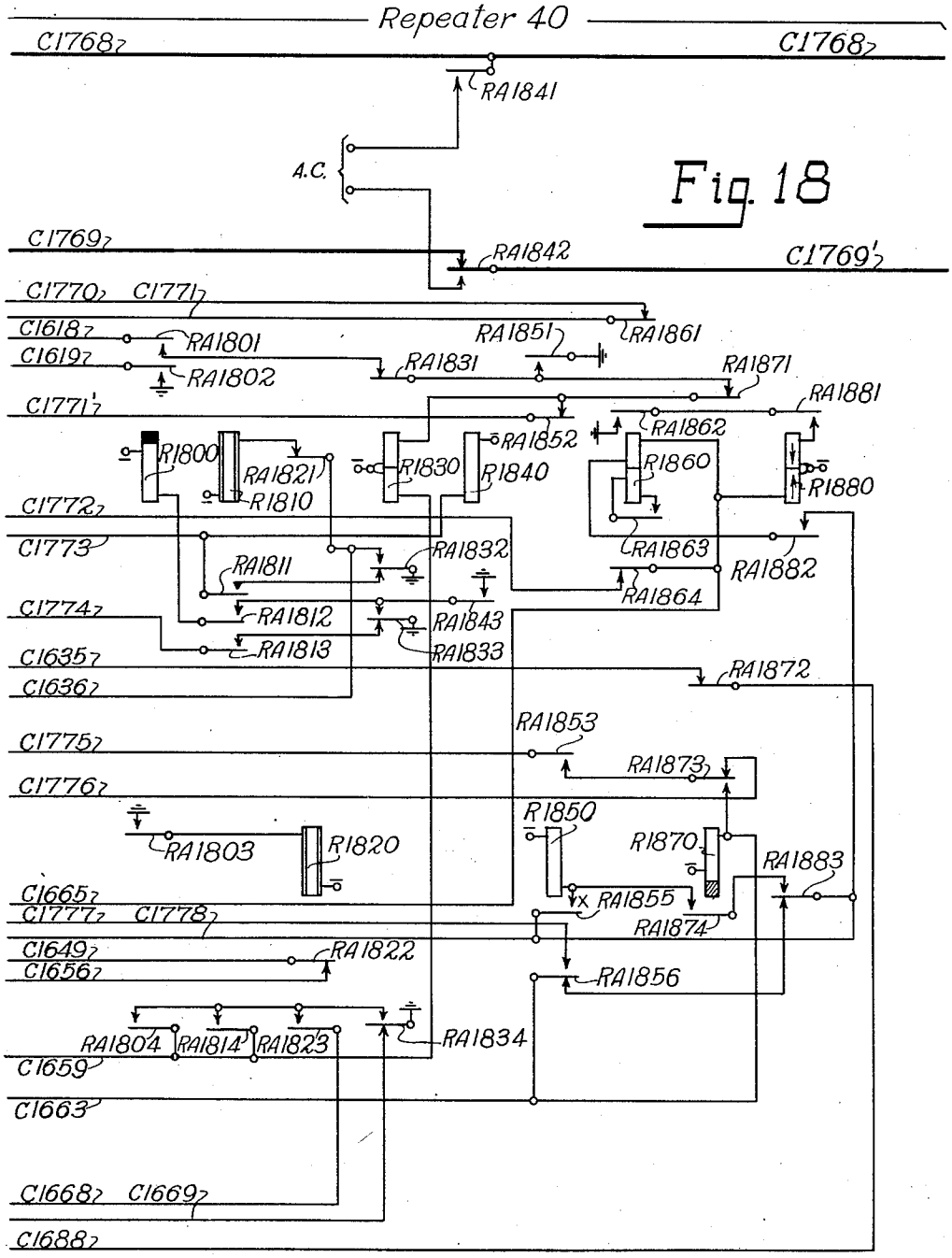


Fig. 18

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TELEPHONE SYSTEM

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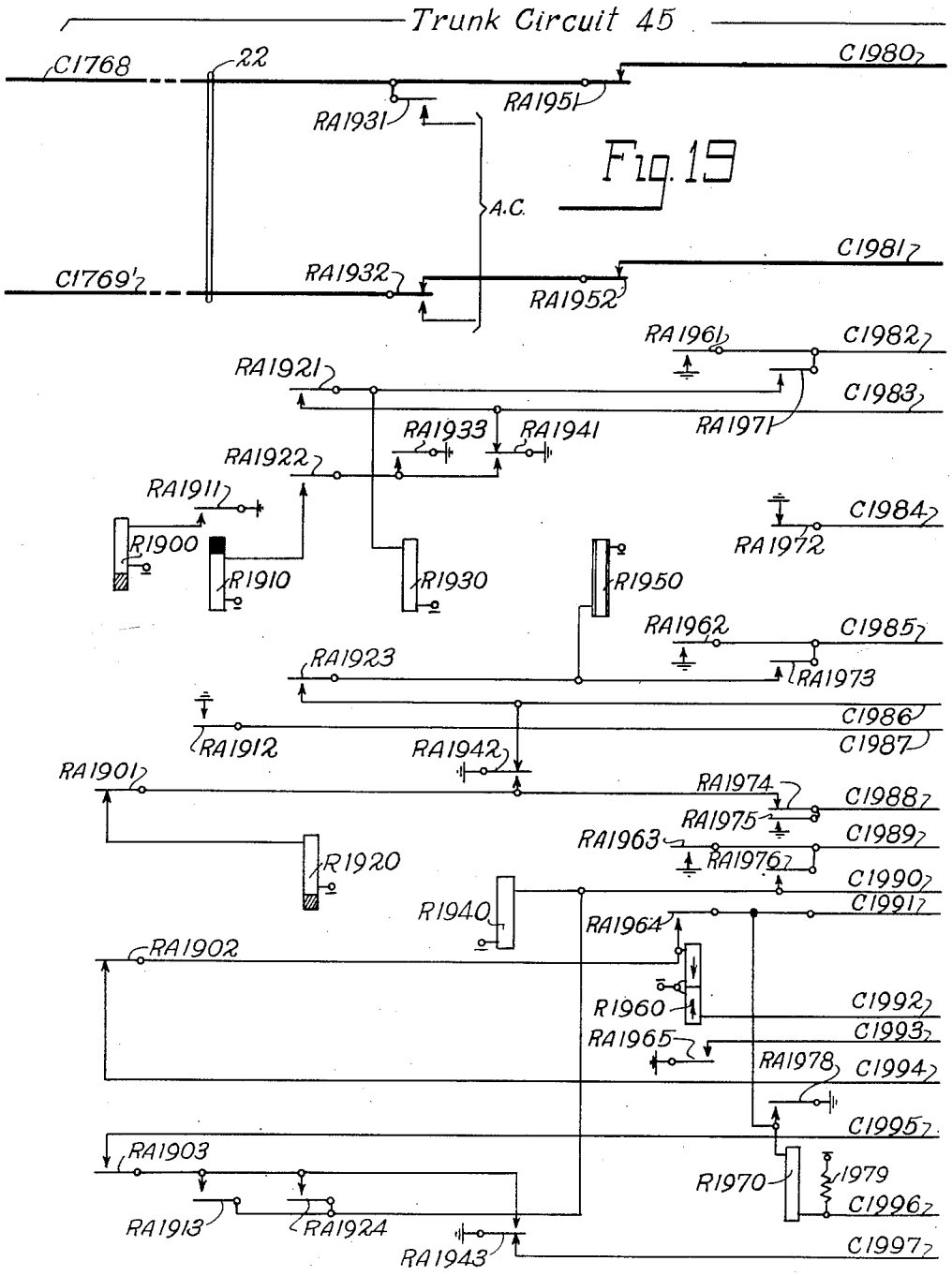


Fig. 19

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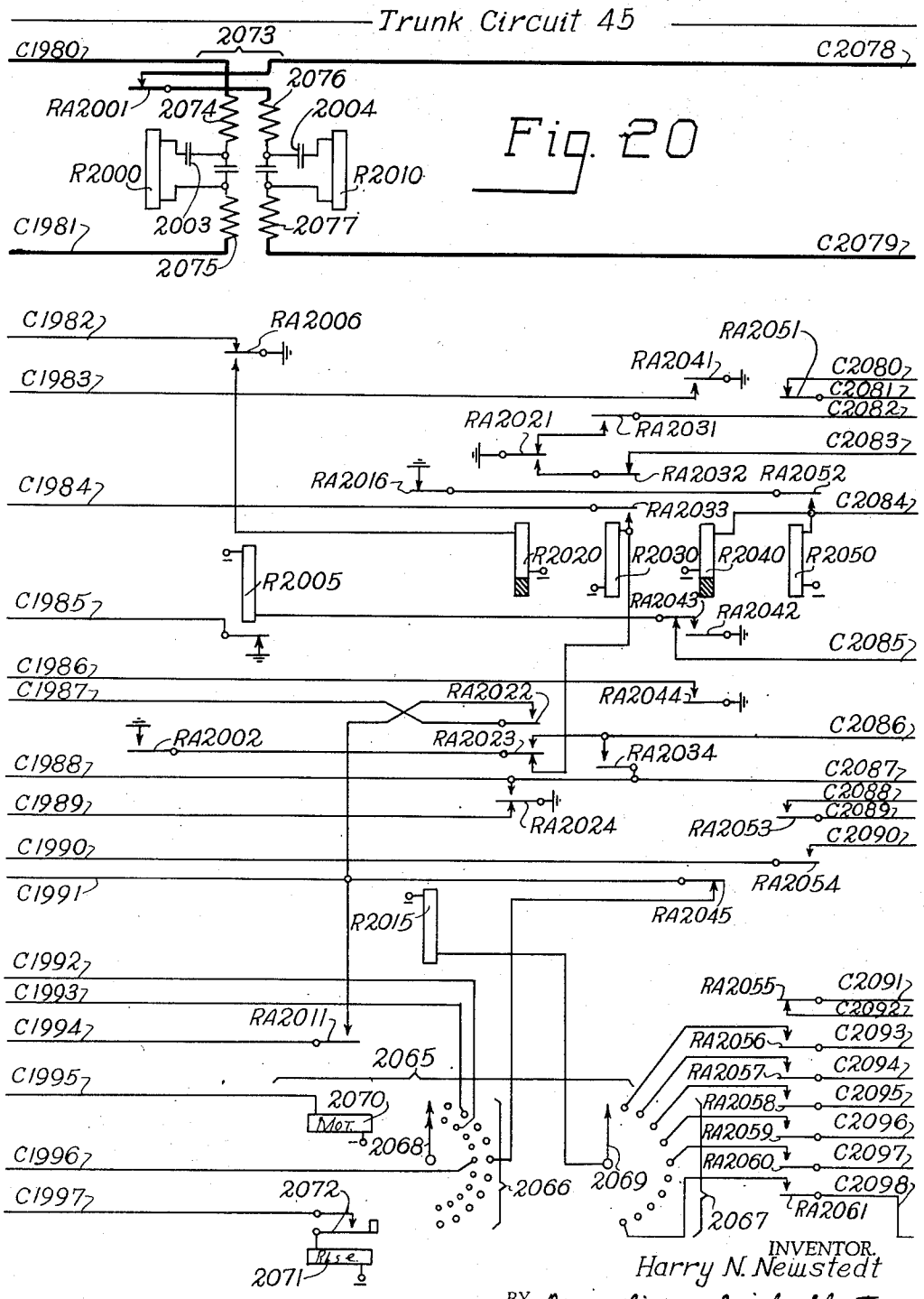


Fig. 20

INVENTOR.
Harry N. Newstedt

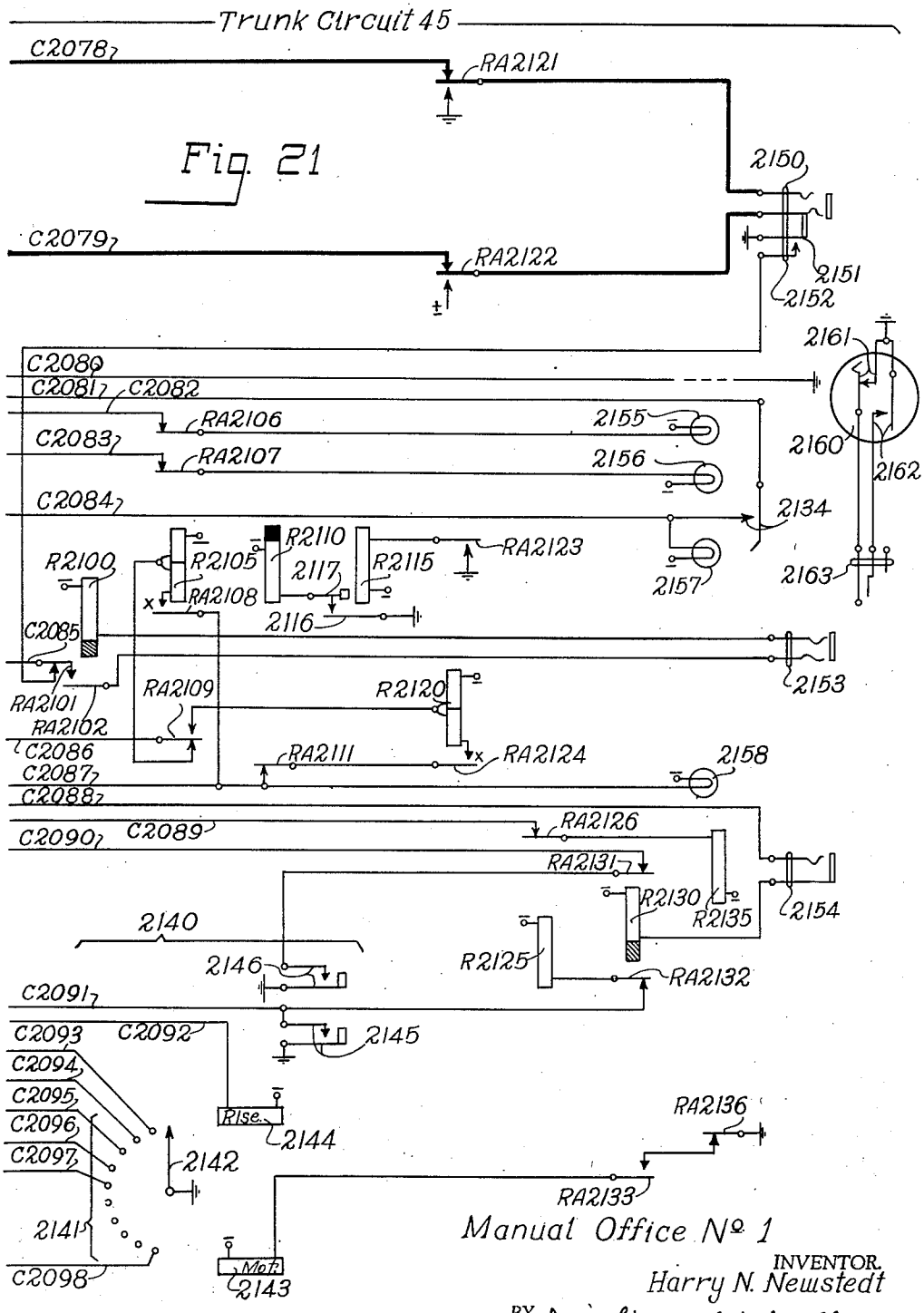
BY Davis, Lindsey, Smith & Shorts

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July 28, 1942. H. N. NEWSTEDT 2,291,496

TELEPHONE SYSTEM

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INVENTOR.
Harry N. Newstedt
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Patented July 28, 1942 2,291,496

UNITED STATES PATENT OFFICE

2,291,496

TELEPHONE SYSTEM

Harry N. Newstedt, Chicago, Ill., assignor to Associated Electric Laboratories, Inc., Chicago, Ill., a corporation of Delaware

Application February 1, 1940, Serial No. 316,748

21 Claims. (Cl. 179—7.1)

The present invention relates to improvements in switching apparatus for use in telephone systems, and, more particularly, to improved apparatus for providing call storage facilities and for controlling the metering of calls in setting up connections between the subscribers' lines of a multi-exchange network which includes two or more interconnected automatic exchanges.

It is an object of the present invention to provide, in a telephone system of the character described, improved switching apparatus which is so arranged that the call metering devices associated with calling subscribers' lines terminating at one of the automatic exchanges may automatically be controlled by improved zone metering circuits in accordance with the zones in which the called lines are located on trunk calls intended for subscribers' lines located in different called zones and extending to different exchanges, and may also be controlled from an operator's position on other trunk calls routed through the operator's position to other lines of the system.

It is a further object of the invention to provide, for use in combination with certain of the automatic switches of the system, improved call zone metering apparatus which is simple in arrangement and is positive and reliable in operation.

It is a further and more specific object of the invention to provide improved zone metering apparatus of the character described which is so arranged that a toll connection routed through the associated automatic switching apparatus is forcibly released by the zone metering apparatus after the expiration of a predetermined maximum conversation interval, and signals indicating the approaching ends of minimum and maximum conversation periods are impressed on the connection shortly before the expiraton of these intervals.

It is another object of the invention to provide, in a telephone system of the character described, an improved and exceedingly simple arrangement whereby the call metering devices associated with calling subscribers' lines terminating at one automatic exchange are automatically operated incident to the use of local call connections, and an operator in a second exchange may easily control, over a connection routed through the automatic switching apparatus of the first exchange, the call metering device associated with a calling subscriber line terminating at the first exchange to cause any desired number of registrations on the metering device and thus eliminate all toll call ticketing operations of the character conventionally required in assessing charges for toll call connections.

It is a further object of the invention to provide call metering apparatus of the character just described which is so arranged that the number of registrations of the call metering device associated with a calling subscriber's line may be determined through operation of a calling device provided at the operator's position to which the call is routed.

It is another object of the invention to provide, in a telephone system of the character described and in association with a group of trunk lines extending to an operator's position, an improved call storage circuit which is so arranged that a trunk call is routed thereto for storage when all of the trunk lines of the group are busy, following which the call is automatically forwarded to the operator's position and the calling subscriber is signaled when one of the trunk lines becomes idle.

It is a further object of the invention to provide in conjunction with the automatic switching apparatus of an automatic exchange an improved call storage circuit of the character just described which is so arranged that it functions as an instrumentality for holding operated the automatic switch train through which a trunk call is routed thereto after the usual switch release operation is performed at the calling substation and which responds to repeated switch release operations performed at the calling substation by releasing and initiating the release of the switch train.

It is a further object of the invention to provide in conjunction with the automatic switching apparatus of an automatic telephone exchange an improved call storage circuit of the character described which is so arranged that a signal is transmitted therefrom to the calling subscriber when the circuit is seized and a second signal is transmitted therefrom to the operator following the operation of the circuit to forward the call to the operator's position.

It is a still further object of the invention to provide a call storage circuit of the character described which is of simple and economical arrangement and is thoroughly reliable in operation.

It is an additional object of the invention to provide, in an automatic telephone system, auto-

matic switching aparatus for serving lines arranged for both simplex and loop circuit operation, wherein the link circuits of the automatic switches are arranged in an improved manner such that all desired control operations are realized regardless of the type of line selected by the associated automatic switches.

It is still another object of the invention to provide, in combination with an automatic switch link having access to lines arranged for both common battery and magneto operation, an improved and exceedingly simple arrangement for forcibly releasing the link a reasonable time interval after seizure thereof over a line arranged for either type of operation in the event the selctor portion of the link is not directed to select one of the lines to which it has access.

The invention is illustrated in its embodiment in a telephone system which comprises an automatic exchange interconnected by means of interoffice trunk lines with a plurality of additional exchanges, certain of which are of the manual type. The call storage circuit referred to above is provided in association with the group of trunk lines interconnecting the automatic switching apparatus of the automatic exchange with an operator's switchboard located in one of the distant manual offices, and is accessible only to the local connector switches forming a part of the automatic switching apparatus provided in the automatic exchange. The arrangement is such that a call originating on a subscriber's line terminating at the automatic exchange and intended for the operator's position in the distant manual office is, through operation of the automatic switch train in use, routed to the call storage circuit in the event all of the trunk lines of the selected group are busy. This circuit includes means for transmitting a signal to the calling substation indicating that the connection has been forwarded to the call storage circuit, and apparatus for holding the switch train through which the connection extends operated after a switch release operation has been performed at the calling substation. The circuit further includes means operative in response to repeated switch release operations performed at the calling substation for releasing the operated switch train and the circuit, additional apparatus being provided therein for extending the connection to the distant operator's position over the first of the associated group of trunk lines to become idle after the release of the connection and in the event the switch train and the circuit are not released under the control of the calling subscriber. The arrangement of the relay equipment embodied in the circuit is such that a signal is transmitted to the operator's position over the forwarded connection, which serves to inform the operator that the connection has been routed by way of the call storage circuit. This apparatus further operates in response to the answering of the call at the operator's position to transmit ringing current back over the calling end of the connection to the calling substation for the purpose of informing the calling subscriber that the call has been forwarded to the operator's position.

Each subscriber's line terminating at the automatic exchange mentioned above has associated therewith a call metering device which is automatically operated to register charges for completed local calls to other subscribers' lines terminating at the same exchange, and, in addition, serves as an instrumentality by means of which charges for toll call connections may be recorded. To this end, there is provided in association with each local connector switch of the automatic exchange, zone metering equipment which includes apparatus operative in response to the completion of a connection routed by way of the associated switch to cause the metering device associated with the calling line to register an initial charge determined by the rate zone in which the called line is located. This apparatus also functions to cause the reoperation of the metering device associated with the calling line a predetermined time interval after the connection is established and to initiate the release of the connection a second predetermined time interval after the expiration of the first time interval. Additional means are provided in the circuit for impressing a warning signal upon the established connection shortly before the expiration of each of the two time intervals. The first of these signals serves to inform the calling subscriber that an additional charge is about to be assessed and the second signal serves to inform both subscribers that the connection is about to be forcibly released. In assessing charges for the use of toll call connections resulting from toll calls originating on lines terminating at the automatic exchange and routed to the manual offices, the control of the metering devices associated with the calling lines is under the control of the operators in the distant manual offices who supervise the completion of the connections. More specifically, apparatus is provided in the automatic switching apparatus of the automatic exchange which is arranged to respond to operation of a calling device provided at the operator's position of a manual office to cause a number of operations of the metering device associated with a calling subscriber's line, the number of meter operations being determined by the numerical value of the digit or digits dialed by the operator. The arrangement is such that the operation of the metering device associated with the calling line, as controlled by the supervising operator, may be accomplished after the connection has been released by the calling and called subscribers and before the switch train through which the connection extends is released by the operator. By virtue of this arrangement, the operator may, by computing the elapsed time of a call with reference to the zone in which the called line is located and then controlling the metering device associated with the calling line, cause any desired charge to be assessed against the calling substation.

As indicated above, another feature of the invention relates to the particular arrangement of the link circuits provided in the automatic exchange whereby subscribers' lines arranged for both simplex and loop operation may be served without sacrificing any of the required control operations. To this end, the finder and connector switches of the line switching links located in the automatic exchange are provided with line, private and extra control contacts individual to the lines to which they have access. The line and back-bridge relays of each link are, in accordance with usual practice, adapted to be energized over circuits extending through the finder and connector switches respectively and by way of the calling and called lines respectively. In accordance with this feature of the present invention, circuit means are provided in each link which comprise the indicated extra control contacts for conditioning the line and back

bridge relays of the link to operate regardless of the type of operation for which the lines selected by the associated switches are arranged. Each of the links provided in the automatic exchange is arranged for seizure over a simplex line arranged for magneto operation in response to alternating current transmitted over the line and for seizure over a common battery line in response to the completion of the usual calling loop circuit. Apparatus comprising a first timing device is provided in association with the links for releasing an operated link in the event it is seized over a line of the common battery type and the selector portion of the link is directed to engage a desired line within a predetermined time interval thereafter. Additional apparatus comprising a second timing device is provided for releasing the link in the event it is seized over a line of the simplex or magneto type and the selector portion of the link is not directed to engage a desired line within a predetermined time interval thereafter.

Further features of the invention pertain to the particular arrangement of the circuit elements whereby the above-mentioned and additional operating features are attained.

The novel features believed to be characteristic of the invention are set forth with particularity in the appended claims. The invention, both as to its organization and method of operation, together with further objects and advantages thereof, will best be understood by reference to the specification taken in connection with the accompanying drawings, in which Figure 1 illustrates in schematic form the trunking arrangement of an automatic telephone system having incorporated therein the features of the invention as briefly outlined above; Fig. 2 illustrates the mode of assembling the remaining drawings to form a unified system of the character illustrated in Fig. 1; and Figs. 3 to 21, inclusive, when arranged in accordance with the diagram of Fig. 2, illustrate the details of the system schematically shown in Fig. 1. More specifically, Figs. 3, 4, 5 and 6 illustrate the details of one of the line circuits and one of the connector switches provided in one of the exchanges of the system; Figs. 7 and 8 illustrate the zone metering equipment associated with the automatic switching apparatus provided in the same exchange; Figs. 9 and 10 illustrate the contact bank wiring of certain of the automatic switches provided in the exchange; Fig. 11 illustrates the details of the call storage circuit provided in conjunction with certain of the interoffice trunks and located in the same exchange; Figs. 12 and 13 illustrate the details of one of the inter-office trunk repeaters; Figs. 14 and 15 illustrate the details of one of the toll connector switches provided in the same exchange; Figs. 16, 17 and 18 illustrate one of the alternating current inter-office trunk repeaters provided in the same exchange, and Figs. 19, 20 and 21 illustrate the details of one of the alternating current trunk circuits provided in a distant exchange.

Referring now more particularly to Fig. 1 of the drawings, the system there illustrated comprises a plurality of exchanges including four manual offices numbered from 1 to 4, inclusive, and two automatic exchanges numbered 1 and 2, respectively. The automatic switching apparatus 90 provided in the automatic exchange No. 2 not only serves as the instrumentality for setting up connections between the subscribers' lines local to this exchange, but, in addition, functions as tandem switching apparatus in handling calls routed between the manual office No. 4 and the automatic exchange No. 1. Similarly, the automatic switching apparatus provided in the automtaic exchange No. 1 not only serves the subscribers' lines local to this exchange, but, in addition, is arranged to function as tandem switching apparatus in routing calls between the four manual offices. For the purpose of handling calls routed between the manual office No. 1 and the automatic exchange No. 1, there is provided a group of two-way trunk lines including the trunk line 22 which terminates in the manual office No. 1 in trunk circuit apparatus 45 and in the automatic exchange No. 1 in an alternating current repeater 40. This repeater has individually associated therewith a toll connector switch 50 which has access to all of the lines terminating in the automatic exchange No. 1. On calls outgoing to the manual office No. 1 and routed by way of the trunk line 22, the repeater 40 may be seized by any one of the connector switches located in the automatic exchange No. 1 over an incoming trunk line 12. In a similar manner, the manual office No. 2 is interconnected with the automatic exchange No. 1 by means of a group of two-way trunk lines including the line 23. This trunk line terminates in the manual office No. 2 in a trunk circuit 60 and in the automatic exchange No. 1 in a repeater 55, which repeater has access over a link line 18 to a toll connector switch 65 individual thereto. Calls outgoing to the manual office No. 2 and routed through the automatic exchange No. 1 may be extended to the repeater 55 through any one of the connector switches embodied in the last-mentioned exchange over a link line 13. The manual office No. 3 is interconnected with the automatic exchange No. 1 over a group of two-way trunk lines including the line 24 which terminates in the manual office No. 3 in a trunk circuit 75 and in the automatic exchange No. 1 in a repeater 70. This repeater is connected with a toll connector switch 80 by means of a link line 19 and may be seized by the other connector switches of the automatic exchange No. 1 over a link line 14. As distinguished from the trunk circuits 45 and 60 and the repeaters 40 and 55, which switching units are of the alternating current type and are, therefore, arranged for alternating current pulse control, the trunk circuit 75 and the repeater 70 associated with the interoffice trunk line 24 are of the direct current type, such that the various control operations required incident to the setting up of connections including this line are effected through the transmission of direct current control pulses between the two switching units. The automatic exchange No. 2 and the automatic exchange No. 1 are interconnected by a group of trunk lines including the line 26 which terminates in the automatic exchange No. 2 in a direct current repeater, not shown, and in the automatic exchange No. 1 in a direct current repeater 85. The repeater 85 is accessible to the connector switches of the automatic exchange No. 1 over a trunk line 16 and has access to the local switching apparatus embodied in the automatic exchange No. 1 over a link line 21 which terminates in a line circuit 21_a.

Briefly described, the apparatus provided for use in establishing local connections between the subscribers' lines terminating at the automatic exchange No. 1 comprises a plurality of finder-connector links, one of which is illustrated as including a finder switch 20 and a local con-

nector switch 25. A link distributor 15 is provided for the purpose of assigning these links to the use of calling lines in a definite order. Only two of the subscribers' lines terminating at the automatic exchange No. 1 have been illustrated, these two lines 10 and 11 terminating in line circuits 10_a and 11_a, respectively, and extending to the substations A and B, respectively.

Each of the line circuits provided in the automatic exchange No. 1 to terminate a subscriber's line includes a call metering device, the purpose of which is to indicate the charges to be assessed against the subscriber for whose use the associated substation is provided. The arrangement of the apparatus is such that these call metering devices are susceptible of automatic control in the setting up of toll calls to certain of the other exchanges. To this end, a zone metering circuit 30 is provided in association with the link comprising local connector switch 25. Similar circuits are provided in association with each of the other local call links embodied in the automatic exchange No. 1. Facilities are provided for storing toll or trunk calls outgoing to the manual office No. 1 from the subscribers' lines terminating at the automatic exchange No. 1. More specifically, the call storage facilities are so arranged that if all of the trunk lines interconnecting the two exchanges are busy and a trunk call to the manual office No. 1 is initiated on one of the subscribers' lines local to the automatic exchange No. 1, the call is stored until one of the trunk lines interconnecting the two exchanges becomes idle, following which the call is automatically forwarded by way of the idle trunk line to the operator's position in the distant manual office. To this end, a call storage circuit 35 is provided, which circuit is accessible to each of the local connector switches of the automatic exchange No. 1 over an overflow trunk 28 and has access to the repeaters associated with the trunk lines extending to the manual office No. 1. Similar call storage circuits may, if desired, be provided in association with the groups of trunk lines respectively extending to the other offices of the system.

Referring now in greater detail to the circuits of the automatic switching apparatus provided in the automatic exchange No. 1 and considering first the line circuit 10_a illustrated in Fig. 3 in association with the subscriber's line 10, this circuit comprises a line relay R360, a cut-off relay R350 and a slow-acting line lockout relay R340. There is further embodied in this circuit a call metering device 365 which is provided for the purpose of registering the charges to be assessed for calls originating at the substation A. Two types of wiring or circuit connections are illustrated which may be used alternatively. The wiring used depends in each instance upon the arrangement of the substation apparatus individual to the associated line. Thus, the apparatus provided at the substation A may be arranged for common-battery operation, whereby the conventional loop circuit control of the automatic switching apparatus in the automatic exchange No. 1 is utilized. In such case, the "Y" wiring illustrated in Fig. 1 is used. Alternatively, the substation A may be provided with a hand generator for initiating calls and with local batteries for supplying transmission current, in which case the well-known simplex circuit control of the automatic switching apparatus in the automatic exchange No. 1 is preferable. In the latter case, the circuit conductors of the line circuit 10_a are connected in accordance with the "X" wiring illustrated in Fig. 3. The line circuits 11_a and 21_a individual to the lines 11 and 21, respectively, are substantially similar to the line circuit 10_a, just described. It is pointed out, however, that the line circuit 21_a which is associated with the link line 21 extending to the repeater 85 is arranged for loop circuit operation and does not include a call metering device since such a device would serve no useful function on calls routed by way of the indicated link line.

The finder switch 20 and the distributor switch 15 have been only diagrammatically illustrated in Fig. 3 of the drawings since both of these units are of conventional construction and arrangement. Preferably, the finder switch 20 is of the well-known Strowger type, having embodied therein a Strowger switching mechanism utilizing vertical and rotary movements of its wipers in its operation to select a calling one of the lines to which it has access. This switching mechanism is equipped with an extra contact field and an extra wiper which are utilized in setting up operating circuits for the metering devices, such, for example, as the device 365, individual to the various subscribers' lines.

Each of the local connector switches provided in the automatic exchange No. 1 is identical in arrangement with the local connector switch 25. This switch is illustrated in Figs. 4, 5, 6 and 10 as comprising a Strowger switching mechanism which includes a plurality of sets of bank contacts 1000 arranged in levels; wipers 680 to 684, inclusive, which are adapted to be moved into engagement with a set of contacts terminating the conductors of a desired line; means comprising a vertical magnet 560 for elevating the enumerated wipers to a position opposite a desired level of bank contacts; means comprising a rotary magnet 670 for rotating the wipers into engagement with the desired set of contacts of a selected level; and a release magnet 406 which, when energized, is operative to cause the enumerated wipers to be returned to normal. The Strowger switching mechanism further comprises three sets of off-normal springs 407, 517' and 558 which are respectively operated to their off-normal positions when the wipers 680 to 684, inclusive, are stepped off-normal. A plurality of sets of normal post springs 559, 608, 609 and 616 are also embodied in the Strowger switching mechanism for performing various circuit control operations, described hereinafter with reference to the trunk hunting operations of the connector switch. These normal post springs are arranged to be operated to their respective off-normal positions when the wipers 680 to 684, inclusive, are positioned opposite particular levels of the contact field embodied in the Strowger switching mechanism. The relay equipment of the connector switch comprises a line relay R435, a pulsing relay R430, a pair of slow-acting hold relays R425 and R420, a link release relay R410, a line switching relay R400', a switching-through relay R400, and a transfer relay R440 which functions to adapt the operating circuit for the line relay R435 to be energized over a calling line arranged for either loop or simplex circuit operation. The relay equipment of the connector switch 25 further includes a slow-acting, impulse, responsive relay R500, a pulse correcting relay R516, a back bridge relay R520, a slow-acting ring cut-off relay R530, a digit transfer relay R540, a pair of link release relays R520' and R550, and a transfer relay R510 which

is provided for the purpose of adapting the circuit connections extending to the windings of the back bridge relay R520 so that the latter relay may be energized over a selected called line arranged for either loop or simplex circuit operation. The remaining relays embodied in the local connector switch 25 are illustrated in Fig. 6 and include a relay R600 which is utilized in the operation of the switch to select an idle trunk line, a slow-to-release, impulse-responsive control relay R610, a second back bridge relay R620 of the well-known shunt field type, a trunk hunting control relay R630, a busy test relay R640, a slow-to-operate line switching relay R650 and an additional line switching relay R660.

The arrangement of the local connector switch 25 is such that a connection established by way thereof can only be used for a predetermined time interval, at the expiration of which the connection is automatically released. To this end, timing apparatus 450 is provided which comprises a start relay R460 and a rotary stepping switch of the well-known minor type. This stepping switch includes two contact sets 451 and 452, wipers 453 and 454 individually associated with the two enumerated contact sets, an operating magnet 455, a release magnet 456 and a set of off-normal springs 457. Operation of this switch is controlled in accordance with impulses transmitted thereto from a pulse generator 466 following operation of the timer start relay R460. The pulse generator 466 may be of any conventional arrangement and functions to impress ground pulses upon the pulsing conductor C458 at approximately thirty second intervals.

Provisions are also made for forcibly releasing the connector switch 25, in the event this switch is seized, and no dial pulses are transmitted thereto within a predetermined time interval thereafter. Such a condition may arise as a result of a fault on one of the subscribers' lines or through the initiation of a reverting call on a line of the magneto type, or by failure of a calling subscriber to dial after initiating a call. The forcible release of the local connector switch 25 is under the control of a pair of timing devices 695 and 696 which are commonly associated with the links provided in the automatic exchange No. 1. These devices may be continuously operated or may be so arranged that operation thereof is initiated in response to seizure of any one of the finder-connector links provided in the exchange. The timing device 695 is arranged to cooperate with the link release relay R550 to cause the forcible release of the connector switch 25 when this switch is seized over a calling line arranged for loop operation. More particularly, the last-mentioned timing device functions momentarily to impress ground potential upon the start timing conductor C695' at the beginning of each cycle of operation thereof. A predetermined time interval thereafter the device operates to remove ground potential from the normally grounded time cut-off conductor C697. The timing device 696, in cooperation with the relay R600, functions to initiate the forced release of the local connector switch 25 when this switch is seized over a calling line of the magneto type arranged for simplex operation. The mode of operation of the timing device 696 is identical with that of the timing device 695; i. e., during each cycle of operation thereof, ground potential is momentarily impressed upon the start timing conductor C517 and a predetermined time interval thereafter ground potential is removed from the normally grounded time cut-off conductor C516.

As pointed out previously, the zone metering circuit 30 is individually associated with the local connector switch 25 and is provided for the purpose of controlling the call metering devices, such, for example, as the device 365, associated with calling subscribers' lines, when the calls are routed by way of the local connector switch 25 to another of the automatic exchanges of the system. This circuit, which is illustrated in Figs. 7 and 8 of the drawings, is connected to be controlled in accordance with the operation of the pulsing relay R430 embodied in the local connector switch and is so arranged that when one or two predetermined trunk selecting digits, designating a particular zone, are transmitted to this switch, the metering circuit is conditioned to transmit to the metering device associated with the calling line a number of metering pulses, the number of pulses being determined by the zone in which the called exchange is located. The transmission of the metering pulses occurs when the call is answered at the called substation to complete the desired connection. The zone metering circuit is also so arranged that, shortly before the expiration of a minimum time interval of three minutes, a warning signal is impressed upon the established connection and, if the connection is not immediately released, an additional set of metering pulses is transmitted to the metering device associated with the calling line. Thereafter, and shortly before the expiration of a second time interval of three minutes, the warning signal is again impressed upon the established connection. If the connection is not released immediately following this second warning signal, the apparatus of the zone metering circuit functions to energize the link release relay R520', thereby to initiate the release of the established connection. Briefly described, the zone metering circuit comprises a start pulsing relay R700 which is operative in response to operation of the back bridge relay R620 embodied in the local connector switch 25, a start relay R710 which is operative in response to operation of the hold relay R425 embodied in the indicated local connector switch, a pulsing relay R750 which follows the operation of pulsing relay R430 embodied in the switch 25, a slow-acting, pulse cut-off relay R730, a slow-acting hold relay R770 and a meter pulsing relay R775. The circuit further comprises a zone register or zone selecting switch 870 of the well-known minor type which includes three sets of contacts 871, 872 and 873, wipers 874, 875 and 876 individually associated with the enumerated contact sets, an operating magnet 878 for driving the indicated wipers over the contacts of their respective associated contact sets, a release magnet 879, and two sets of off-normal springs 890 and 891. This switch is provided for the purpose of controlling four zone selecting relays R825, R830, R835 and R840 which are operative selectively to associate the bracketed meter pulsing leads terminating in the contact set 873 of the switch 870 with the four pulsing outlets of zone pulsing apparatus 858 which is common to a group of the zone metering circuits. As explained in detail hereinafter, the circuit 30 is arranged for both one-digit and two-digit zone selection, the arrangement being such that, if the first digit of a two-digit zone is transmitted to the circuit, the wipers of the zone selecting switch 870 are returned to normal

and are then reoperated in response to the impulses of the second digit designating the two-digit zone. In order to perform this switch normalizing operation, a release relay R800 of the two-step type is provided in the circuit. For the purpose of operatively associating the meter pulsing relay R775 with a selected outlet of the common pulsing apparatus 858 and of opening the pulsing circuit after the required meter registration is effected, a connect relay R850 and a stop pulsing relay R810 are provided.

In order to measure the time interval during which a connection to a called line in one of the zones is established and to control the application of warning signal voltages to the established connection, a timing switch 780 of the well-known minor type is provided. This switch is arranged to control three cycle counting relays R720, R740 and R760, each of which is of the well-known two-step type. The relay R760 is arranged to control a slow-to-operate slave relay R770' which is provided for the purpose of supplying locking ground to the holding armature of the relay R810. Briefly described, the switch 780 comprises three contact sets 781, 782 and 783, each having ten contact points, wipers 784, 785 and 786 individually associated with the enumerated contact sets, an operating magnet 787 for driving the indicated wipers over the contacts of their respective associated contact sets, a release magnet 789 and a pair of off-normal springs 790 for controlling the energization of the release magnet. The pulsing equipment 858 which is common to the various zone metering circuits includes a pulsing switch 892 of the well-known rotary type. Briefly described, this switch comprises four sets of bank contacts 893, 894, 895 and 896 individually comprising eleven contact points and each corresponding to a different set of pulses, wipers 866 to 869, inclusive, individually associated with the enumerated contact sets and comprising pulse outlets, an operating magnet 897 for driving the wipers over the contacts of their respective associated contact sets, and a set of off-normal springs 847 which are opened each time the wipers of the switch 892 are operated to engage their eleventh contact points. The wipers of this switch are arranged to be connected to the zone metering leads of any operated zone metering circuit under the control of a start relay R860 which is arranged to be energized by way of the start conductor C865 each time one of the local finder-connector links embodied in the automatic exchange No. 1 is assigned to the use of a calling subscriber's line. The common equipment 858 also includes a pulsing relay R820 which is operative to transmit a ground pulse to each timing switch during the initial portion of each cycle of operation of the pulsing switch 892, and a pulsing relay R845 for transmitting current pulses to the operating magnet 897 of the switch 892. The relay R845 is connected to be intermittently energized under the control of a continuously driven impulsing cam 859.

The alternating current repeater 40 is illustrated in Figs. 16, 17 and 18 as comprising a repeating coil 1745 to which the conductors of the trunk lines 12, 17 and 22 are adapted to be connected, and control equipment which includes a timing switch 1680 and a plurality of interconnected control relays. The switch 1680 is of the well-known minor type and comprises three sets of contacts, one of which is indicated at 1681 in association with the wiper 1683 and two of which are indicated at 1682 in association with the wiper 1684. For the purpose of driving the two wipers over their associated contact sets and of returning these wipers to normal, operating and release magnets 1685 and 1686 are provided, the operating circuit for the release magnet being controlled by a set of off-normal springs 1687. The relay equipment of the repeater 40 includes a line relay R1610, a slow-acting hold relay R1605, a differentially wound supervisory relay R1630, a slow-acting meter pulsing relay R1600, a busy relay R1603, and four supervisory pulse control relays R1620, R1640, R1650 and R1660, the first of which is differentially wound and the last three of which are of the well-known two-step type. The relay equipment further comprises a combined line switching and control relay R1670, a slow-to-operate relay R1700 which is arranged to control the locking circuits of the three supervisory relays R1640, R1650 and R1660, a control relay R1705, a slow-to-release relay R1710 which functions to control the release of the repeater, a combined line switching and control relay R1720, a slow-acting, pulse-responsive control relay R1730, a pair of supervisory pulse control relays R1740 and R1755, an electropolarized back bridge relay R1750 and an alternating current relay R1760 which responds to alternating current pulses transmitted to the repeater 40 over the trunk line 22 from the distant trunk circuit apparatus 45. The timing switch 1680, in cooperation with certain of the relays embodied in the repeater, functions to control the release of the repeater, the length of supervisory pulses of alternating current transmitted from the repeater over the trunk line 22 to the trunk circuit apparatus 45 and the transmission of metering pulses to the control device or metering relay R1600. In order to control the operation of this timing switch, three cyclically operating relays R1800, R1810 and R1820 are provided, the first of which is of the slow-to-operate type and the last two of which are of the slow-acting type. Operation of these three cyclically operating relays may be initiated in a number of different ways, all described with particularity hereinafter. For example, the cyclic operation of these relays is initiated in response to operation of the line and hold relays R1610 and R1605, respectively, when the trunk line 12 incoming to the repeater 40 is seized. Operation of the cyclically operating relays may also be initiated in response to operation of the relay R1830 which is arranged to respond to the operation of the alternating current, pulse-responsive relay R1760 which occurs when the trunk line 22 is seized at the distant end thereof. The three cyclically operating relays also cooperate to control an alternating current pulsing relay R1840 which functions to connect the conductors of the trunk line 22 to a source of alternating current, not shown, and also to control a slow-acting relay R1765 which is arranged to disconnect the conductors of the trunk line 22 from the repeating coil 1745, during those intervals when alternating current is being transmitted by way of the indicated trunk line. The relay equipment of the repeater 40 further comprises an impulse correcting network which includes a pair of relays R1860 and R1880, these two relays being operative to transmit, by way of an established loop circuit including the trunk line 17 and extending to the toll connector switch 50, impulses of substantially uniform length in response to alternating current impulses of varying lengths or

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7.1

nonuniform characteristics transmitted to the repeater 40 over the trunk line 22. One of the operating features of the repeater 40 relates to the arrangement whereby an established loop circuit, extending over the trunk line 17 to the toll connector switch 50, may be unbalanced in order to cause the toll connector switch to establish a toll offering connection to a selected line at a time when the selected line is busy. To this end, there is provided in the repeater a slow-to-release relay R1870, which, in cooperation with the alternating current relay R1760 and the slow-acting relay R1730, functions to perform the loop unbalancing operation in the manner more fully explained hereinafter. The slow-to-release relay R1870 in cooperation with another control relay R1850 also functions to perform additional circuit control operations which are subsequently described in detail.

The toll connector switch 50, individual to the repeater 40, is illustrated in Figs. 10, 14 and 15 of the drawings as comprising a Strowger switching mechanism having two extra contact fields and two extra wipers. More specifically, this mechanism includes a plurality of sets of bank contacts 1050 arranged in levels, wipers 1405 to 1409, inclusive, means comprising a vertical magnet 1423 for elevating the enumerated wipers to a position opposite a desired level of bank contacts, means comprising a rotary magnet 1417 for rotating the wipers into engagement with a set of contacts terminating a desired line, a release magnet 1537 and two sets of off-normal springs 1426 and 1538. The switching mechanism further includes two sets of normal post springs 1425 and 1539 which are utilized in certain control operations required incident to the operation of the switch to select an idle line in certain groups of trunk lines. The connector switch 50 further comprises a repeating coil 1570 having one side normally connected to the conductors of the trunk line 17 and the other side arranged for connection to the line wipers 1408 and 1409 of the above-described Strowger switching mechanism. The relay equipment of the toll connector switch comprises a line relay R1500, a slow-acting hold relay R1450, a slow-acting digit transfer relay R1440, a trunk hunting control relay R1420, a slow-to-release busy test relay R1410, a pair of slow-acting, pulse-responsive control relays R1400 and R1460, a slow-to-operate line switching and ringing control relay R1540, a slow-acting, ring cut-off relay R1550, a switching-through relay R1530 and a back bridge or battery reversing relay R1520. Two additional relays R1510 and R1560, the first of which is differentially wound, are provided for the purpose of establishing a toll offering connection to a busy called line so that a toll call may be offered to the party at the called substation. For the purpose of arranging the circuit connections extending to the back bridge relay R1520 so that this relay may be energized over a called line, arranged for either simplex or loop operation, a transfer relay R1430 is provided.

The trunk circuit apparatus 45 terminating the trunk line 22 in the manual office No. 1 is illustrated in Figs. 19, 20 and 21 of the drawings as comprising a call and answer jack 2150 which is adapted to receive the call and answer plugs of an operator's cord circuit, a dialing jack 2153 and a meter control dialing jack 2154. The two last-mentioned jacks are adapted to receive a plug 2163 which is connected by way of a cord to the pulsing springs 2161 and shunt springs 2162 of a calling device 2160 of the conventional dial operated type. A plurality of supervisory signal lamps comprising an incoming call lamp 2155, a supervisory lamp 2156, a meter busy indicating lamp 2157 and a trunk busy lamp 2158 are provided in the trunk circuit apparatus for the purpose of enabling an operator attending the position at which this apparatus is located properly to supervise calls routed by way of the trunk line 22. This trunk line is normally connected to one side of a repeating coil 2073, the opposite side of which is connected to the tip and ring contacts of the call and answer jack 2150. The relay equipment embodied in the trunk circuit apparatus 45 comprises an alternating current relay R2000 which is arranged to respond to alternating current pulses transmitted thereto over the trunk lines 22, an incoming call signal control relay R2030, and a plurality of supervisory circuit control relays R2105, R2110, R2115 and R2120, the first and last of which are of the well-known two-step type and the second of which is of the slow-to-operate type. The relay R2115 is of the well-known pendulum type. The relay equipment further comprises a call and answer relay R2005, a slow-to-release control relay R2020, and three cyclically operating relays R1900, R1910 and R1920. The three last-named relays, in cooperation with a fourth relay R1940, are arranged to control the operation of the pulse control switch 2065. The four enumerated relays are also arranged to control a relay R1930, which functions to impress alternating current upon the conductors of the trunk line 22, and a slow-acting relay R1950 which is provided for the purpose of disconnecting the conductors of the trunk line 22 from the repeating coil 2073 during those intervals when alternating current is being transmitted over this line. The relay equipment of the trunk circuit apparatus also includes a release relay R1970 and a pair of additional control relays R1960 and R2015. The timing switch 2065, which is provided for the purpose of controlling the duration of the various alternating current pulses transmitted over the trunk line 22 incident to the setting up of connections routed by way of this line, is of the wellknown minor type and comprises three sets of contacts, one of which is indicated at 2067 in association with the wiper 2069 and two of which are indicated at 2066 in association with the wiper 2068. The switch also includes an operating magnet 2070 for driving the wipers over the contacts of their respective associated contact sets, a release magnet 2071 and off-normal springs 2072 for controlling the energization of the release magnet. This timing switch, in cooperation with an impulse register switch 2140, also functions to control the transmission of alternating current metering pulses over the trunk line 22 to the distant repeater 40. Operation of the register switch 2140 is under the control of a group of relays R2040, R2050, R2125, R2130 and R2135, and a non-locking metering key 2134. The register switch 2140 is similar in construction to the timing switch 2065 and comprises a single set of contacts 2141, a wiper 2142, an operating magnet 2143, a release magnet 2144 and two sets of off-normal springs 2145 and 2146. The transmission of alternating current, switch control impulses over the trunk line 22 to the repeater 40 is under the control of the two relays R2005 and R1930, which relays are arranged to respond to direct current pulses transmitted thereto through oper-

ation of the calling device 2160 when the dial plug 2163 is inserted in the dial jack 2153. In order to place the relay R2005 under the control of the pulsing springs 2163 included in the calling device 2160, there is provided a slow-to-release relay R2100 which is arranged to operate in response to operation of the dial controlled device to an off-normal position. For the purpose of transmitting supervisory and control pulses of alternating current over the trunk line 22, there is provided an alternating current relay R2010 which is operative to energize the two relays R1930 and R1950, thereby to start the alternating current transmission and to initiate the operation of the cyclically operating relays R1900, R1910 and R1920 and the operation of the pulse timing switch 2065. The indicated alternating current relay R2010 is arranged to respond to ringing current transmitted thereto through the tip and ring contacts of the jack 2150 from the operator's cord circuit, not shown.

The call storage circuit 35 is associated only with the group of trunk lines extending between the automatic exchange No. 1 and the manual office No. 1, and is illustrated in Fig. 11 as comprising a trunk line selecting switch 1180 having access to the trunk lines in the indicated group, a repeating coil 1145, and a group of relays arranged to control the required line selecting and line switching operations. This circuit is accessible only to the local connector switches provided in the automatic exchange No. 1. To this end the trunk line 28 incoming to the storage circuit 35 is terminated only in the bank contacts of the local connector switches, this line being connected as the last trunk line of the indicated group of trunk lines. The line selecting switch 1180 is of the well-known rotary type, comprising four sets of contacts 1181, 1182, 1183 and 1184, wipers 1185 to 1188, inclusive, individually associated with the contact sets, and an operating magnet 1189 for driving the enumerated wipers over the contacts of their associated contact sets. The relay equipment of the circuit comprises a line relay R1130; a pair of slow-acting hold relays R1120 and R1138, which in cooperation with a lockup relay R1150, function to hold operated any switch train through which a call is routed to the call storage circuit after the connection has been released at the calling end thereof; and a slow-to-release all-trunks-busy relay R1165 which is arranged to be energized when all of the trunk lines of the group interconnecting the automatic exchange No. 1 with the manual office No. 1 are busy. The relay R1165, when deenergized, functions to initiate the operation of the switch 1180 to select the trunk line which has been released. This selecting operation is carried out under the control of a combined line test and line switching relay R1170. The relays R1130, R1138 and R1120, in cooperation with a fourth relay R1110, further function, in response to repeated switch release operations performed at the substation at which the call originates, to release the switch train which has been locked up and over which the call was routed. The relay equipment of the call storage circuit also includes an electropolarized back bridge relay R1140 and a slow-to-release control relay R1160, which two relays, in cooperation with the relay R1110, function to transmit ringing current over the calling end of a connection routed to the call storage circuit when the call as forwarded through this circuit and over a selected idle one of the trunk lines to the operator's position in the manual office No. 1 is answered. A slow-to-operate ring cut-off relay R1100 is provided for arresting ringing operation when the call is answered at the calling end thereof. An additional slow-to-release relay R1135 is provided which, in combination with certain of the other relays already mentioned, functions to prevent the calling substation from being resignaled when the connection routed by way of the circuit 35 to the manual office No. 1 is released at the calling substation. The arrangement of the relay equipment and the circuits controlled thereby is such that a distinctive signal is transmitted over a connection routed to the call storage circuit immediately this circuit is seized, thereby to indicate to the calling subscriber that the desired connection cannot immediately be obtained but will automatically be forwarded to the manual office No. 1 when an idle trunk line extending to this office becomes available. The circuit arrangement further includes provisions whereby a distinctive signal is transmitted to the operator in the distant manual office when a call routed through the call storage circuit is answered.

The circuit arrangement of the trunk circuit apparatus, the repeaters and the toll connector switches associated with the other interoffice trunk lines interconnecting the manual office No. 1 with the automatic exchange No. 1 and also the manual office No. 2 with the automatic exchange No. 1 is exactly the same as the arrangement of the corresponding units 45, 40 and 50 which are individual to the trunk line 22. For this reason the trunk circuit apparatus 60, the repeater 55 and the toll connector switch 65 associated with the interoffice trunk line 23 have been only schematically illustrated in the drawings. The character and arrangement of the trunk terminating equipment provided in the manual office No. 4, the automatic switching apparatus 90 provided in the tandem automatic exchange No. 2 and the repeaters, such for example, as the repeater 85 individually associated with the trunk lines interconnecting the last-mentioned exchange with the automatic exchange No. 1, may be entirely conventional in arrangement and operation, although preferably this apparatus is constructed and arranged to utilize automatic switches of the well-known Strowger type. Since this apparatus may be of conventional arrangement, it has been only schematically illustrated in the drawings.

The trunk circuit apparatus 75 and the repeater 70 associated with the interoffice trunk line 24 interconnecting the manual office No. 3 with the automatic exchange No. 1 are illustrated in Figs. 12 and 13 as being arranged for simplex circuit control operations effected over both sides of the indicated trunk line. More particularly, the trunk circuit apparatus 75, which is provided at one of the operator's positions in the manual office No. 3 and terminates one end of the trunk line 24, comprises a repeating coil 1350, a call and answer jack 1355, and a dial jack 1361 which is arranged to receive a plug 1363 terminating one end of a dial cord extending to a conventional dial operated calling device 1362. This trunk circuit apparatus also includes a supervisory signal device 1369, a supervisory control relay R1370, and a visual signal device in the form of a drop 1360 which is adapted to be energized by ringing current transmitted thereto over the trunk line 24. In order to transmit over the trunk line 24 to the repeater 70 pulses of booster bat-

tery potential, there is provided a key 1364 which is of the well-known nonlocking type. Such booster battery pulses may be utilized, in the manner more fully explained subsequently, to cause corresponding pulses to be transmitted to the call metering device associated with a calling line on a call incoming to the manual office No. 3 and also for operator recall signaling purposes on calls routed between this operator's position and the operator's positions in the other manual offices of the system.

The repeater 70 includes a repeating coil 1340 at which the other end of the trunk line 24 terminates and is accessible to the various local and toll connector switches provided in the automatic exchange No. 1 over the trunk line 14. The control equipment of this repeater includes a line relay R1240, a slow-acting hold relay R1270 and a set of ringing control relays including the slow-acting relay R1305, the pendulum-type relay R1310 and the slow-to-operate relay R1320. These five relays are utilized to energize the signal device 1360 on a call routed by way of the repeater 70 to the distant manual office No. 3. On a call of this character, control of the supervisory signal control relay R1370 is effected through the operation of a pair of additional relays R1230 and R1300, the first of which is of the differentially wound type and is arranged to respond to the unbalancing of a loop circuit established by way of the trunk line 14. The relay equipment of the repeater 70 also includes a battery reversing relay R1220 which is arranged to be controlled by a call and answer relay R1260. Two additional relays R1210 and R1200, the last-mentioned of which is of the slow-acting type and the first-mentioned of which is of the marginal type, are provided, these two relays being arranged to respond to booster battery pulses impressed upon the conductors of the trunk line 24 through operation of the key 1364 in the manner explained above. Battery potential for marking the trunk line 14 as idle in the bank contacts of the connector switches having access thereto is derived through an impedance element 1250. On calls originating at the operator's position in the manual office No. 3 and routed by way of the trunk line 24, the call and answer relay R1260 cooperates with a slow-acting line switching relay R1330 to extend a connection from the repeating coil 1340 to the toll connector switch 80 in response to seizure of the trunk circuit apparatus 75. On calls of this character, the transfer relay R1300 cooperates with a back bridge relay R1335 to control the operation of the supervisory control relay R1370 included in the trunk circuit apparatus 75. A slow-to-release relay R1300' is also provided, which relay functions to short-circuit the repeater winding 1341 and the upper winding of the relay R1210 during the transmission of impulses to the connector switch 80. The manner in which the above-mentioned relays operate to perform the designated control functions is set forth with particularity in the following explanation of the circuit operation. Since the toll connector switch 80 is identical in construction and arrangement with the toll connector switch 50 illustrated in Figs. 14 and 15, the details thereof have not been illustrated.

I. *Local call—Substation A to substation B*

Referring now to the details of operation of the system, the mode of operation of the apparatus illustrated in Figs. 3, 4, 5, 6 and 10 to set up a connection between the substations A and B on a call originating at the substation A will first be considered. Assuming that the calling line 10 is of the magneto type, the call is initiated through operation of the hand generator provided at the substation A. In response to this operation ringing current is projected over the line 10 to energize the upper winding of the line relay R360, the circuit traversed by this current extending by way of the line conductor C301, the upper winding of R360, RA352 and the line conductor C302. When energized over this circuit, the relay R360 operates to complete at the "X" contacts associated with RA361, a holding circuit for itself, this holding circuit extending from ground by way of RA351, RA361 and the lower winding of R360 to battery. By way of completing the description with reference to the operation of the line circuit 10_a, it is pointed out that if the line 10 is arranged for common battery, loop operation, the Y wiring illustrated in Fig. 3 is employed instead of the X wiring just described. In such case, the relay R360 is energized when the receiver at the substation A is removed from its supporting hook or cradle, over a circuit extending from ground at RA351 by way of C301, the bridging direct current path between the conductors C301 and C302, C302, RA352 and the two windings of R360 in series to battery. It will be understood that in the case last described, the X wiring illustrated in Fig. 3 and the armature RA361 of the relay R360 are not provided.

Upon operating, the relay R360 completes, at RA362, an obvious path for impressing guarding ground potential upon the private conductor C303 of the line 10, thereby to mark this line as busy in the bank contacts of the connector switches having access thereto. At RA363, the relay R360 completes a path for marking the line 10 as a calling line in the bank contacts of the finder switches having access thereto, this path extending from the negative terminal of the exchange battery by way of the resistor 356 and RA354 in parallel with the winding of R350, RA341, RA363 and C304 to the multipled private contacts individual to the line 10 and provided in the banks of the various finder switches having access to the line 10. At RA364, the relay R360 completes a path extending by way of RA343 for impressing ground potential upon the distributor start conductor C306. As a result, the distributor 15 functions to initiate the operation of one of the associated finder switches to search for the calling line 10. Assuming that the link illustrated, namely, the link comprising the finder switch 20 and the local connector switch 25 is assigned to the use of the calling line 10, operation of the finder switch 20 to search for the line 10 is initiated under the control of the distributor 15, when ground potential is impressed upon the distributor start conductor C306. When the calling line is found, operation of the finder switch 20 is arrested and the conductors C301 and C302 are connected through to the conductors C370 and C371, respectively, of the trunk line extending to the connector portion of the link. In addition, ground potential is impressed upon the control wiper of the finder switch, thus completing a circuit for energizing the cut-off relay R350, this circuit extending by way of the grounded conductor C304, RA363, RA341 and the winding of R350 to battery. The relay R350, upon operating, completes, at RA353, an obvious holding circuit for itself and, at RA355, an obvious circuit for energizing the slow-acting line lockout relay R340. At RA351 and RA352, the

relay R350 opens the respective operating and holding circuits for the line relay R360, thus causing the latter relay to restore. At RA354, the relay R350 opens a point in the above-traced battery marking path and completes a circuit for energizing the metering device 365, this circuit extending by way of the grounded conductor C304, the operating magnet embodied in the metering device 365, RA354 and the resistor 356 to battery. The metering device 365 is so constructed and arranged that it does not operate when energized over the circuit just traced. At RA343, the relay R340 prepares a holding circuit for itself and disconnects the distributor start conductor C306 from ground, thereby to release the distributor 15 for use in handling other calls. At RA341, the relay R340 opens a further point in the above-traced marking path and prepares a circuit for transmitting paystation tone signal current by way of the line circuit 10a and one of the associated finder-connector links to an operator's position in one of the distant manual offices. The line relay R360 restoring, opens at RA362, the initially completed path for impressing ground potential upon the private conductor C303 and connects this private conductor to ground over an alternative path extending by way of RA362 and RA353 to the grounded conductor C304. At RA361, the relay R360 opens a further point in one of its previously traced holding circuits. Finally, the relay R360 opens, at RA364, a further point in the above-traced path for impressing ground potential upon the distributor start conductor C306.

When the finder switch 20 seizes the calling line 10, the control conductor C304 is connected to the control conductor C488 and ground potential is impressed upon both of these conductors. In addition, the metering conductors C305 is connected through the finder switch 20 to the metering conductor C372. The operation of the finder switch 20 to extend the calling line to the connector portion 25 of the link results in the energization of the relay R600 over a circuit extending by way of the grounded conductor C488, RA416, RA406', C490, C585 and the upper winding of R600 to battery. An obvious branch of this circuit extends through the lower winding of R440 to battery but this relay is so constructed that it does not operate when its lower winding is alone energized. When its upper winding is energized over the circuit just traced, the relay R608 operates to complete at RA607, a holding circuit for itself, this holding circuit extending from ground at RA515 by way of the off-normal springs 517', C489', RA607, C487, RA405, RA416, RA406', C490, C585 and the upper winding of R600 to battery. The application of ground potential to the control conductor C488 over the path just traced also serves to hold the line circuit 10a and the finder switch 20 operated in the usual manner. If the line 10 is arranged for magneto operation such that the "X" wiring illustrated in Fig. 3 is used, no further relay operations occur following operation of the relay R600 until the receiver provided at the calling substation is removed from its supporting hook or cradle to establish a simplex circuit for energizing the pulsing relay R435. One branch of this simplex circuit may be traced as extending from ground through the pulsing springs of the calling device provided at the substation A and by way of C301, C370, RA401, C467, the winding 566, RA522', C472, RA442 and the upper winding of the relay R435 to battery. The parallel branch of the simplex circuit extends from ground through the pulsing springs of the calling device provided at the substation A and by way of C302, C371, RA402, C469, the winding 568, RA521', C471 and the upper winding of the relay R435 to battery. When this circuit is completed the relay R435 operates to prepare, at RA436, a circuit for energizing the slow-acting hold relay R425. At RA437, the relay R435 completes a circuit for energizing the control relay R430, this circuit extending from ground by way of RA414, RA437 and the winding of R430 to battery. The relay R430 operating, completes, at RA432, an obvious circuit for energizing the relay R425. At RA433, the relay R430 completes a holding circuit for itself, this holding circuit extending from ground by way of the resistor 429, RA433, RA437 and the winding of R430 to battery. At RA431, the relay R430 prepares a circuit traced hereinafter for energizing the right winding of the shunt field relay R620. At RA434, the relay R430 operates to impress ground potential upon the pulsing lead C496 extending to the zone metering circuit shown in Figs. 7 and 8. At RA432, the relay R430 also completes a circuit for energizing the relay R540, this circuit extending from ground by way of RA432, C478, the off-normal springs 558 and the lower winding of R550 to battery.

When energized over this circuit, the relay R540 operates to prepare, at RA543, a holding circuit for itself. At RA544, the relay R540 also opens a point in the circuit traced hereinafter for transmitting impulses to the rotary magnet 670. At RA544, the relay R540 prepares a circuit for energizing the vertical magnet 560 in accordance with the first series of impulses transmitted to the connector switch 25. At RA542, the relay R540 opens a point in the circuit traced hereinafter for energizing the line switching relay R650 and prepares certain operating and release circuits described more fully subsequently. At RA545, the relay R540 completes a circuit for energizing the upper winding of the relay R640 in series with the relay R610. The relays R640 and R610 are thus momentarily operated, but without effect at this time. At RA541, the relay R540 completes a path for conducting dial tone current through the windings of the repeating coil 565, whereby the usual dial tone signal is reproduced by the receiver provided at the calling substation. The circuit locally traversed by the dial tone current may be traced as extending from one terminal of the dial tone source by way of C546, RA541, the condenser 546', the winding 567, the condenser 567', C576, RA663, C575, the upper winding of R520 and the exchange battery to the opposite terminal of the dial tone current source. Due to the alternating character of this current, induced voltages are developed in the windings 566 and 568 which are impressed over the calling line 10 across the receiver provided at the calling substation to be reproduced in the usual manner.

The relay R425, upon operating, completes, a holding circuit for itself, this circuit extending from ground by way of RA426, RA436 and the winding of R425 to battery. At RA427, the relay R425 completes an obvious circuit for energizing the slow-acting relay R420. At RA428, the relay R425 connects the conductor C495 to ground for a purpose to be described subsequently with reference to the zone metering circuit 30. The relay R420, upon operating, completes, at RA421, an obvious circuit for energizing the relay R410. At RA422, the relay R420 completes a circuit for

energizing the left winding of the shunt field relay R620, this circuit extending from ground by way of RA422, C477 and the left winding of R620 to battery. The relay R620 is so constructed and arranged that it does not operate in response to the energization of its left winding over the circuit just traced. At RA423, the relay R420 prepares a circuit traced hereinafter for energizing the link release relay R550, this latter relay only being operated in the manner subsequently described in the event a call is not forwarded by way of the connector switch 25 within a predetermined time interval following seizure of this switch.

The relay R410 operating, opens, at RA411, a point in the circuit for energizing the release magnet 406. At RA412, the relay R410 prepares a circuit for energizing the slow-acting relay R500 in parallel with the vertical magnet 560 during the first series of impulses transmitted to the connector switch. At RA413 and RA414, the relay R410 prepares holding circuits for the line switching relay R400. At RA414, the relay R410 also opens the previously traced operating circuit for the relay R430 and prepares a locking circuit for the ring cut-off relay R530. At RA416 and its associated resting contact, the relay R410 interrupts the previously traced operating circuit for the relay R600 and the momentarily completed circuit for energizing the relays R640 and R610 in series, causing these three relays to restore. At RA415 and RA416, the relay R410 completes an alternative path for maintaining ground potential upon the control conductor C488, this path extending from ground by way of RA554, C489, RA415 and RA416 to the indicated control conductor. Following the operation of the relay R410, the apparatus embodied in the connector switch 25 is conditioned to respond to the first series of impulses dialed at the calling substation.

In the event the calling line 10 is arranged for common battery, loop operation, such that the Y wiring is used in the line circuit 10_a instead of the X wiring, the relay equipment provided in the local connector switch 25 responds in a manner slightly different from that just described when the finder switch 20 operates to establish a connection between the calling line 10 and the trunk line conductors C370 and C371. More particularly, in the Y wiring arrangement provisions are made for energizing the upper winding of the relay R440 in response to the above-described switching-through operation on the part of the finder switch 20. The circuit for energizing the relay R440 extends from ground by way of the upper winding of this relay, C476, C372, C305, RA354 and the resistor 356 to battery. When its upper and lower windings are both energized, the relay R440 operates to complete a circuit for energizing the line relay R435 over the calling loop, this circuit extending from ground by way of the lower winding of R435, RA441, RA442, C472, RA522', the winding 566, C467, RA401, C370, C301, the bridge across C301 and C302 at the calling substation, C302, C371, RA402, C469, the winding 568, RA521', C471 and the upper winding of R435 to battery. When energized over this loop circuit, the relay R435 operates to cause the operation of the relays R430, R540, R425, R420, R410 and the release of the relay R600 in the manner described above.

Each time the calling device provided at the calling substation is operated in accordance with one of the digits of the directory number designating the desired substation B, the previously traced operating circuit for the pulsing relay R435 is interrupted one or more times determined by the numerical value of the digit. In this regard it will be understood that if the line 10 is of the magneto type such that a simplex pulsing circuit is employed, both sides of the line are disconnected from ground during the open circuit period of each impulse. On the other hand, if the line 10 is arranged for loop operation, the loop circuit over which the two windings of the relay R435 are energized in series is opened during the open circuit period of each impulse. Upon restoring at the beginning of the first impulse of the first digit, the relay R435, at RA436, opens the above-traced holding circuit for the relay R425 and completes a priming circuit for itself, this priming circuit extending from ground by way of RA426, RA436, the resistor 438 and the upper winding of R435 to battery. The resistance of this circuit is such that the relay R435 does not reoperate when the circuit is completed, but is rendered fast to operate when the open circuit period of the impulse is ended and the loop circuit is recompleted. At RA437, the relay R435, upon restoring, opens the above-traced holding circuit for the relay R430. The relay R430 releasing, opens, at RA433, a further point in its holding circuit and interrupts, at RA432, the holding circuit for the relay R425. At RA434, the relay R430 disconnects the pulsing lead C496 of the zone metering circuit from ground. At RA432, the relay R430 also completes the above-mentioned circuit for energizing the slow-acting relay R500 in parallel with the vertical magnet 560, this circuit extending from ground by way of RA432, RA412 to C479 where it divides; one branch extending through the winding of R500 to battery and the other branch extending by way of RA544 and the winding of the magnet 560 to battery. The relay R500, upon operating, completes, at RA501, an obvious path for short-circuiting the repeater winding 568, thereby to exclude this winding from each of the above-traced alternative circuits for energizing the pulsing relay R435. At RA502, the relay R500 completes a holding circuit for the relay R540, this circuit extending from ground by way of RA502, RA543, and the upper winding of R540 to battery. The vertical magnet 560, when energized over the circuit just traced, operates to elevate the wipers 680 to 684, inclusive, one step in the usual manner. At its armature 561, the magnet 560 prepares an alternative circuit for energizing the relay R430, this alternative circuit being completed in response to the reoperation of the pulsing relay R435 at the end of the open circuit period of the first impulse and extending from ground by way of the armature 561, C486, RA437 and the winding of R430 to battery. When this alternative circuit is completed, the relay R430 reoperates to recomplete its holding circuit and to open the circuit for energizing the magnet 560 and the relay R500 in parallel. The magnet 560 releasing, opens the above-traced alternative operating circuit for the relay R430. During each succeeding impulse of the first digit, the relays R435 and R430 and the magnet 560 function in the exact manner just described. The relays R425 and R500, due to their slow-to-release characteristics, remain operated throughout each series of impulses transmitted to the connector switch. Since the magnet 560 is energized and deenergized once during each impulse of the first digit, the wipers 680 to 684, inclusive, of the

connector switch 25 are elevated to a position opposite the level of bank contacts corresponding to the numerical value of the digit dialed. If it be assumed, for example, that the line 11 is the fourth line terminated in the fifth level of the contact bank embodied in the connector switch 25, the first digit dialed at the calling substation A will necessarily comprise five impulses so that the indicated wipers are moved five steps in the vertical direction. When these wipers are elevated to the first vertical off-normal position, the off-normal springs 407 are moved into engagement to prepare a circuit for energizing the release magnet 406 and the off-normal springs 558 and 517' are respectively disengaged. At the springs 558, the previously traced operating circuit for the relay R540 is interrupted. Since, however, the relay R500 is operated at this time, the holding circuit for the relay R540 is not interrupted and the latter relay remains operated throughout the series of impulses. At the springs 517', the lead C489' is disconnected from ground further to open the above-traced holding circuit for the relay R600.

Shortly following the end of the first digit dialed at the calling substation and with the relays R435 and R430 in their respective operated positions such that the operating circuit for the slow-acting relay R500 is held open, the latter relay restores to interrupt at RA502 the holding circuit for the relay R540. Upon restoring, the relay R540, at RA543, opens a further point in its holding circuit and prepares a circuit for energizing the relay R630. At RA544, the relay R540 opens a point in the above-traced circuit for energizing the vertical magnet 560 and prepares a circuit for energizing the rotary magnet 670 in parallel with the slow-to-release relay R610 during the impulses of the second digit.

At the beginning of the first impulse of the second digit, the pulsing relay R435 restores to open, at RA437, the holding circuit for the relay R430 in the manner previously explained. The relay R430 releasing, opens, at RA433, a further point in its holding circuit and completes, at RA432, the above-mentioned circuit for energizing the rotary magnet 670, this latter circuit extending from ground at RA432 by way of RA412, C479, RA544, C582, RA645, RA655, RA665 and the winding of the magnet 670 to battery. An obvious branch of the circuit just traced extends through the winding of the relay R500. Accordingly the relay R500 reoperates at the beginning of the first impulse of the second digit to recomplete, at RA501, the path for short-circuiting the repeater winding 568. At RA502, the relay R500 completes the above-mentioned circuit for energizing the relay R630, this circuit extending from ground by way of RA502, RA543, C580, RA604 and the winding of R630 to battery. The relay R630 operating, completes, at RA632, an obvious circuit for energizing the slow-to-release relay R610. At RA633, the relay R630 opens a point in an incomplete circuit for energizing the relay R600. At RA631, the relay R630 completes an obvious locking circuit for itself. The relay R610, upon operating, prepares, at RA613, a circuit for energizing the busy test relay R640, and prepares, at RA614, a circuit for energizing the relay R600. At RA611', the relay R610 opens a point in the circuit traced hereinafter for transmitting busy tone current by way of the calling loop circuit to the calling substation.

When energized over the above-traced pulsing circuit, the rotary magnet 670 attracts its associated armatures 671 and 672. At the armature 672, the magnet 670 opens a point in the circuit for energizing the busy test relay R640. At its armature 671, the magnet 670 prepares an alternative circuit for energizing the relay R430, the last-mentioned circuit being completed at the end of the open circuit period of the first impulse and extending from ground by way of the armature 671, C486, RA437 and the winding of R430 to battery. Upon reoperating, the relay R430 recompletes its holding circuit and opens, at RA432, the above-traced circuit for energizing the relay R500 in parallel with the rotary magnet 670. Thus, the magnet 670 is deenergized and releases to open the operating circuit for the relay R430. During each succeeding impulse of the second digit, the relays R435 and R430 and the rotary magnet 670 interact in the exact manner just explained. Due to the slow-to-release characteristic of the relay R500, this relay and the two relays R610 and R630 are held operated throughout the impulses of the second digit. Each time the rotary magnet 670 is energized and deenergized, it functions to step the wipers 680 to 684, inclusive, one step in the rotary direction in the usual manner. Since, in the present case, the line 11 is assumed to be the fourth line of the fifth level, the second digit will necessarily comprise four impulses so that at the conclusion thereof the indicated wipers are left standing in engagement with the contacts terminating the conductors of the line 11. Immediately these wipers are advanced into engagement with the contacts terminating the conductors of the called line and the rotary magnet 670 releases, the previously mentioned test circuit including the lower winding of the busy test relay R640 is completed. This test circuit extends by way of the private wiper 683, C676, RA658, RA613, the armature 672 and the lower winding of R640 to battery. If the called line 11 is busy at the time it is selected, ground potential as derived from the line circuit 11_a, is impressed upon the private wiper 683 so that relay R640 is energized over the test circuit just traced.

The relay R640 operating, opens at RA643, a point in the circuit for energizing the line switching relay R650. At RA643, the relay R640 also prepares a holding circuit for itself. At RA641, the relay R640 prepares the above-mentioned circuit for transmitting busy tone current by way of the calling loop circuit to the called substation. Shortly following the end of the second digit, the relay R500 restores and opens, at RA502, the operating circuit for the relay R630. Thus, the relays R500, R630 and R610 are sequentially released in an obvious manner. The relay R610 restoring, completes the prepared holding circuit for the busy test relay R640. This holding circuit extends from ground by way of RA542, C578, RA643, RA611, the armature 672 and the lower winding of R640 to battery. At RA613, the relay R610 opens a point in the previously traced test circuit including the lower winding of the relay R640. At RA611', the relay R610 completes the circuit for transmitting busy tone current back over the calling line to the called substation. This circuit may partially be traced as extending from one terminal of the busy tone current source by way of C673, RA611', RA641, C572, the condenser 546', the repeater winding 567, the condenser 567', C576, RA663, C575, the upper winding of R520 and the exchange battery to the opposite terminal of the busy tone current source. Due to the alternating character of this

current, a corresponding induced voltage is impressed across the conductors of the calling line which results in the energization of the receiver provided at the calling substation so that the usual busy tone signal is reproduced. Following the release of the relay R610, no further operation of the apparatus embodied in the local connector switch 25 occurs until the connection is cleared out at the calling substation. In this regard, it will be noted that with the busy test relay R640 operated the armatures RA644 and RA645 controlled thereby are in their respective operated positions so that the circuit for energizing the rotary magnet 670 is open. Accordingly, the dialing of the additional digit at the calling substation is without effect to cause any further operation of the connector switch. The manner in which the finder-connector link, comprising the finder switch 20, the connector switch 25 and the line circuit 10_a, is released when the connection is cleared out at the calling substation is described in detail hereinafter.

In the event the called line 11 is idle at the time it is selected in the manner described above, battery potential is impressed upon the private wiper 683 from the line circuit 11_a. Accordingly, the busy test relay R640 is not energized and remains in its restored position. Shortly following the end of the second digit and when the relays R500, R630 and R610 restore in the order named, the previously mentioned circuit is completed for energizing the slow-to-operate line switching relay R650, this circuit extending from ground at RA542 by way of C578, RA643, the upper winding of R650, the off-normal springs 615, RA613, RA658, C676, the private wiper 683 and through the winding of the cut-off relay embodied in the line circuit 11_a to battery. When its upper winding is energized over this circuit, the relay R650 first completes, at the "X" contacts associated with RA656, a holding circuit for itself; this holding circuit extending from ground by way of RA554, C489, RA415, RA416, RA405', C487, RA656 and the lower winding of R650 to battery. Following the completion of this circuit, the relay R650 fully operates to open, at RA658 and its associated resting contact, a point in its operating circuit as traced above. At RA658 and RA658', the relay R650 completes a path for impressing ground potential upon the private conductor of the line 11, thus marking this line as busy in the bank contacts of the other connector switches having access thereto. This marking path extends by way of the grounded conductor C489, RA415, RA416, C488, RA658', RA658, C676 and the private wiper 683 to the private conductor of the line 11. At RA657, the relay R650 opens a point in the circuit traced hereinafter for energizing the link release relay R550. At RA659 and RA659', the relay R650 prepares a multiple path for grounding the release conductor C489. At RA655, the relay R650 opens a point in the above-traced circuit for transmitting current pulses to the rotary magnet 670, thereby to preclude further operation of this magnet in response to additional digits dialed at the calling substation.

The bank wiring arrangement of the connector switch 25 is such that when the wipers 680 to 684, inclusive, are moved into engagement with a set of contacts terminating a line arranged for loop operation, the extra control wiper 682 is grounded. On the other hand if a selected called line is arranged for simplex operation, the contact corresponding to this line and engaged by the extra control wiper 682 is not wired. In the present case if it be assumed that the line 11 is arranged for loop operation a circuit is completed for energizing the relay R510 when the relay R650 fully operates, this circuit extending by way of the grounded extra control wiper 682, C675, RA654, C477', RA408', C478' and the winding of R510 to battery. The relay R510 operating, prepares, at RA511, a circuit for energizing the two windings of the relay R520 in series when the call is answered at the called substation. Obviously, the relay R510 is not energized if the wiper 682 engages an unwired contact corresponding to a selected line arranged for simplex operation.

At RA651 and RA653, the relay R650 completes a circuit for transmitting ringing current over the line 11 to energize the signal device provided at the called substation. This circuit may be traced as extending from the ungrounded terminal of the ringing current generator 555 by way of the interrupter springs 556, C694, RA401', C694', RA531, C570, RA651, C468, the positive line wiper 680, the positive side of the called line 11, the signal device bridged between the conductors of the line 11 in series with a condenser at the called substation, the negative side of the called line, the wiper 681, C470, RA653, C574, RA532, C469', RA402', C470', the upper winding of R530 and the exchange battery to the grounded terminal of the ringing current source.

At RA652, the relay R650 completes a circuit for transmitting ringing current by way of the calling loop circuit in order to give the calling subscriber the usual ring-back tone signal. This latter circuit extends from the ungrounded terminal of the ringing current source 555 by way of the interrupter springs 556, C694, RA401', C694', RA531, C570, RA651, RA652, C572, the condenser 546', the repeater windings 567, the condenser 567', C576, RA663, C575, the upper winding of R520 and the exchange battery to the grounded terminal of the source 555. Due to the alternating character of the current, a corresponding induced voltage is impressed across the conductors of the calling loop circuit so that the usual ring back tone signal is reproduced by the receiver provided at the calling substation, thus indicating to the calling subscriber that the called substation is being rung.

The desired talking circuit between the calling and called substation is completed when the call is answered at the substation B. Assuming that the called line 11 is arranged for loop operation, the ring cut-off relay R530 is energized by direct current traversing the above-traced ringing current circuit when the call is answered at the called substation. When energized over this circuit the relay R530 first completes at the "X" contacts associated with RA534 a holding circuit for itself, this circuit extending from ground by way of RA414, C482, RA534 and the two windings of R530 in series to battery. After this circuit is completed, the relay R530 fully operates to interrupt, at RA531 and RA532 and their respective associated resting contacts, two points in the circuit traversed by the ringing current. At RA531, the relay R530 also opens the circuit for transmitting ringing current over the calling loop circuit, thereby to terminate the ring-back tone signal. At RA531 and RA532 and their respective associated working contacts, the relay R530 completes the desired talking connection between the calling and called substations. The relay R530, upon operating to complete the talking circuit between the calling and called sub-

stations, extends the called loop circuit to the line terminals of the relay R520 so that this relay is energized thereover. More particularly, the circuit for energizing the relay R520 extends from ground by way of the lower winding of R520, RA511, the repeater winding 567, RA531, C570, RA651, C468, the positive line wiper 680, the positive side of the called line 11, the direct current bridge connected between the conductors of the called line at the called substation, the negative side of the called line, the wiper 681, C470, RA653, C574, RA532, the repeater winding 569, C576, RA663, C575 and the upper winding of R520 to battery. Current for energizing the transmitter provided at the called substation is supplied to the transmitter over this circuit. Upon operating, the relay R520 opens, at RA521, a point in the circuit traced hereinafter for energizing the switching through relay R400. At RA522, the relay R520 completes a multiple holding circuit for the relay R420, this circuit extending from ground by way of RA522, C481 and the winding of R420 to battery. At RA523, the relay R520 completes a circuit for energizing the timer start relay R460, thereby to initiate the operation of the timing device 450 in the manner subsequently explained.

As explained above, talking battery is supplied to the loop extending to the called substation through the windings of the back bridge relay R520 when the called line is arranged for loop operation. Talking battery is impressed upon the loop extending to the calling substation through the windings of the pulsing relay R435 in the event the calling line is also arranged for loop operation. If the calling line is arranged for simplex operation, the pulsing relay R435 is held operated from ground as impressed upon the negative side of the calling line at the calling substation and current for energizing the transmitter provided at this substation is supplied from the local battery conventionally embodied in the substation apparatus. If the called line 11 is also arranged for simplex operation, the relay R510 is not caused to operate in response to operation of the relay R650 for the reasons pointed out above. When the call is answered at the called substation, ground potential is impressed upon the negative side of the called line 11 so that the ring cut-off relay is energized over a circuit extending by way of the grounded negative side of the called line, the wiper 681, C470, RA653, C574, RA532, C469', RA402', C470' and the upper winding of R530 to battery. Upon operating, the relay R530 performs the functions previously described, among which is the completion of a circuit for energizing the back bridge relay R520. In this case, however, the back bridge relay may be energized over a circuit extending from ground over either side of the called line, one circuit for energizing this relay including the wiper 680, C468, RA651, C570, RA531, the repeater winding 567, RA511, C577, RA664, RA663, C575 and the upper winding of R520 to battery. The other side of the circuit may include the wiper 681, C470, RA653, C574, RA532, the winding 569, C576, RA663, C575 and the upper winding of R520 to battery. Current for energizing the transmitter provided at the called substation is supplied from the battery locally provided at this station.

The release of the operated switch train is initiated when the last of the calling and called parties hangs up. More particularly, if the connection is cleared out at the calling substation A before it is released at the substation B, the pulsing relay R435 is deenergized and restores to open, at RA437, the holding circuit for the relay R430 and to interrupt, at RA436, one of the multiple holding circuits for the relay R425. The relay R430 restoring, opens, at RA432, the remaining holding circuit for the relay R425 causing the latter relay to restore. At RA427, the relay R425 opens one of the multiple holding circuits for the relay R420, this latter circuit being held energized over the circuit traced above and extending from ground by way of RA522 until the connection is cleared out at the called substation. Upon restoring, the relay R430 also completes the previously traced circuit for energizing the relay R500, thereby to cause the sequential operation of this relay and the two relays R630 and R610 in the order named. The reoperation of the three indicated relays is without effect at this time.

When the connection is released at the called end thereof the circuit for energizing the back bridge relay R520 is interrupted, causing this relay to restore. Upon restoring, the relay R520 completes, at RA521, the previously mentioned circuit for energizing the relay R400, this circuit extending from ground at RA426 by way of C473, RA533, RA521, C483 and the lower winding of R400 to battery. At RA522, the relay R520 interrupts the holding circuit for the relay R420. At RA523, the relay R520 opens the above-mentioned operating circuit for the start relay R460 embodied in the call timing device 450. The relay R400, upon operating, completes, at RA404, a holding circuit for itself, this holding circuit extending from ground at RA414 by way of RA404 and the lower winding of R400 to battery. At RA403, the relay R400 completes a circuit for energizing its upper winding in series with the metering device 365, this circuit extending from ground at RA554 by way of C489, RA415, RA416, C488, the control wiper of the finder switch 20, the winding of the metering device 365, C305, C372, RA403, RA404', RA413 and the upper winding of R400 to battery. The resistance of the circuit just traced is such that the metering device 365 is caused to operate to register the call. At RA405, the relay R400, upon operating, interrupts the previously traced holding circuit for the relay R650, causing the latter relay to restore. The relay R650 restoring, opens, at RA654, a point in the previously traced circuit for energizing the relay R510 causing the last-mentioned relay to restore, if operated. Shortly following the operation of the metering device, the relay R420 which is deenergized in response to the release of the back bridge relay R520 restores to open, at RA421, the operating circuit for the relay R410. At RA422, the relay R420 opens the previously traced circuit for energizing the left winding of the shunt field relay R620. At RA423, the relay R420 opens a point in the prepared operating circuit for the link release relay R550. The relay R410 in restoring opens, at RA412, the previously traced operating circuit for the relay R500, thereby to cause the sequential release of the relays R500, R630 and R610 in the order named and in an obvious manner. At RA413, the relay R410 opens the above-traced circuit for energizing the upper winding of R400 in series with the metering device 365. At RA414, the relay R410 interrupts the above-traced holding circuits for the relays R400 and R530, causing both of these relays to restore. At RA411, the relay R410 completes a circuit extending by

way of RA403' and the operated off-normal springs 407 for energizing the release magnet 406, thereby to cause the wipers 680 to 684 of the connector switch 25 to be returned to normal in the usual manner. When the indicated wipers are restored to normal, the off-normal springs 407 are disengaged to open the operating circuit for the release magnet 406 and the off-normal springs 558 and 517' are respectively moved into engagement. At RA415 and RA416, the relay R410 opens a point in the previously traced path over which ground potential is impressed upon the control conductor C488, thereby to cause the deenergization of the lower winding of R440 and the release of the finder switch 20. When ground potential is removed from the control conductor C488 the cut-off relay R350 is deenergized and restores to open, at RA355, the operating circuit for the lockout relay R340 causing the last-mentioned relay to restore. At RA354, the relay R350 disconnects the negative battery terminal from the metering lead C305, assuming that the Y wiring illustrated in Fig. 3 is used. In response to the last-mentioned operation the relay R340 is deenergized and restores. Following the release of the line circuit 10_a, in the manner just described, all of the apparatus utilized in completing the connection between the substation A and B is fully restored to normal.

If the connection is cleared out at the called substation B before it is released at the calling substation A, the back bridge relay R520 is the only relay which is affected. More particularly, when the loop circuit extending to the called substation is interrupted the back bridge relay is deenergized and restores. This relay releasing, prepares, at RA521, the above-traced circuit for energizing the relay R400 and opens, at RA522, one of the multiple holding circuits for the relay R420. At RA523, the relay R520 opens a point in the above-mentioned operating circuit for the timer start relay R460. When the connection is thereafter released at the calling substation A, the relays R435, R430 and R425 are caused sequentially to restore in the manner previously explained. The relay R430 restoring, recompletes, at RA432, the above-traced operating circuit for the relay R500, thereby to cause the sequential reoperation of the relays R500, R630 and R610. At RA427, the relay R425, upon restoring, opens the holding circuit for the relay R420, thereby to cause the sequential release of the relays R420 and R410 in the manner just explained. At RA426, the relay R425, upon restoring, recompletes the above-traced circuit for energizing the relay R400, whereby the last-mentioned relay is caused to operate and complete the operating circuit for the metering device 365. At RA405, the relay R400 also interrupts the previously traced holding circuit for the line switching relay R650 causing the latter relay to restore. The relay R650, in turn, opens the operating circuit for the relay R510, whereby the last-mentioned relay is caused to restore, if operated. The relay R410, upon restoring, performs the functions described above, that is, it interrupts the circuit for energizing the metering device 365, opens the holding circuit for the relay R400, disconnects the control conductor C488 from ground, opens the holding circuit for the relay R530 and the circuit for energizing the lower winding of R400, opens the above-traced operating circuit for the relay R500 and completes the circuit for energizing the release magnet 406. Thus, the operated relays R500, R530, R630 and R610 are all caused to release and the wipers of the connector switch 25 are restored to normal. When the Strowger switching mechanism is thus released the off-normal springs 407 are opened and the off-normal springs 558 are moved into engagement. When ground potential is removed from the control conductor C488, the finder switch 20 and the line circuit 10_a are released in the manner explained above.

The manner in which the link comprising the finder switch 20 and the local connector switch 25 is released when a busy called line is selected by the connector portion of the link is somewhat different from the release of the link as described above. More particularly, if, following the dialing operation, busy tone is returned to the calling substation the calling party is expected to abandon the call. In response to this operation, the calling loop circuit is interrupted, thereby to cause the sequential release of the relays R435, R430, R425, R420 and R410 in the order named. During the interval which elapses between the release of the relay R430 and the release of the relay R410, the above-traced operating circuit for the relay R500 is completed, thereby to cause the sequential operation of the relays R500, R630 and R610. The relay R610, upon operating, opens the holding circuit and recompletes the operating circuit for the busy test relay R640. In the present case, the ring cut-off relay R530 is not operated and, accordingly, the previously traced circuit for energizing the relay R400 is not completed in response to the release of the relay R425. Accordingly, the metering device 365 is not caused to operate to register the call. When the relay R410 restores, it opens, at RA412, the above-traced circuit for energizing the relay R500, thereby to cause the sequential release of the relays R500, R630, R610 and R640. In addition, the relay R410 completes the above-traced operating circuit for the release magnet 406, opens the circuit for energizing the lower winding of R440 and disconnects the control conductor C488 from ground. Accordingly, the line circuit 10_a and the finder switch 20 are released in the manner pointed out above. Energization of the release magnet 406 causes the wipers of the connector switch to be returned to rotary and vertical normal at which time the off-normal springs 407 are opened and the off-normal springs 558 and 517' are respectively moved into engagement. Thus, the operated switch train is fully released.

As indicated previously, the timer 450 is provided in order to cause the link comprising the finder switch 20 and the connector switch 25 to be forcibly released at the end of a predetermined time interval regardless of whether or not the conversation being held over the established connection is still in progress. Operation of this timing apparatus is initiated in response to operation of the back bridge relay R520 which occurs when the connection between the calling and called substations is initially completed. More particularly, when the relay R520 operates, it completes, at RA523, a circuit extending by way of C491 and RA464 for energizing the timer start relay R460. The relay R460 operating, completes, at RA463 and RA464, a holding circuit for itself, this holding circuit extending from ground at RA554 by way of C489, RA415, RA416, RA463, RA464 and the winding of R460 to battery. Following the completion of this holding circuit the relay R460 opens its operating circuit in an

obvious manner. At RA462, the relay R460 prepares a circuit for energizing the relay R400. At RA461, the relay R460 opens a point in the circuit for energizing the release magnet 456. At RA465, the relay R460 prepares a pulsing circuit which extends to the operating magnet 455. This pulsing circuit is completed once every thirty seconds through the operation of the pulse sender 466 which functions to impress ground potential upon the pulsing lead C458 at thirty second intervals. Each time the magnet 455 is energized over its pulsing circuit it operates to advance the wipers 453 and 454 one step. Operation of these wipers to their first off-normal positions is accompanied by engagement of the off-normal springs 457 to prepare a circuit for energizing the release magnet 456. When the indicated wipers have been operated into engagement with their respective associated eighth contacts, a path is completed for transmitting by way of the established talking circuit a signal voltage which when reproduced serves to indicate that the connection is about to be released. This signal voltage is reproduced by the receivers respectively provided at the calling and called substations as a tick-tone signal. More particularly, one path traversed by the signal current extends from one side of the tick-tone current source, not shown, by way of the condenser 451', the wiper 454 and its associated eighth contact, C467, the winding 566, the condenser 566', RA521', C471, the upper winding of R435 and the exchange battery to the other terminal of the source. The current traversing the winding 566 causes an induced voltage to be developed in the winding 567 so that current is transmitted by way of the loop circuit extending to the called substation to energize the receiver provided at this substation. Another portion of the tick-tone current traverses a circuit which may be traced as extending from one terminal of the source by way of the condenser 451', the wiper 454, C467, RA401, C370, C301, the receiver provided at the calling substation, C302, C371, RA402, C469, the winding 568, C471, RA521', the upper winding of R435 and the exchange battery to the grounded terminal of the source. The signal thus transmitted to the calling and called substations serves to inform the parties conversing over the established connection that the connection will shortly be released. When the wipers 453 and 454 are subsequently stepped into engagement with their respective associated ninth contacts in response to the ninth current pulse transmitted to the operating magnet 455, the above-traced paths traversed by the tick-tone signal current are interrupted at the wiper 454 and its associated eighth contact. At the wiper 453 and its associated ninth contact, the above-mentioned alternative circuit is completed for energizing the relay R400. This circuit extends from ground at RA462 by way of the wiper 453 and its associated ninth contact, C483 and the lower winding of R400 to battery. The relay R400, upon operating, completes, at RA403, the previously traced circuit for energizing its upper winding in series with the metering device 365, whereby the last-mentioned device is caused to operate to register the call. At RA404, the relay R400 completes the previously traced holding circuit for itself and in so doing completes an obvious multiple locking circuit for the relay R530. At RA405, the relay R400 interrupts the above-traced holding circuit for the relay R650. At RA401 and RA402 and their respective associated resting contacts, the relay R400 opens two points in the loop circuit extending from the calling substation to the repeating coil 565, thereby to deenergize the line relay R435 and thus initiate the sequential release of the relays R430, R425, R420 and R410 in the manner previously explained. When the relay R650 restores, it opens, at RA654, a point in the above-mentioned operating circuit for the relay R510, thus causing the release of the last-mentioned relay, if operated. At RA651 and RA653, the relay R650 opens two points in the loop circuit extending from the repeating coil 565 to the called substation B, thus causing the release of the back bridge relay R520. With the relays R520 and R425 restored, the holding circuit for the relay R420 is interrupted so that this relay and the relay R410 will restore. From this point on, the manner in which the connection is released is exactly the same as described previously. During the release of the link and when ground potential is removed from the control conductor C488, the relay R460 is deenergized and restores. The relay R460 releasing, opens, at RA462, the circuits for the relays R400 and R530. At RA465, the relay R460 opens the circuit over which current pulses are delivered to the operating magnet 455. At RA461, the relay R460 completes a circuit extending by way of the operated off-normal springs 457 for energizing the release magnet 456. When this magnet is energized, the wipers 453 and 454 are returned to their respective normal positions, at which time the off-normal springs 457 are opened to interrupt the operating circuit for the release magnet 456. Thus, the timing device 450 is fully released.

It will be apparent that if the connection as set up by way of the finder switch 20 and the connector switch 25 is released before the timing apparatus 450 has completed its cycle of operation, the operated switches will be released without interference occasioned by operation of the apparatus 450 and, further, the apparatus 450 will also be released. Thus, during the normal release of the link as described above, the control conductor C488 is disconnected from ground in response to the release of the relay R410. In response to this operation, the start relay R460 is deenergized and restores to open, at RA465, the operating circuit for the magnet 455 and to complete, at RA461, the operating circuit for the release magnet 456. Thus, the wipers 453 and 454 are restored to normal and the timing apparatus 450 is released.

IA. *Local call—Substation A to private branch exchange*

In the event a call, originating at the substation A and routed to the link comprising the finder switch 20 and the local connector switch 25, is intended for a private branch exchange or the like wherein the call may be routed over any one of a number of trunk lines to the called substation, the calling subscriber dials a first digit designating the level of contacts at which the groups of trunk lines are terminated, and a second digit designating the first trunk line of the group. The manner in which the control apparatus of the connector switch 25 responds to cause the wipers 680 to 684, inclusive, to be rotated into engagement with the bank contacts terminating the conductor of the first trunk line in the selected group is exactly the same as described in the preceding section with reference to the call routed to the substation B. The ar-

rangement of the apparatus is such that the automatic trunk hunting facilities are provided. More particularly, the control apparatus operates to cause the indicated wipers to be stepped over the contact sets terminating the trunk lines until an idle trunk line is found or until the last trunk line of the group has been tested and found to be busy. To this end, the control and extra control bank contacts of each contact set terminating one of the trunk lines, with the exception of the contact set terminating the last trunk line of the group, are strapped together. Accordingly, if the first selected trunk line of the group is busy at the time the wipers 680 to 684 are operated into engagement with the contacts of the set terminating the line, the previously traced circuit is completed for energizing the busy test relay R640. Shortly following the end of the second digit designating the group of trunk lines, the relays R500 and R630 are caused sequentially to restore in the manner previously explained. The relay R630 releasing completes, at RA633, a circuit for energizing the lower winding of R600, this circuit extending by way of the grounded extra control wiper C684, C677, RA633, RA614 and the lower winding of R600 to battery. The relay R600, upon operating, opens, at RA604, a point in the operating circuit for R630. At RA601, the relay R600 prepares a holding circuit for itself. At RA603, the relay R600 completes a holding circuit for the relay R640, this holding circuit extending from ground at RA542 by way of C578, RA643, RA603, the armature 672 and the lower winding of R640 to battery. At RA602, the relay R600 completes a circuit for energizing the rotary magnet 670 in parallel with the operated relay R610 and the relay R500, this circuit extending from ground at RA542 by way of C578, RA602, RA644, RA645 and RA655 to RA665 where it divides; one branch extending through the winding of the magnet 670 to battery, a second branch extending by way of the resistor 622, RA632 and the winding of R610 to battery, and the third branch extending by way of RA612, C582, RA544, C479 and the winding of R500 to battery. When this circuit is completed, the relay R500 reoperates. The relays R500 and R610 are held operated until an idle one of the group of trunk lines has been selected or all of the trunk lines have been tested. When energized over the circuit just traced, the magnet 670 operates to advance the wipers 680 to 684, inclusive, into engagement with the contacts terminating the second trunk of the selected group and to complete, at its armature 671, the previously traced circuit for energizing the relay R430. At its armature 672, the relay R670 opens a point in the previously traced operating and holding circuits for the busy test relay R640, causing the last-mentioned relay to restore. Upon restoring, the relay R640, at RA643, opens a further point in its holding circuit and prepares the circuit for energizing the line switching relay R550. At RA644 and RA645, the relay R640 opens the above-traced alternative circuit for energizing the magnet 670 in parallel with the relays R610 and R500. When deenergized in this manner, the magnet 670 restores to reprepare, at its armature 672, the operating circuit for the busy test relay R640. In the event the second trunk line of the selected group is also busy, ground potential is present upon the control and extra control conductors thereof so that the upper winding of the relay R650 is short-circuited and, when the magnet 670 retracts its armature 672, the previously traced operating circuit for the busy test relay R640 is recompleted. In addition, ground potential is maintained upon the extra control lead C677 to hold the relay R600 operated. Upon reoperating, the relay R640 recompletes the above-traced holding circuit for itself and the previously traced circuit for energizing the magnet 670 in parallel with the relays R610 and R500. Accordingly, the wipers 680 to 684, inclusive, are advanced a second step to engage the contacts terminating the conductors of the third trunk line of the selected group. Upon reoperating, the magnet 670 again opens, at its armature 672, a point in the operating and holding circuits for the busy test relay R640, thus causing this relay to restore. The interrelated operation of the busy test relay R640 and the rotary magnet 670 continues until an idle one of the trunk lines is found or until all of the trunk lines have been tested and found to be in a busy condition. As explained above, the extra control contact of the contact set which terminates the last trunk line of the group is not strapped to its associated control contact. Accordingly, if the wipers 680 to 684, inclusive, are operated into engagement with this contact set at a time when the trunk line terminated thereby is busy, the above-traced circuit for energizing the busy test relay R640 is recompleted in response to the release of the magnet 670. Since the extra control wiper 684 is, however, disconnected from ground, the circuit for energizing the relay R600 is interrupted. Accordingly, this relay restores, to open, at RA602, a point in the above-traced circuit for energizing the magnet 670 in parallel with the relays R610 and R500. Thus, further operation of the magnet 670 is prevented. Shortly following the release of the relay R600, the relays R500 and R610 restore. The relay R610 releasing completes, at RA611, the initially traced holding circuit for the busy test relay R640. Accordingly, the relay R640 is locked in its operated position. The relay R610 releasing also completes, at RA611', the previously traced circuit for transmitting busy tone current to the calling substation. Thus, the calling subscriber is signaled that the desired connection cannot be obtained. From this point on, the manner in which the apparatus is released when the connection is cleared out at the calling substation is exactly the same as described in section I.

If, during the trunk hunting operation of the connector switch, the wipers 680 to 684, inclusive, are operated into engagement with a set of contacts terminating an idle one of the lines of the selected group, the trunk hunting operation is arrested and the call is forwarded by way of this line to the distant private exchange. In such case, the wipers 683 to 684 encounter battery potential upon the control and extra control contacts of the contact set terminating the idle trunk line. Accordingly, the lower winding of the relay R600 and the lower winding of the busy test relay R640 are both short-circuited and both of these relays restore. The relay R600, upon restoring, opens, at RA602, a point in the above-traced circuit for energizing the magnet 670 in parallel with the relays R500 and R610. At RA603, the relay R600 opens a point in the above-traced alternative holding circuit for the relay R640. Shortly following the release of the two relays R600 and R640, the relays R500 and R610 restore. The relay R610 releasing completes the previously traced operating circuit for

the line switching relay R650, which latter relay, upon operating, completes it holding circuit and performs the other functions previously described with reference to the call routed to the substation B. The manner in which the desired talking circuit is established when the call is answered at the distant operator's position, and the connection is released is identical with the operation of the apparatus as described in section I with reference to the local call routed to the substation B.

II. *Trunk call—Substation A to Manual Office No. 1*

If a call, originating at the substation A and routed to the link comprising the finder switch 20 and the connector switch 25, is intended for a substation associated with a line terminating at the manual office No. 1, the calling subscriber, in order to obtain the assistance of the operator in the distant manual office, dials the single digit designating the group of trunk lines extending to this manual office. The manner in which the control apparatus of the connector switch 25 functions to repeat the impulses of the first digit to the vertical magnet 560 is exactly the same as described in section I of the specification. During the vertical movement of the wipers 680 to 684, inclusive, and when these wipers are positioned opposite the level of contacts terminating the trunk lines extending to the manual office No. 1, the normal post springs 609 and 616 are respectively operated into engagement. When the springs 609 are closed, a circuit is completed for energizing the relay R600, this circuit extending from ground at RA542 by way of C579, the normal post springs 609 and the upper winding of R600 to battery. At the normal post springs 609, a circuit is also completed for energizing the lower winding of R640 in series with the winding of R610. This circuit extends from ground at RA542 by way of C579, the springs 609, C585, C490, RA545, C586, the upper winding of R640 and the winding of R610 to battery. The relay R600 operating, prepares, at RA601, holding circuits for itself and the two relays R610 and R640. At RA602, the relay R600 prepares an alternative circuit traced hereinafter for energizing the rotary magnet 670 in parallel with the relay R500. At RA603, the relay R600 prepares an alternative holding circuit for the relay R640. At RA604, the relay R600 opens a point in the above-traced circuit for energizing the relay R630. At RA605, the relay R600 prepares a holding circuit for the relay R510. At RA606, the relay R600 opens a point in the circuit traced hereinafter for energizing the line switching relay R660. The relay R610, upon operating, opens, at RA611', a point in the previously traced circuit for transmitting busy tone current over the calling end of the connection, and opens, at RA611, a point in the previously traced holding circuit for the busy test relay R640. At RA613, the relay R610 prepares the above-traced test circuit including the lower winding of R640 and extending to the private wiper 683. At RA614, the relay R610 prepares the circuit for energizing the lower winding of R600. The busy test relay R640, upon operating, prepares the above-traced circuit for transmitting busy tone current over the calling end of the connection. At RA642, the relay R640 completes the above-mentioned holding circuits for itself and the two relays R600 and R610. One branch of the last-mentioned circuit extends from ground by way of RA642, RA601, the normal post springs 609 and the upper winding of R600 to battery. The holding circuit for the relays R640 and R610 extends from ground at RA642 by way of RA601, the springs 609, C585, C490, RA545, C586, the upper winding of R640 and the winding of R610 to battery. At RA643, the relay R640 opens a point in the previously traced circuit for energizing the line switching relay R650 and further prepares its own holding circuit. At RA644 and RA645, the relay R640 further prepares the above-traced alternative circuit for energizing the rotary magnet 670 in parallel with the relay R500. At RA646, the relay R640 opens a further point in the above-mentioned circuit for energizing the line switching relay R660.

Shortly following the single series of impulses transmitted to the connector switch 25, the relay R500 is caused to restore in the manner previously described. This relay restoring, opens, at RA502, the holding circuit for the relay R540, causing the last-mentioned relay to restore. Upon restoring, the relay R540 completes, at RA542, the above-mentioned alternative holding circuit for the relay R640, this holding circuit extending from ground by way of RA542, C578, RA643, RA603, the armature 672 and the lower winding of R640 to battery. At RA542 and its associated working contact, the relay R540 also opens a point in the above-traced operating circuit for the relay R600 and a point in the above-traced circuit for energizing the upper winding of R640 and the winding of R610 in series. At RA545, the relay R540 opens a point in the above-traced holding circuit serially including the upper winding of R640 and the winding of R610. At RA544, the relay R540 opens the above-traced circuit for energizing the vertical magnet 560 and prepares the previously traced impulsing circuit extending through the winding of the rotary magnet 670. At RA543, the relay R540 opens a further point in its own holding circuit, prepares the previously traced circuit for energizing the relay R630, and prepares the previously traced circuit for energizing the relay R500. At RA541, the relay R540 opens a point in the above-traced circuit over which dial tone current is transmitted over the calling end of the connection. At RA542 and its associated resting contact, the relay R540 also completes the previously traced circuit for energizing the rotary magnet 670 in parallel with the relays R610 and R500. The reoperation of the relay R500 is without effect. Since this circuit is completed substantially simultaneously with the interruption of the above-traced circuit which serially includes the lower winding of R640 and the winding of R610, the relay R610 is held operated. When the rotary magnet 670 is thus energized, it operates to step the wipers 680 to 684, inclusive, into engagement with the first set of contacts of the selected level, that is, with the set of contacts terminating the first trunk line of the selected group. At its armature 671, the magnet 670 completes the previously traced holding circuit for the relay R430. At its armature 672, the magnet 670 opens the above-traced holding circuit for the busy test relay R640, causing the latter relay to restore. The relay R640 releasing opens, at its armatures RA644 and RA645, the above-traced alternative circuit for energizing the rotary magnet 670 in parallel with the relays R610 and R500. At RA643, the relay R640 opens a further point in

its holding circuit and prepares the above-traced circuit for energizing the upper winding of the line switching relay R650. At RA646, the relay R640 prepares a point in the above-mentioned circuit for energizing the line switching relay R660. At RA642, the relay R640 opens a point in the previously traced holding circuit for the relay R600.

The operation of the control apparatus which occurs following the initial step taken by the wipers 680 to 684, inclusive, depends upon the condition of the first trunk line of the selected group at the time it is thus selected. If this trunk line is busy, ground potential is impressed upon the control and extra control conductors thereof. Accordingly, when the wipers 680 to 684, inclusive, are stepped into engagement with the set of contacts terminating this first line, an alternative circuit is completed for energizing the relay R600. This alternative circuit extends by way of the grounded wiper 684, C677, RA633, RA614, and the upper winding of R600 to battery. Also, when the magnet 670 restores its armature 672 in response to the release of the busy test relay R640, the previously traced circuit is completed for again energizing the busy test relay. Accordingly, the busy test relay reoperates to recomplete, at RA642, the holding circuit for the relay R600; to recomplete, at RA643, the holding circuit for itself; and to recomplete, at RA644 and RA645, the above-traced circuit for energizing the magnet 670 in parallel with the relays R610 and R500. The magnet 670 is thus caused to advance the wipers 680 to 684, inclusive, a second step to engage the contacts terminating the conductors of the second trunk line in the selected group. Upon operating the second time, the magnet 670 again opens, at its armature 672, the holding circuit for the relay R640, whereby this relay is caused to restore to perform the functions described above. The interrelated operation of the busy test relay R640 and the rotary magnet 670 continues until the wipers 680 to 684, inclusive, have been operated into engagement with the set of contacts terminating an idle trunk line in the selected group or until these wipers have been operated into engagement with the set of contacts terminating the link line 28 extending to the call storage circuit 35 illustrated in Fig. 11, this last-mentioned circuit only being seized if all of the trunk lines of the selected group are busy at the time the call is initiated. Assuming that the trunk line 12 is the third trunk line of the selected group and, further, that this line is the first available idle line in the group; when the wipers 680 to 684, inclusive, are stepped into engagement with the contacts terminating the conductors of this line, the interrelated operation of the busy test relay R640 and the magnet 670 is arrested. More particularly, if the line 12 is idle, battery potential is present upon the control and extra control conductor thereof. Accordingly, the previously traced holding circuit for the relay R600, which extends by way of the wiper 684, is not completed. In addition, the above-traced operating circuit for the relay R640 is not completed. Hence, the relays R600 and R640 are deenergized and restore. The relay R640 releasing opens, at RA644 and RA645, the circuit for energizing the magnet 670 in parallel with the relays R610 and R500. At RA643, the relay R640 prepares the previously traced circuit for energizing the upper winding of the line switching relay R650. The last-mentioned circuit is completed in response to the release of the relay R610, which occurs shortly following the release of the relays R600 and R640. Upon restoring, the relay R610 also reprepares, at RA611', the circuit for transmitting busy tone current over the calling end of the connection, reprepares, at RA611, the initially traced holding circuit for the busy test relay R640 and opens, at RA614, a further point in the above-traced alternative circuit for energizing the relay R600. The relay R650, upon operating, completes, at RA656, the previously traced holding circuit for itself. At RA656, the relay R650 also completes a circuit for energizing the relay R400', this circuit extending from ground at RA554 by way of C489, RA415, RA416, RA405, C487, RA656, the normal post springs 616, C483' and the winding of R400' to battery. At RA659 and RA659', the relay R650 disconnects the time cut-off conductor C585 from the conductor C697 extending to the timing apparatus 695.

The relay R400' operating opens, at RA401' and RA402', two points in the previously-traced circuit for projecting ringing current over a selected line. At RA403', the relay R400' opens a further point in the circuit for energizing the release magnet 406. At RA408', the relay R400' prepares an alternative circuit for energizing the metering device 365. At RA404', the relay R400' opens a point in the previously traced circuit for energizing the metering device 365 and the upper winding of R400. At RA405', the relay R400' completes an obvious multiple locking circuit for itself and the relay R650. At RA406', the relay R400' opens a point in one of the multiple paths for impressing ground potential upon the release conductor C488. Finally, the relay R400' completes at RA407' an obvious circuit for energizing the relay R400. The relay R400 operating, completes, at RA404, its own holding circuit. At RA405, the relay R400 opens a point in the initially completed holding circuit for the relay R650. At RA403, the relay R400 prepares the previously traced circuit serially including its own upper winding and the winding of the metering device 365. At RA401 and RA402 and their respective associated resting contacts, the relay R400 opens the loop circuit extending between the calling substation A and the repeating coil 565, thereby to cause the deenergization and release of the line relay R435. At RA401 and RA402 and their associated working contacts, the relay R400 connects the link line conductors C370 and C371 to the link line conductors C468 and C470, respectively, thereby to extend the calling loop circuit to the repeater 40 illustrated in Figs. 16, 17 and 18. In response to this switching through operation, certain of the control relays embodied in the repeater 40 are caused to operate in the manner explained hereinafter to impress ground potential upon the control conductor 12_c of the trunk line 12. When this occurs, the upper winding of the line switching relay R650 is short-circuited, thereby to render this relay slow to release. In addition, ground potential is forwarded by way of C676, RA658 and RA658' to the control conductor, thereby to provide holding circuits for certain of the relays embodied in the operated finder switch 20 and a holding circuit for the operated cut-off relay R350 forming a part of the line circuit 10_a. Thus, the finder switch 20 and the line circuit 10_a are prevented from releasing. With ground potential impressed upon the release conductor C488 in the repeater 40 the relays R650, R400' and

R400 are held energized independently of the other relays embodied in the connector switch 25. When the relay R435 is deenergized and restores in response to the switching through operation of the relay R400, it initiates the sequential release of the relays R430, R425, R420 and R410 in the manner previously explained. During the sequential release of these relays and when the relay R430 restores, the previously traced operating circuit for the relay R500 is completed. Thus, the three relays R500, R630 and R610 are caused momentarily to reoperate in the order named, but the operation thereof is without effect at this time. When the relay R410 restores, it opens, at RA412, the completed operating circuit for the relay R500, thereby to cause the relays R500, R630 and R610 sequentially to restore. At RA411, the relay R410 prepares the previously traced circuit for energizing the release magnet 406. At RA413, the relay R410 opens another point in the previously traced circuit for energizing the upper winding of R400 in series with the metering device 365. At RA416 and RA415, the relay R410 opens one of the multiple paths over which ground potential is impressed upon the control conductor C488, leaving this conductor connected to ground in the repeater 40 only. After the relay R410 has released, no further operation of the control apparatus embodied in the connector switch 25 occurs until the connection is released. In this regard, it will be noted that on a trunk call of the character under consideration a full metallic loop circuit is established by way of the connector switch to the selected outgoing trunk line. Further, only the relays R400, R400' and R650 are operated after the switching through operation is performed. These relays are held in their operated position only because ground potential is impressed upon the control conductor C676 by certain of the control relays embodied in the repeater 40

When the trunk line 12 is seized in the manner described above and the calling loop circuit is extended thereto, the line relay R1610 is energized and operates. More particularly, one branch of the extended portion of the calling loop circuit may be traced as extending by way of C470, the wiper 681, the line conductor 12_b, RA1652, RA1642, the lower winding of R1630 and the lower winding of R1610 to battery. The other branch of the loop circuit extends by way of C468, the wiper 680, the line conductor 12_a, RA1651, RA1641, the upper winding of R1630 and the upper winding of R1610 to ground. Since the relay R1630 is differentially wound, it does not operate when its two windings are energized in series with the windings of the relay R1610. The line relay R1610 operating completes, at RA1611, an obvious circuit for energizing the slow-acting hold relay R1605. At RA1611 and its associated resting contact, the relay R1610 opens a point in the circuit traced hereinafter for energizing the relay R1840. At RA1612, the relay R1610 opens a point in the circuit traced hereinafter for energizing the relay R1765. The relay R1605, upon operating, completes, at RA1606, an obvious circuit for impressing ground potential upon the control conductor 12_c of the trunk line 12, thereby to hold the connector switch 25 operated in the manner previously explained. When ground potential is impressed upon this control conductor 12_c the repeater 40, illustrated in Figs. 16 to 18, inclusive, is marked as busy in the bank contacts of the other connector switches having access thereto. In addition, the relay R1603 is energized over an obvious circuit and operates to prepare one point in the chain path for impressing ground potential upon the all-trunks-busy conductor C1176. At RA1607, the relay R1605 prepares a circuit for energizing the relays R1670 and R1705. At RA1608, the relay R1605 prepares a path traced hereinafter for impressing ground potential upon the wiper 1683 of the timing switch 1680. At RA1609, the relay R1605 completes a circuit for energizing the slow-acting relay R1810, this circuit extending from ground by way of RA1609, RA1678, C1636, RA1821 and the winding of R1810 to battery. The relay R1810, upon operating, prepares, at RA1812, a circuit for energizing the slow-to-operate relay R1800. At RA1811, the relay R1810 completes a circuit for energizing the relay R1840, this circuit extending from ground at RA1832 by way of RA1811 and the winding of R1840 to battery. At RA1813, the relay R1810 completes a circuit for energizing the slow-acting relay R1765, this circuit extending from ground at RA1833 by way of RA1813, C1774 and the winding of R1765 to battery. The relay R1840, upon operating its armatures RA1841 and RA1842, connects the link line conductors C1768 and C1769' to an alternating current source, thereby to cause an alternating current pulse to be transmitted over the trunk line 22 to the trunk circuit apparatus illustrated in Figs. 19, 20 and 21. At RA1843, the relay R1840 completes the above-mentioned circuit extending by way of RA1812 for energizing the slow-to-operate relay R1800. The relay R1765, upon operating, disconnects, at its armatures RA1766 and RA1767, the trunk line conductors C1768 and C1769 from the line terminals of the repeating coil 1745, thereby to prevent the alternating current from being transmitted back over the calling loop circuit to the calling substation. The relay R1800, upon operating, shortly following the operation of the relay R1840, completes, at RA1803, an obvious circuit for energizing the slow-acting relay R1820. At RA1801, the relay R1800 prepares a circuit for energizing the relay R1830. At RA1802, the relay R1800 completes the above-mentioned circuit for energizing the relays R1670 and R1705, this circuit extending from ground by way of RA1802, C1619 to RA1607 where it divides, one branch extending through the two windings of R1670 in series to battery and the other branch extending by way of C1627 and the winding of R1705 to battery.

The relay R1670, upon operating its armatures RA1671 and RA1672, extends the calling loop circuit to the repeating coil 1745. At RA1673, the relay R1670 prepares a multiple path for impressing ground potential upon the control conductor 12_c of the trunk line 12. At RA1674, the relay R1670 opens a point in the circuit for energizing the relay R1720 and prepares a point in the circuit for energizing the relay R1640. At RA1675, the relay R1670 completes a holding circuit for itself and the relay R1705, this circuit extending from ground at RA1726 by way of C1626 to RA1675 where it divides, one branch extending through the two windings of R1670 to battery and the other branch extending by way of C1627 and the winding of R1705 to battery. At RA1676, the relay R1670 prepares an alternative circuit for energizing the relay R1840. At RA1677, the relay R1670 prepares an alternative circuit for energizing the relay R1765. At RA1678, the relay R1670 interrupts the above-

traced operating circuit for the relay R1810. At RA1679, the relay R1670 connects the conductor C1656 to ground, thereby to prepare certain operating and holding circuits referred to in detail hereinafter. At RA1679', the relay R1670 prepares a circuit for energizing the relay R1830.

The relay R1705, upon operating, prepares, at RA1707, a further point in the above-mentioned path for impressing ground potential upon the wiper 1683 of the timing switch 1680. At RA1708, the relay R1705, prepares a holding circuit for the relay R1640. At RA1706, the relay R1705 opens a point in the incomplete operating circuit for the relay R1700. At RA1709, the relay R1705 further prepares the circuit for energizing the relay R1830.

The relay R1820, upon operating, further opens, at RA1821, the previously traced operating circuit for the relay R1810. At RA1822, the relay R1820 opens a point in one of the circuits traced hereinafter for energizing the relay R1620. At RA1823, the relay R1820 prepares the operating circuit for the stepping magnet 1685 embodied in the timing switch 1680. The relay R1810 restoring, opens, at RA1811, RA1812 and RA1813, respectively, the above-traced operating circuits for the relays R1840, R1800 and R1765, causing all of these relays to restore. The relay R1840 releasing, disconnects the trunk line conductors C1768 and C1769' from the alternating current source and opens, at RA1843, a further point in the operating circuit for the relay R1800. The relay R1800, upon restoring, opens the operating circuits for the relays R1670, R1705 and R1820, whereby the last-mentioned relay is caused to restore. The relay R1765, upon restoring, reconnects the trunk line conductors C1768 and C1769' to the repeating coil 1745. Following the release of the relays R1810, R1840, R1800, R1765 and R1820, in the manner just explained, no further operation on the part of the relay equipment embodied in the repeater 40 occurs until the call is answered at the operator's position terminating the distant end of the trunk line 22. In this regard it will be apparent from the foregoing explanation, that a pulse of alternating current is transmitted over the trunk line 22 to the trunk circuit apparatus 45 terminating the distant end of this trunk line when the repeater 40 is seized. Further, the duration of this pulse is determined by the combined operating periods of the relays R1800 and R1820 and the release period of the relay R1810.

The alternating current relay R2000 is energized by the alternating current transmitted over the trunk line 22 in response to seizure of the repeater 40. More particularly, this current traverses a circuit extending from one terminal of the alternating current source by way of RA1841, C1768, RA1951, C1980, the winding 2074, the condenser 2003, the winding of R2000, the repeater windings 2075, C1981, RA1952, RA1932, C1769' and RA1842 to the opposite terminal of the alternating current source. Upon operating, the relay R2000 opens, at RA2001, a point in the circuit for energizing the relay R2010 and completes, at RA2002, a circuit extending by way of RA2023 for energizing the relay R2030. The relay R2030, upon operating, completes, at RA2033, a holding circuit for itself, this holding circuit extending from ground at RA1972 by way of C1984, RA2033 and the winding of R2030 to battery. Thus, the relay R2030 is held operated following the release of the relay R2000, which occurs at the end of the alternating current pulse transmitted over the trunk line 22. At RA2031, the relay R2030 completes a circuit for energizing the signal lamp 2155, this circuit extending from ground by way of RA2021, RA2031, C2082, RA2106 and the filament of the lamp 2155 to battery. At RA2032, the relay R2030 opens a point in the circuit for energizing the supervisory lamp 2156. At RA2034, the relay R2030 prepares a circuit for energizing the upper winding of the relay R2105.

The operator, upon observing the lighted condition of the signal lamp 2155, may, by inserting the plug terminating one end of her cord circuit in the jack 2150, answer the call. In response to this operation, the desired conversational circuit is completed between the operator's telephone set and the calling substation. In addition, the jack springs 2151 and 2152 are moved into engagement to complete a circuit for energizing the relay R2005, this circuit extending from ground by way of the springs 2151 and 2152, RA2101, C2085, RA2043 and the winding of R2005 to battery. Upon operating, the relay R2005 opens, at RA2007, a point in the circuit for energizing the relay R1950. At RA2006, the relay R2005 opens a point in the operating circuit for the relay R1930 and completes an obvious circuit for energizing the slow-to-release relay R2020. The relay R2020, upon operating, opens, at RA2021, the above-traced circuit for energizing the lamp 2155, causing this lamp to be extinguished. At RA2021 and its associated working contact, the relay R2020 prepares the above-mentioned circuit for energizing the supervisory lamp 2156. At RA2022, the relay R2020 prepares a circuit for energizing the relay R1970. At RA2023, the relay R2020, opens a point in the above-traced operating circuit for the relay R2030 and prepares a circuit for energizing the relay R2105. At RA2024, the relay R2020 completes a circuit for energizing the relays R1920 and R2105 in multiple with the busy signal lamp 2158, one branch of this circuit extending from ground by way of RA2024, C1983, RA1974, RA1901 and the winding of R1920 to battery; the second branch extending from ground by way of RA2024, RA2034, C2086, RA2109 and the upper winding of R2105 to battery, and the third branch extending from ground by way of RA2024, C2087 and the filament of the lamp 2158 to battery. When its upper winding is energized over the circuit just traced, the relay R2105, which is of the two-step type, operates to complete, at the "X" contacts associated with RA2108, a path for short-circuiting its lower winding, this path extending from C2087 by way of RA2034, C2086, RA2109, the lower winding of R2105 and RA2108 back to C2087. The completion of this path prevents the relay R2105 from fully operating.

The relay R1920, upon operating, completes, at RA1921, a circuit for energizing the relay R1930. This circuit extends from ground by way of RA1941, RA1921 and the winding of R1930 to battery. At RA1922, the relay R1920 prepares a circuit for energizing the slow-to-operate relay R1910. At RA1923, the relay R1920 completes a circuit for energizing the slow-acting relay R1950, this circuit extending from ground by way of RA1942, RA1923 and the winding of R1950 to battery. At RA1924, the relay R1920 prepares a circuit for energizing the relay R1940. The relay R1930 operating, completes, at RA1933, the above-mentioned circuit for energizing the slow-to-operate relay R1910. At RA1931 and

RA1932, the relay R1930 connects the conductors of the trunk line 22 to the alternating current source provided in the manual office No. 1. The relay R1950, upon operating its armatures RA1951 and RA1952, disconnects the conductors of the trunk line 22 from the repeating coil 2073, thereby to prevent alternating current from being transmitted to the operator's telephone set. The relay R1910 operating, completes, at RA1911, an obvious circuit for energizing the slow-to-release relay R1900. At RA1912, the relay R1910 completes the above-mentioned circuit for energizing the relay R1970. This circuit extends from ground by way of RA1912, C1987, RA2022, C1991, the winding of R1970 and the resistor 1979 to battery. At RA1913, the relay R1910 prepares a multiple circuit for energizing the relay R1940.

The relay R1970 operating, completes, at RA1978, an obvious holding circuit for itself. At RA1975, the relay R1970 completes a multiple circuit for energizing the upper winding of R2105 in parallel with the busy signal lamp 2158, this circuit extending from ground by way of RA1975 to C1988 where it divides, one branch extending by way of RA2034, C2086, RA2109 and the upper winding of R2105 to battery, and the other branch extending by way of C2087 and the filament of the lamp 2158 to battery. At RA1974, the relay R1970 opens the previously traced operating circuit for the relay R1920. At RA1976, the relay R1970 prepares another circuit for energizing the relay R1940. At RA1973, the relay R1970 prepares an alternative circuit for energizing the relay R1950. At RA1971, the relay R1970 prepares an alternative circuit for energizing the relay R1930. At RA1972, the relay R1970 interrupts the previously traced holding circuit for the relay R2030.

The relay R1900 operating, opens, at RA1901, a further point in the operating circuit for the relay R1920 and opens, at RA1902, a point in the incomplete operating circuit for the relay R1960. At RA1903, the relay R1900 prepares a circuit for energizing the stepping magnet 2070 of the timing switch 2065. The relay R1920 restoring, opens, at its armatures RA1921, RA1922 and RA1923, respectively, the previously traced operating circuits for the relays R1930, R1910 and R1950, causing all of these relays to restore. At RA1912, the relay R1910 opens a point in the previously traced operating circuit for the relay R1970. The relay R1910, upon restoring, opens, at RA1911, the operating circuit for the relay R1900, causing the last-mentioned relay to restore. The relay R1930, upon restoring its armatures RA1931 and RA1932, disconnects the conductors of the trunk line 22 from the alternating current source, thereby to terminate the alternating current pulse being transmitted over this trunk line to the repeater 40 illustrated in Figs. 16 to 18, inclusive. The relay R1950, upon restoring, reconnects the conductors of the trunk line 22 to the line terminals of the repeating coil 2073, thereby to reestablish the talking circuit between the calling substation and the operator's telephone set.

The relay R2030, upon restoring, further opens, at RA2031, the above-traced circuit for energizing the signal lamp 2155. At RA2032, the relay R2030 prepares a further point in the circuit for energizing the supervisory lamp 2156. At RA2033, the relay R2030 opens a further point in its holding circuit. Finally, at RA2034, the relay R2030 opens a point in the above-traced path short-circuiting the lower winding of R2105, thus permitting the two windings of the latter relay to be energized in series. Accordingly, the relay R2105 completes its operation to open, at RA2109, a point in its operating circuit and a further point in the above-traced short-circuiting path. At RA2109 and its associated working contact, the relay R2105 prepares a further point in the operating circuit for the relay R2120. At RA2107, the relay R2105 opens a point in the circuit for energizing the supervisory lamp 2156. At RA2106, the relay R2105 opens a further point in the circuit for energizing the lamp 2155. Following the relay operations just described, no further operation of the relay equipment embodied in the trunk circuit 45 occurs until a release operation is performed at the calling substation or the connection is cleared out at the operator's position.

When the relay R1930 operates to impress the voltage of the alternating current source provided in the manual office No. 1 across the conductors of the trunk line 22, the alternating current relay R1760 is energized and operates. More particularly, the circuit traversed by the alternating current may be traced as extending from one side of the current source by way of RA1931, C1768, RA1766, the repeater winding 1748, the winding of R1760, the condenser 1713, the repeater winding 1749, RA1767, C1769, RA1842, C1769' and RA1932 to the opposite terminal of the current source. When energized over this circuit, the relay R1760 operates, to open, at RA1761, a point in the transmission channel extending between the repeating coil 1745 and the calling substation, thereby to prevent alternating current from being transmitted to the receiver provided at this substation. At RA1762, the relay R1760 completes a circuit for energizing the lower winding of R1640, this circuit extending from ground by way of RA1762, C1617, RA1674, RA1645 and the lower winding of R1640 to battery. When its lower winding is thus energized, the relay R1720 only partially operates to complete, at the "X" contacts associated with RA1644, a path for short-circuiting its upper winding, this path extending from ground at RA1708 by way of C1646, RA1644, the upper winding of R1640, RA1645, RA1674, C1617 and RA1762 back to ground. When the alternating current pulse transmitted over the trunk line 22 is terminated in the manner explained above the relay R1760 is deenergized and restores. Upon restoring, this relay opens the path short-circuiting the upper winding of R1640, permitting the two windings of this relay to be energized in series over a circuit extending from ground by way of RA1708, C1646, RA1644 and the two windings of R1640 to battery. The relay R1640 now completes its operation, to open, at RA1645, a further point in the above-traced short-circuiting path and a point in its initially completed operating circuit. At RA1645 and its associated working contact, the relay R1640 prepares a circuit for energizing the upper winding of R1650. At its armatures RA1641 and RA1642, the relay R1640 reverses the direction of current flow over the loop circuit extending to the calling substation A. In the present case, this current reversal is without effect. The current reversal just described is, however, utilized in signaling between two operators' positions in the manner described subsequently in Section VIII with reference to a call routed from an operator's position in the manual office No. 1 to an operator's position in the man-

ual office No. 2. Following the operation of the relay R1640, no further relay operations occur until the connection is released at the calling substation or the connection is cleared out at the operator's position in the manual office.

After the call originating at the substation A has been forwarded to the operator's position in the manual office No. 1, in the manner set forth in the preceding paragraph, the operator may extend the connection to the desired called substation in the manner usually followed in manual office practice. After the call has been forwarded to the operator's position, the release of the switch train comprising the finder switch 20, the connector switch 25, the repeater 40 and the trunk circuit 45 is entirely under the control of the operator. Supervision of the calling end of the connection is attained through energization and deenergization of a supervisory lamp embodied in the operator's cord circuit. More particularly, if the calling subscriber operates the switchhook provided at the calling substation to interrupt the loop circuit extending from this substation to the repeating coil 1745, the line relay R1610 is deenergized and restores. Upon restoring, this relay opens, at RA1611, the operating circuit for the relay R1605. At RA1611 and its associated resting contact, the relay R1610 completes an alternative circuit for energizing the relay R1840, this circuit extending from ground by way of RA1611, RA1676, C1629, RA1741, C1773 and the winding of R1840 to battery. At RA1612, the relay R1610 completes an alternative circuit for energizing the relay R1765, this alternative circuit extending from ground by way of RA1612, RA1677, C1633, RA1742 and the winding of R1765 to battery. The relay R1765 operating, disconnects the trunk line conductors 1768 and 1769 from the line terminals of the repeating coil 1745 in the manner previously explained. The relay R1840 operating, prepares, at RA1843, the previously traced operating circuit for the relay R1800 and completes, at RA1841 and RA1842, the previously traced circuit for transmitting alternating current over the conductors of the trunk line 22 to energize the alternating current relay R2000.

Shortly following the release of the line relay R1610, the slow-acting hold relay R1605 restores, to open, at RA1606, the initially completed path for impressing ground potential upon the control conductor 12_c of the trunk line 12. At this same armature and its associated resting contact, the relay R1605 connects the conductor 12_c to ground over an alternative path extending by way of RA1606 and RA1673. At RA1607, the relay R1605 opens another point in the operating circuit for the relays R1670 and R1705. At RA1609, the relay R1605 completes a circuit for energizing the relay R1830, this circuit extending from ground by way of RA1609, C1657, RA1757, C1658, RA1679', C1659 and the lower winding of R1830 to battery. When energized over this circuit, the relay R1830 operates, to complete, at RA1832, a circuit extending by way of RA1821 for energizing the slow-acting relay R1810. At RA1833, the relay R1830 opens a point in the previously traced operating circuit for the relay R1765 and prepares the circuit for energizing the slow-to-operate relay R1830. The relay R1810, upon operating, prepares, at RA1811, the previously traced operating circuit for the relay R1840; prepares, at RA1813, the operating circuit for the relay R1765; and completes, at RA1812, the circuit for energizing the relay R1800. The relay R1800 in operating prepares, at RA1802, the operating circuit for the relay R1670 and R1705; prepares, at RA1801, the circuit for energizing the upper winding of R1830; and completes, at RA1803, the operating circuit for the slow-acting relay R1820. The relay R1820 operating, opens, at RA1821, the above-traced operating circuit for the relay R1810, thereby to cause the sequential release of the relays R1810, R1800 and R1820 in the order named. The relay R1820 releasing, recompletes, at RA1821, the above-traced operating circuit for the relay R1810, thereby to cause the sequential reoperation of this relay and the relays R1800 and R1820. From the above it will be apparent that the relays R1810, R1800 and R1820 operate in a cyclic manner.

During the portion of each operating cycle of these three relays when the relay R1820 is operated, the previously mentioned circuit is completed for energizing the operating magnet 1685 of the timing switch 1680, this circuit extending from ground by way of RA1834, RA1823, C1668 and the winding of the magnet 1685 to battery. When the indicated wipers are stepped off-normal, the off-normal springs 1687 are moved into engagement to prepare a circuit for energizing the release magnet 1686. When either of the two relays R1800 and R1810 is operated, a holding circuit is completed for the relay R1830, this holding circuit extending from ground by way of RA1834, RA1804 or RA1814 and the lower winding of R1830 to battery. Each time the operating magnet 1685 of the timing switch 1680 is energized over the above-traced circuit, it operates to step the wipers 1683 and 1684 one step. This stepping operation continues until the wipers have been operated into engagement with their respective associated fourth contacts, at which time, a circuit is completed for energizing the relay R1755, this circuit extending from ground at RA1679 by way of the fourth contact of the inner contact set associated with the wiper 1684, the wiper 1684, the fourth contact of the outer contact set associated with this wiper, C1667, RA1744 and the winding of R1755 to battery. When energized over this circuit, the relay R1755 operates, to complete, at RA1756, a path for short-circuiting the winding of the relay R1740, this path extending by way of the grounded conductor C1656, RA1756, the winding of R1740, RA1744, C1667 and the wiper 1684 bridging the fourth contacts of its two associated fourth contacts back to the conductor C1656. At RA1757, the relay R1755 opens the previously traced operating circuit for the relay R1830. Following the operation of the relay R1755 and when the two relays R1810 and R1800 restore, the previously traced holding circuit for the relay R1830 is interrupted at RA1804 and RA1814. Accordingly, the relay R1830 is caused to restore, to open, at RA1832 and RA1833, the operating circuits for the two relays R1810 and R1800. The cyclic operation of the relays R1810, R1800 and R1820 is thus arrested. At RA1834, the relay R1830 completes the previously mentioned circuit for energizing the release magnet 1686, this circuit extending from ground by way of RA1834, C1669, the off-normal springs 1687 and the winding of the release magnet 1686 to battery. When energized over this circuit, the release magnet 1686 operates to release the wipers 1683 and 1684, causing these wipers to be restored to their respective normal positions. In response to this operation the off-normal springs

1687 are disengaged to interrupt the operating circuit for the release magnet 1686. During the release of the timing switch 1680 and when the wiper 1684 is moved out of engagement with its respective associated fourth contacts, the above-traced path short-circuiting the winding of the relay R1740 is interrupted, permitting this relay to be energized in series with the relay R1755 over a circuit extending from ground at RA1679 by way of C1656, RA1756, the winding of R1740 and the winding of R1755 to battery. The relay R1740 in operating opens a further point in the above-traced operating circuit for the relay R1755 and prepares an alternative circuit for energizing the relay R1670. At RA1743, the relay R1740 prepares the previously mentioned path for impressing ground potential upon the wiper 1683 of the timing switch 1680. At RA1741 and RA1742, the relay R1740 interrupts the previously traced operating circuits for the relays R1765 and R1840, causing both of these relays to restore. The relay R1840 in releasing disconnects the conductors of the trunk line 22 from the alternating current source. The relay R1765, upon restoring, reconnects the conductors of the trunk 22 to the line terminals of the repeating coil 1745. Following the release of the two relays R1840 and R1765, no further operation of the relay equipment embodied in the repeater 40 occurs until the connection is cleared out at the operator's position in the distant manual office. In this regard it is pointed out that if the switchhook provided at the calling substation is repeatedly operated between its normal and off-normal positions momentarily to open and recomplete the loop circuit extending through the connector switch 25 to the repeating coil 1745, the resulting response of the line relay R1610 and the slow-acting hold relay R1605 causes the relays R1765, R1830 and R1840 to be released each time the loop circuit is opened and to be reoperated each time the loop circuit is recompleted. These relays releasing arrest the cyclic operation of the three relays R1810, R1800 and R1820 and cause the release of the switch 1680. These relays reoperating reinitiate the cyclic operation of the relays R1810, R1800 and R1820 and operation of the switch 1680. In addition the relay R1605 transfers the control conductor 12_c from a connection to ground at RA1606 to a connection to ground at RA1673. Each time the relay R1840 operates and restores an alternating current pulse is transmitted over the trunk 22 to the trunk circuit 45 but no provisions are made in this circuit for utilizing more than one pulse at this time. Hence no provisions are made whereby the calling subscriber may recall the operator in the distant manual office.

From the foregoing explanation it will be apparent that when the connection is released at the calling end thereof a relatively long pulse of alternating current is transmitted over the trunk line 22 to the trunk circuit apparatus 45. The length of this pulse is measured by the time required for the wipers of the timing switch 1680 to be operated to their respective fourth off-normal positions. The alternating current relay R2000 operates at the beginning of this pulse and remains operated until the pulse is ended. Upon operating, this relay opens, at RA2001, a point in the established talking circuit, thereby to prevent the alternating current from being transmitted over the called end of the established connection. At RA2002, the relay R2000 completes the previously mentioned circuit for energizing the upper winding of R2120, this circuit extending from ground by way of RA2002, RA2023, C2086, RA2109 and the upper winding of R2120 to battery. When its upper winding is energized over this circuit the relay R2120, which is of the two-step type, partially operates to complete, at the "X" contacts associated with RA2124, a path for short-circuiting its lower winding, this path extending from ground at RA2024 by way of C2087, RA2111, RA2124, the lower winding of R2120, RA2109, C2086, RA2023 and RA2002 back to ground. When the pulse is ended, the relay R2000 restores, to open, at RA2002, the short-circuiting path just traced. When this path is interrupted the two windings of R2120 are energized in series over a circuit extending from ground at RA2024 by way of C2087, RA2111, RA2124 and the two windings of R2120 to battery. The relay R2120 now fully operates, to complete, at RA2123, an obvious circuit for energizing the pendulum type relay R2115. At its armatures RA2121 and RA2122, the relay R2120 connects the tip and ring contact springs of the jack 2150 across the source of alternating ringing current provided in the manual office, thereby to cause the operation of a supervisory signal control relay embodied in the operator's cord circuit. The operation of this relay results in the energization or deenergization of an associated signal lamp, thereby to indicate to the operator that the connection is ready to be released. The relay R2115 in operating, also attracts its armature 2116 into engagement with the associated weighted armature 2117. As a result, vibration of the armature 2117 is initiated. Due to the slow-to-operate characteristic of the relay R2110, this relay does not operate until the vibratory movement of the armature 2117 is substantially ended and this armature settles into resting engagement with the armature 2116. A predetermined time interval after the relay R2120 operates, the relay R2110 is caused to operate, to open, at RA2111, the above-traced circuit for energizing the two windings of R2120 in series, causing the last-mentioned relay to restore. The relay R2120 releasing, opens the operating circuit for the relay R2115, thereby to cause the sequential release of this relay and the relay R2110. At its armatures RA2121 and RA2122, the relay R2120 disconnects the tip and ring contacts of the jack 2150 from the alternating current source and reconnects these contacts to the link line conductors C2078 and C2079.

Call Metering

As indicated in the introductory portion of the specification, the arrangement of the switching apparatus is such that the operator in the manual office No. 1 who handles calls routed by way of the trunk line 22 and the other similar trunks, may control the metering devices associated with the calling substations in order to cause the proper charges to be assessed. More particularly, the operator may, by inserting the dial plug 2163 in the meter jack 2154 and operating the calling device 2160, cause any desired number of registrations on the part of a metering device associated with a calling line terminated at the distant automatic exchange No. 1. Operation of the metering device associated with a calling line is initiated by the operator after the disconnect signal is received and before the connection is released. Thus, if the charge to be assessed for the above-described

call originating at the substation A and routed to the operator's position in the manual office No. 1 is such that four registrations on the part of the metering device 365 are required, the operator inserts the dial plug 2163 in the jack 2154 and dials the digit four. Before performing this operation, the operator momentarily operates the metering key 2134 to its off-normal position. When the springs of this key are moved into engagement a circuit is completed for energizing the relays R2040 and R2050 in parallel, this circuit extending from ground through the chain connected armatures of a group of relays and by way of C2080, RA2051, C2081, the springs of the metering key 2134, C2084 and the two windings of R2040 and R2050 in parallel to battery. An obvious branch of this circuit extends through the filament of the lamp 2157 to battery, whereby this lamp is energized. Upon operating, the relay R2050 completes, at RA2052, an obvious holding circuit for itself and the relay R2040. At RA2051, the relay R2050 opens a point in the above-mentioned relay armature chain, whereby the metering keys associated with the other trunk circuits are rendered ineffective to cause operation of the associated meter control relays. At RA2053, the relay R2050 completes a circuit for energizing the pulling relay R2135, this circuit extending from ground by way of the pulsing springs 2161, the tip contact of the plug 2163, the tip contact of the jack 2154, C2088, RA2053, C2089, RA2126 and the windings of R2135 to battery. At RA2054, the relay R2050 prepares a circuit for energizing the relay R1940. At RA2055, the relay R2050 opens a point in the operating circuit for the release magnet 2144. At its armatures RA2056 to RA2061, inclusive, the relay R2050 connects the ten contacts of the contact set 2141 embodied in the minor switch 2140 to the ten contacts of the contact set 2067 embodied in the minor switch 2065.

The relay R2040, upon operating, prepares, at RA2041, an alternative circuit for energizing the relay R1930. At RA2044, the relay R2040 prepares an alternative circuit for energizing the relay R1950. At RA2042 and RA2043, the relay R2040 completes an obvious alternative circuit for energizing the relay R2005 and then opens the operating circuit for the latter relay. At RA2045, the relay R2040 opens a point in the path, traced hereinafter, for short-circuiting the winding of the relay R1970. The relay R2135 operating, opens, at RA2136, a point in the circuit for energizing the operating magnet 2143 of the minor switch 2140.

When the dial of the calling device 2160 is moved off-normal, the shunt springs 2162 are operated into engagement in the usual manner to complete a circuit for energizing the slow-to-release relay R2130, this circuit extending from ground by way of the shunt springs 2162, the sleeve contact of the plug 2163, the sleeve contact of the jack 2154 and the winding of R2130 to battery. When energized over this circuit, the relay R2130 operates, to open, at RA2131, the prepared circuit for energizing the relay R1940. At RA2132, the relay R2130 opens a point in the operating circuit for the relay R2125. At RA2133, the relay R2130 prepares the circuit for energizing the operating magnet 2143. During the return movement of the dial embodied in the calling device 2160, the pulsing springs 2161 are opened and closed a number of times determined by the numerical value of the digit dialed. In the present case when the digit four is dialed, these springs are opened and closed four times. Each time the springs 2161 are opened the previously traced circuit for energizing the relay R2135 is interrupted and this relay restores, to complete, at RA2136, the operating circuit for the magnet 2143. When this wiper is stepped to its first off-normal position, the off-normal springs 2145 are closed to prepare a circuit for energizing the release magnet 2144 and the relay R2125 in parallel, and the off-normal springs 2146 are closed further to prepare the circuit for energizing the relay R1940. Each time the magnet 2143 is energized it operates to step the wiper 2142 one step. Accordingly, at the end of the digit of four impulses, this wiper is left standing in engagement with its associated fourth contact. When the dial of the calling device 2160 is returned to normal at the end of the digit, the shunt springs 2162 are disengaged in the usual manner to open the above-traced circuit for energizing the relay R2130. The relay R2130 restoring, completes, at RA2132, the above-mentioned circuit for energizing the relay R2125. This circuit extends from ground by way of the off-normal springs 2145, RA2132 and the winding of R2125 to battery. At RA2133, the relay R2130 opens the operating circuit for the magnet 2143. At RA2131, the relay R2130 completes the circuit for energizing the relay R1940, this circuit extending from ground by way of the off-normal springs 2146, RA2131, C2090, RA2054, C1990 and the winding of R1940 to battery. The relay R2125, upon operating, opens the operating circuit for the pulsing relay R2135, causing the latter relay to restore and reprepare, at RA2136, the operating circuit for the magnet 2143.

The relay R1940 operating, prepares, at RA1941, the circuit for energizing the relay R1910 and, completes, at RA1942, a circuit extending by way of RA1901 for energizing the relay R1920. At RA1943, the relay R1940 prepares a holding circuit for itself and a circuit for energizing the operating magnet 2070 of the minor switch 2065. At RA1943 and its associated resting contact, the relay R1940 opens a point in the circuit for energizing the release magnet 2071. The relay R1920, upon operating, completes, at RA1922, the operating circuit for the relay R1910. At RA1921, the relay R1920 completes the previously mentioned circuit for energizing the relay R1930, this circuit extending from ground at RA2041 by way of C1983, RA1921 and the winding of R1930 to battery. At RA1923, the relay R1920 completes the above-mentioned operating circuit for the relay R1950, this circuit extending from ground by way of RA2044, C1986, RA1923 and the winding of R1950 to battery. At RA1924, the relay R1920 completes the above-mentioned holding circuit for the relay R1940, this circuit extending from ground by way of RA1943, RA1924 and the winding of R1940 to battery. The relay R1930, upon operating its armatures RA1931 and RA1932, connects the conductors of the trunk line 22 to the source of alternating current provided in the manual office No. 1. At RA1933, the relay R1930 completes an obvious multiple circuit for energizing the relay R1910. The relay R1950, upon operating, disconects the conductors of the trunk line 22 from the line terminals of the repeating coil 2073 for the purpose previously explained. The relay R1910 in operating, completes the circuit for energizing the slow-to-release relay R1900 and completes the operating circuit for the relay R1970. At RA1913, the relay R1910

completes an obvious multiple holding circuit for the relay R1940. The relay R1900, upon operating, opens, at RA1901, the above-traced operating circuit for the relay R1920, thereby to cause the sequential release of the relays R1920, R1910 and R1900 in the order named. At RA1902, the relay R1900 opens a point in the circuit for energizing the relay R1960. When the relay R1900 restores it functions to recomplete, at RA1901, the operating circuit for the relay R1920, thereby to cause the sequential reoperation of the three relays R1920, R1910 and R1900. Thus, the three indicated relays operate in a cyclic manner, alternately operating and then restoring. During the portion of each cycle of operation thereof when the relay R1900 is operated, a circuit is completed for energizing the operating magnet 2070 of the minor switch 2065, this circuit extending from ground by way of RA1943, RA1903, C1995 and the winding of the magnet 2070 to battery. Each time the magnet 2070 is energized over this circuit, it operates to step the wipers 2068 and 2069 one step. When these wipers are moved to their respective first off-normal positions, the off-normal springs 2072 are moved into engagement to prepare the above-mentioned circuit for energizing the release magnet 2071. Each time the relay R1920 restores it interrupts, at RA1921, the operating circuit for the relay R1930 and, at RA1923, the operating circuit for the relay R1950. Accordingly, the two relays R1930 and R1950 are caused to restore during the period of each operating cycle of the three relays R1900, R1910 and R1920 when the relay R1920 is restored. The two relays R1930 and R1950 are obviously caused to reoperate in response to each reoperation of the relay R1920. Thus, it will be apparent that the relay R1930 operates to cause an alternating current pulse to be transmitted over the trunk line 22 to the repeater 45 during each cycle of operation of the three relays R1900, R1910 and R1920.

The cyclic operation of these three relays and the alternate operation and restoration of the two relays R1930 and R1950 continue until the wipers 2068 and 2069 have been stepped to the position corresponding to the position occupied by the wiper 2142 of the minor switch 2140. In the case under consideration, the wiper 2142 occupies its fourth off-normal position. Accordingly, the wipers 2068 and 2069 are operated four steps, at which time, a circuit is completed for energizing the relay R2015, this circuit extending from ground by way of the wiper 2142 and its assoelated fourth contact, C2096, RA2059, the wiper 2069 and the winding of R2015 to battery. It will be understood from the foregoing explanation that had the operator dialed a metering digit of five impulses, for example, to position the wiper 2142 in engagement with its associated fifth contact, five steps on the part of the wipers of the minor switch 2065 would be required to complete the operating circuit for the relay R2015. In the latter case, the circuit for energizing the relay R2015 extends from ground by way of the wiper 2142 and its associated fifth contact, C2097, RA2060, the wiper 2069 and the winding of R2015 to battery. When energized over any one of the ten available circuits the relay R2015 operates to interrupt, at RA2016, the previously traced holding circuit for the relays R2050 and R2040, thus causing these two relays to restore in the order named. The relay R2050, upon restoring, reprepares, at RA2051, the previously traced operating circuit for the two relays R2050 and R2040. At RA2052, the relay R2050 opens another point in the circuit for energizing itself in parallel with the relay R2040 and the signal lamp 2157. At RA2053, the relay R2050 opens another point in the operating circuit for the pulsing relay R2135. At RA2054, the relay R2050 interrupts the operating circuit for the relay R1940. At its armatures RA2056 to RA2061, inclusive, the relay R2050 disconnects the ten contacts of the contact set 2141 from the ten contacts of the contact set 2067 and in so doing interrupts the previously traced operating circuit for the relay R2015. At RA2055, the relay R2050 completes the operating circuit for the release magnet 2144, this circuit extending from ground by way of the off-normal springs 2145, C2091, RA2055, C2092 and the winding of the magnet 2144 to battery. When energized over this circuit, the magnet 2144 operates to cause the wiper 2142 to be returned to its normal position in the usual manner, at which time the off-normal springs 2145 are disengaged to interrupt the operating circuit for the release magnet 2144. The off-normal springs 2146 are also disengaged to open another point in the operating circuit for the relay R1940. When the off-normal springs 2145 are disengaged the operating circuit for the relay R2125 is interrupted, causing this relay to restore and reprepare, at RA2126, the operating circuit for the pulsing relay R2135. The relay R2040, upon restoring, opens, at RA2041, the above-traced operating circuit for the relay R1930, causing the last-mentioned relay to restore. At RA2044, the relay R2040 opens the previously traced operating circuit for the relay R1950, causing the last-mentioned relay to restore. At RA2043 and its associated resting contact, the relay R2040 recompletes the initially traced operating circuit for the relay R2005. After this circuit has been recompleted, the relay R2040, opens, at RA2042 and RA2043, the above-traced alternative circuit for energizing the relay R2005.

After the operating circuit for the relay R1940 is interrupted, this relay is deenergized and restores during the portion of the next operating cycle of the three relays R1900, R1910 and R1920 when the relays R1910 and R1920 are restored. The relay R1940 in releasing, opens, at RA1941, the operating circuit for the relay R1910. At RA1942, the relay R1940 opens the operating circuit for the relay R1920. Thus, the cyclic operation of the three indicated relays is arrested. With the relay R1920 in its restored position the operating circuit for the relay R1930 is held open at RA1921. Similarly, the operating circuit for the relay R1950 is held open at RA1923. Accordingly, the two relays R1930 and R1950 are prevented from reoperating after the wipers of the minor switch 2065 have been operated to the position corresponding to the numerical value of the metering digit dialed by the operator. Thus, it will be apparent that the number of alternating current pulses transmitted over the trunk line 22 to the repeater 40 in the manner just explained is determined by the numerical value of the particular metering digit dialed by the operator.

The relay R1940, upon restoring, also functions to complete, at RA1943, the above-mentioned circuit for energizing the release magnet 2071, this circuit extending from ground by way of RA 1943, C1997, the off-normal springs 2072 and the winding of the release magnet 2071 to

battery. When energized over this circuit, the release magnet 2071 operates to release the wipers 2068 and 2069, permitting these wipers to be returned to normal in the usual manner. When the indicated wipers are restored to normal, the off-normal springs 2072 are disengaged to open the operating circuit for the release magnet 2071. Following the release of the minor switch 2065, the trunk circuit apparatus 45, illustrated in Figs. 19, 20 and 21, is in the condition which prevailed before the metering digit was dialed. In this regard it will be apparent from the foregoing explanation that the operator may dial a plurality of metering digits if more than ten meter registrations are required in order to assess the proper charge against the calling subscriber. The manner in which the trunk circuit apparatus 45 operates when each additional metering digit is dialed is exactly the same as set forth above.

The control apparatus of the repeater 45 responds to each alternating current pulse transmitted thereto over the trunk line 22 by operating to impress a pulse of booster battery potential upon the metering conductor 12_d of the trunk line 12. More particularly, the relay R1760 operates at the beginning of each pulse and restores at the end of each pulse. Upon operating at the beginning of the first alternating current pulse, the relay R1760, completes, at RA1762, the previously traced circuit for energizing the lower winding of R1830. The relay R1830 operating, initiates the cyclic operation of the three relays R1800, R1810 and R1820 in the manner previously explained. Each pulse of alternating current transmitted over the trunk line 22 to the alternating current relay R1760 is sufficiently long to enable the relays R1800, R1810 and R1820 to complete one cycle of operation. With the relay R1830 operated, the previously traced operating circuit for the magnet 1685 is completed each time the relay R1820 operates, that is, each time a pulse of alternating current is transmitted over the trunk line 22 to the repeater 45. Shortly following the operation of the relay R1820 to cause the wipers of the switch 1680 to be stepped one step the alternating current pulse is ended and the relay R1760 restores to complete a circuit for energizing the slow-acting metering relay R1600. This circuit extends from ground by way of RA1762, RA1751, RA1707, RA1743, C1635, RA1872, C1688, the wiper 1683, the first contact of the set 1681 and the winding of R1600 to battery. Upon restoring, the relay R1760 also interrupts, at RA1762, the previously traced operating circuit for the relay R1830. Thereafter and when the two relays R1810 and R1800 sequentially restore in response to operation of the relay R1820, the holding circuit for the relay R1830 is interrupted in the manner previously explained. Accordingly, the relay R1810 restores to open the respective operating circuits for the two relays R1810 and R1800. Thus, all four of the relays R1800, R1810, R1820 and R1830 are caused to restore during the interval between the first and second alternating current pulses. The relay R1830, upon restoring, also completes, at RA1834, the previously traced operating circuit for the release magnet 1686, whereby this magnet is caused to operate to return the wipers 1683 and 1684 to normal. In response to this operation the off-normal springs 1687 are opened to interrupt the operating circuit for the release magnet. Thus, the timing switch 1680 is normalized during the interval which elapses between the first and second alternating current pulses transmitted to the repeater 45. When the wiper 1683 of the switch 1680 is returned to normal, the previously traced operating circuit for the metering relay R1600 is interrupted. The manner in which the relays R1760, R1830, R1810, R1800 and R1820, the minor switch 1680, and the metering relay R1600 operate during each succeeding alternating current pulse transmitted to the repeater 45 is exactly the same as set forth above. Obviously, at the end of the last alternating current pulse transmitted to the repeater 40 all of the enumerated circuit elements are normalized in the manner explained above.

Each time the metering relay R1600 operates it functions to complete a circuit for energizing the metering device 365 associated with the calling substation A. This circuit extends from ground at RA1673 by way of RA1606, the control conductor 12_c, the wiper 683, C676, RA658, RA658', C488, the winding of the device 365, C305, C372, RA408', C477', RA654, C675, the wiper 682, the metering control lead 12_d, RA1601 and the resistor 1602 to the source of booster battery potential. Obviously, this circuit is interrupted each time the relay R1600 is caused to restore. Accordingly, a number of current pulses are transmitted to the metering device 365, this device operating to make one registration in response to each received current pulse. In the present case wherein the metering relay R1600 is caused to operate and restore four times, four current pulses are transmitted to the metering device 365 so that this device is caused to make four registrations.

Release of Connection

In order to release the connection, the operator withdraws the plug terminating one end of her cord circuit from the jack 2150. In response to this operation the jack springs 2151 and 2152 are disengaged to interrupt the previously traced operating circuit for the relay R2005. The relay R2005 releasing, opens, at RA2006, the operating circuit for the slow-to-release relay R2020. At RA2006 and its associated resting contact, the relay R2005 completes a circuit extending by way of C1982 and RA1971 for energizing the relay R1930. At RA2007, the relay R2005 completes a circuit extending by way of C1985 and RA1973 for energizing the relay R1950. The relay R1950, upon operating, disconnects the conductors of the trunk line 22 from the line terminals of the repeating coil 2073. The relay R1930, upon operating, connects the conductors of the trunk line 22 to the alternating current source provided in the manual office No. 1. At RA1933, the relay R1930 prepares the operating circuit for the slow-to-operate relay R1910. At RA2021, the relay R2020 in releasing, opens a point in the prepared circuit for energizing the supervisory lamp 2165 and reprepares the circuit for energizing the signal lamp 2155. At RA2022, the relay R2020 opens a point in the previously traced operating circuit for the relay R1970. At RA2023, the relay R2020 opens a point in the previously traced operating circuit for the relays R2105 and R2120 and reprepares the operating circuit for the relay R2030. At RA2024, the relay R2020 opens the multiple circuit for energizing the relay R2105 and the busy signal lamp 2158 in parallel. At RA2024 and its associated resting contact, the relay R2020 completes a circuit extending by way of C1989 and RA1976 for energizing the relay R1940.

Upon operating, the relay R1940 again initiates the cyclic operation of the three relays R1920,

R1910 and R1900 in the manner previously explained. During each cycle of operation of these relays the operating magnet 2070 of the minor switch 2065 is completed and then interrupted. Accordingly, the wipers 2068 and 2069 of the switch 2065 are stepped one step during each cycle of operation of the three indicated relays. When these are stepped off-normal, the off-normal springs 2072 are moved into engagement to prepare the operating circuit for the release magnet 2071. Thereafter and when the wiper 2068 is moved into engagement with its associated fifth contacts, a path is completed for short-circuiting the winding of the relay R1970, this path extending from the upper terminal of R1970 by way of C1991, RA2045, the wiper 2068 and C1996 to the lower terminal of R1970. When this path is completed, the relay R1970 restores, to interrupt its holding circuit at RA1978. At RA1971, the relay R1970 opens the above-traced operating circuit for the relay R1930. At RA1972, the relay R1970 reprepares the holding circuit for the relay R2030. At RA1973, the relay R1970 interrupts the above-traced operating circuit for the relay R1950. At RA1974, the relay R1970 reprepares one of the operating circuits for the relay R1920. At RA1975, the relay R1970 interrupts the circuit for energizing the relay R2105 and the busy signal lamp 2158 in parallel. At RA1976, the relay R1970 interrupts the above-traced operating circuit for the relay R1940. When the relays R1920, R1910 and R1900 restore following the release of the relay R1970, the above-traced holding circuit for the relay R1940 is interrupted at RA1913 and RA1924. Accordingly, the relay R1940 restores and the four relays R1900, R1910, R1920 and R1940, remain in their respective restored positions. The relay R1930 in releasing, disconnects the alternating current source from the conductors of the trunk line 22, thereby to terminate the pulse of alternating current being transmitted over this trunk line. The relay R1950, upon restoring, reconnects the conductors of the trunk line 22 to the line terminals of the repeating coil 2073. The relay R1940 in restoring, completes, at RA1943, the previously traced operating circuit for the release magnet 2071, whereby the wipers 2068 and 2069 are returned to normal and the off-normal springs 2072 are disengaged to deenergize the release magnet. The relay R2105, upon restoring, further opens, at RA2108, its holding circuit and reprepares its operating circuit at RA2109. At RA2106 and RA2107, the relay R2105 reprepares the circuits for energizing the signal lamps 2155 and 2156, respectively. Following the release of the minor switch 2065, the trunk circuit apparatus 45, illustrated in Figs. 19, 20 and 21, is fully restored to normal. From the foregoing explanation it will be apparent that during the release of the trunk circuit apparatus 45, a relatively long alternating current release pulse is transmitted over the trunk line 22 to the repeater 40 illustrated in Figs. 16, 17 and 18. The length of this pulse is measured by the time interval required for the wipers of the minor switch 2065 to be operated to their respective fifth off-normal positions.

The relay R1760 operates at the beginning of the alternating current release pulse and remains operated until the pulse is ended. Upon operating, this relay, completes, at RA1762, the previously traced circuit for energizing the lower winding of the relay R1830. The relay R1830, upon operating, initiates the cyclic operation of the three relays R1810, R1800 and R1820 in the exact manner previously explained. During each cycle of operation of these relays, the previously traced holding circuit is completed for the relay R1830 and the previously traced circuit is completed for energizing the operating magnet 1685 of the timing switch 1680. Accordingly, the wipers 1683 and 1684 are operated one step during each cycle of operation of the three enumerated relays. When these wipers are moved off-normal, the off-normal springs 1687 are moved into engagement to prepare the circuit for energizing the release magnet 1686. Thereafter and when the wiper 1684 is stepped into engagement with its associated fourth contacts a path is completed for short-circuiting the upper winding of the relay R1670, this path extending from ground at RA1726 by way of C1626, RA1675, the upper winding of R1670, C1664, RA1744, C1667, the wiper 1684 and RA1679 back to ground. When its upper winding is short-circuited over this path, the relay R1670 restores. Upon restoring, this relay, opens, at RA1671 and RA1672, the connection between the line conductors of the trunk line 12 and the line terminals of the repeating coil 1745. At RA1673, the relay R1670 disconnects the control conductor 12_c of the trunk line 12 from ground, thereby to initiate the release of the connector switch 25 and the finder switch 20 in the manner explained subsequently. At RA1674, the relay R1670 opens the above-traced operating circuit for the relay R1830. At RA1675, the relay R1670 interrupts the holding circuit for itself and the relay R1705, causing the last-mentioned relay to restore. At RA1679, the relay R1670 interrupts the circuit serially including the windings of R1740 and R1755, causing these two relays to restore. The relay R1705, upon restoring, opens, at RA1708, the holding circuit for the relay R1640, causing the last-mentioned relay to restore.

Following the release of the relay R1670 and when the two relays R1810 and R1800 restore to open the previously traced holding circuit for the relay R1830, the latter relay restores to open the respective operating circuits for the relays R1810 and R1800, whereby the cyclic operation of the three relays R1800, R1810 and R1820 is terminated. The relay R1830 in releasing, also completes, at RA1834, the previously traced circuit for energizing the release magnet 1686, whereby the wipers 1683 and 1684 are restored to their respective normal positions. When these wipers are restored to normal, the off-normal springs 1687 are disengaged to interrupt the circuit for energizing the release magnet 1686. Following the release of the timing switch 1680, all of the control equipment embodied in the repeater 40 is fully released and this repeater is conditioned for further use.

When ground potential is removed from the control conductor 12_c of the trunk line 12, the control conductor C488 is also disconnected from ground, and the relays R400' and R650, embodied in the local connector switch 25, are deenergized and restore. When ground potential is removed from the control conductor C488, the finder switch 20 and the line circuit 10_a are caused to release in the manner previously explained in Section I. The relay R400', upon restoring, opens, at RA407', the previously traced holding circuit for the relay R400, causing the latter relay to restore. At RA403', the relay R400' completes the previously traced circuit for energizing the release magnet 406, whereby the wipers 680

to 684, inclusive, are restored to rotary and vertical normal in the usual manner. When these wipers are returned to normal, the off-normal springs 407 are opened to interrupt the circuit for energizing the release magnet 406. Further, the normal post springs 609 are disengaged and the off-normal springs 558 and 517' are respectively operated into engagement. Following the release of the connector switch 25, all of the apparatus utilized in setting up the connection between the substation A and the operator's position in the manual office No. 1 is fully released.

ALL TRUNKS BUSY—CALL STORAGE

As indicated previously, the arrangement of the system is such that if the trunk call originating at the substation A and intended for the operator's position in the manual office No. 1 is initiated at a time when all of the group of trunk lines interconnecting the manual office No. 1 and the automatic exchange No. 1 are busy, the call is automatically routed to the call storage circuit 35, illustrated in Fig. 11, where it may be stored until one of the indicated group of trunk lines is released. Under such conditions, the wipers 680 to 684, inclusive, of the local connector switch 25 continues to rotate until all of the selected group of trunk lines have been tested, following which they are moved into engagement with the contacts terminating the conductors of the trunk line 28 incoming to the call storage circuit. Assuming that this circuit is idle, the trunk line 28 is marked as idle, and the local connector switch 25 operates to extend the calling loop circuit to the storage circuit and to arrest the rotary movement of its wipers in the manner previously explained. In response to the switching through operation just described, the line relay R1130 is energized over the calling loop circuit, one side of which may be traced as including the conductor C468, the wiper 680, the conductor 28_a, RA1114, the winding 1146 and the upper winding of R1130 to battery, and the other side of which extends by way of C470, the wiper 681, the conductor 28_b, RA1116, the winding 1147 and the lower winding of R1130 to ground. When energized over this circuit, the relay R1130 operates to complete, at RA1132, an obvious circuit for energizing the slow-acting relay R1138. At RA1131, the relay R1130 completes a circuit for energizing the slow-to-release all-trunks-busy relay R1165, this circuit extending through the operated chain conected contacts controlled by the relay R1603, and the other similar relays individual to the repeaters respectively associated with the trunk lines of the selected group, and by way of the all-trunks-busy conductor C1176, RA1131 and the winding of R1165 to battery. The relay R1165, upon operating, opens, at RA1166, a point in the circuit for energizing the operating magnet 1189 of the trunk selecting switch 1180. At RA1167, the relay R1165 opens a point in the circuit over which the test relay R1170 is energized in response to operation of the switch 1180 to select an idle one of the trunk lines of the associated group. The relay R1138, upon operating, opens, at RA1139, a point in the operating circuit for the relay R1110 and prepares a circuit for energizing the relay R1100. At RA1139', the relay R1138 completes an obvious circuit for energizing the slow-acting hold relay R1120. The relay R1120, upon operating, prepares, at RA1121 the operating circuit for the magnet 1189, and prepares, at RA1122, an operating circuit for the relay R1150. At RA1123, the relay R1120 connects the control conductor 28_c of the trunk line 28 to ground, thereby to complete the previously traced holding circuits for the relays R400' and R650 of the local connector switch 25. The connector switch 25 and the preceding finder switch 20 are thus prevented from releasing. At RA1123, the relay R1120 also completes an obvious circuit for energizing the polarizing winding of the electro polarized back-bridge relay R1140. At RA1124, the relay R1120 prepares a holding circuit for the ring cut-off relay R1100. At RA1126, the relay R1120 opens a point in the circuit, traced hereinafter, for impressing across the conductors of a selected trunk line accessible to the switch 1180 a signal voltage identifying the call as one which has been stored in the call storage circuit 35. At RA1125, the relay R1120 completes a circuit for transmitting over the calling end of the connection a tick-tone signal current which indicates to the calling subscriber that the call has been routed to the call storage circuit. The path traversed by this signal current may partially be traced as extending from the one terminal of the signal current source, not shown, by way of RA1173, the condenser 1177, RA1125, RA1115 and RA1116 to the line conductor 28_b. From this point the signal current is transmitted over one side of the established loop circuit and through the receiver provided at the calling substation to a ground return path. The resulting operation of the receiver serves to inform the calling subscriber that the desired connection to the operator's position in the manual office No. 1 cannot immediately be obtained. The character of the signal is such that the subscriber is also informed that if the connection is released, the call will automatically be forwarded to the operator's position when an idle trunk becomes available and the substation in use will be resignaled when the forwarded call is answered. If, upon receiving this information as indicated by the character of the reproduced signal, the subscriber desires to have the call forwarded to the operator's position in the manual office No. 1, he will simply restore his receiver to its supporting hook to open the calling loop circuit and await the recall operation just mentioned.

When the established loop circuit extending to the call storage circuit 35 is interrupted at the calling substation, the line relay R1130 is de-energized and restores. Upon restoring, this relay, at RA1132 and its associated working contact, opens the operating circuit for the relay R1138. At RA1132 and its associated resting contact, the relay R1130 completes the above-mentioned circuit for energizing the relay R1150, this circuit extending from ground by way of RA1132, RA1122, RA1152 and the upper winding of R1150 to battery. When its upper winding is energized over this circuit, the relay R1150 partially operates to complete, at the "X" contacts associated with RA1154, a path extending from ground at RA1113 for short-circuiting its lower winding. At the "X" contacts associated with RA1153, the relay R1150 completes an obvious multiple path for impressing ground potential upon the control conductor 28_c of the trunk line 28. The relay R1138, upon restoring, opens the operating circuit for the hold R1120. The relay R1120 releasing, opens, at RA1125, the above-traced path traversed by the tick-tone signal current and opens, at RA1123 the initially completed path for impressing ground potential upon the control conductor 28_c. At RA1122, the relay

R1120 opens the path short-circuiting the lower winding of R1150, permitting the two windings of the last-mentioned relay to be energized in series. In response to this operation, the relay R1150 fully operates to prepare, at RA1151, a multiple circuit for energizing the operating magnet 1189, and further to open, at RA1152 its own operating circuit. At RA1151', the relay R1150 completes an obvious alternative circuit in shunt with the restored armature RA1131 for holding the slow-to-release all-trunks-busy relay R1165 energized. At RA1152 and its associated working contact, the relay R1150 prepares one of the circuits for energizing the line switching relay R1110. Finally, at RA1155, the relay R1150 prepares a loop circuit which, when ultimately established, extends by way of the trunk line incoming to one of the repeaters selected by the switch 1180. Following the relay operations just described, no further operation of the call storage circuit 35 occurs until one of the trunk lines of the associated group is released.

In the event the calling subscriber does not wish to hold the connection until one of the interoffice trunk lines extending to the operator's position in the manual office No. 1 becomes idle, he may cause the operated switch train and the call storage circuit 35 to be released by performing an additional switch release operation at the calling substation. More particularly, if the switchhook provided at the substation A is operated to reclose and then reopen the calling loop circuit after the call has been stored in the manner just described, the operated switch train and the call storage circuit are caused to be released. In response to the reclosing of the calling loop circuit, the three relays R1130, R1138 and R1120 are caused sequentially to reoperate in the order named and in the manner pointed out above. The reoperation of the enumerated relays is without effect aside from the recompletion of the above-traced signal current path. When, however, the calling loop circuit is interrupted, the second time, the line relay R1130 restores to complete, at RA1132 and its associated resting contact, the above mentioned circuit for energizing the relay R1110, this circuit extending from ground by way of RA1132, RA1122, RA1152 and its associated working contact, and the winding of R1110 to battery. When energized over this circuit the relay R1110 operates to complete, at RA1111, an obvious holding circuit for itself. At RA1112, the relay R1110 completes the operating circuit for the slow-to-release relay R1135, but the resulting operation of the latter relay is without effect at this time. Shortly following the release of the line relay R1130, the two relays R1138 and R1120 sequentially restore in the manner pointed out above, the last-mentioned thereof functioning to open, at RA1122, a point in the common portion of the operating circuits for the relays R1110 and R1150. The relay R1110, upon operating in the manner explained above, opens, at RA1113, the above-traced holding circuit for the relay R1150, causing the last-mentioned relay to restore. The relay R1150 releasing disconnects the control conductor 28_c from ground, thereby to deenergize the relay R1110, the relay R1135 and the polarizing winding of the relay R1140. At RA1151', the relay R1150 opens the operating circuit for the relay R1165. When ground potential is removed from the control conductor 28_c, the connector switch 25, the finder switch 20 and the line circuit 10_a are released in the exact manner previously explained. When the relays R1110, R1165 and R1135 restore in response to the release of the relay R1150, all of the relays embodied in the call storage circuit 35 are fully released. Thus, this circuit is conditioned for further use.

Assuming that the calling subscriber at the substation A desires to avail himself of the call storage and call forwarding facilities incorporated in the system through the provision of the call storage circuit 35, he hangs up his receiver and waits until the substation A is recalled. Under such circumstances, the two relays R1150 and R1165 of the call storage circuit remain operated, the last mentioned relay only being released when one of the trunk lines of the associated group becomes idle. More particularly, when one of the trunk lines is released, the chain circuit over which the relay R1165 is being held energized is interrupted. The relay R1165 restores, after an interval, to complete the above-mentioned circuit for energizing the magnet 1189, this circuit extending from ground by way of RA1151, RA1166, RA1171, the armature 1190 and the winding of the magnet 1189 to battery. Due to the circuit interrupting action of the contact springs associated with the armature 1190, the magnet 1189 operates buzzer fashion to drive the wipers 1185 to 1188, inclusive, over the contacts of their respective associated contact sets until they are positioned on the set of contacts terminating the conductors of the idle trunk line. Assuming, for example, that the trunk line 12 extending to the repeater 40 is the trunk line which has been released, the wipers of the switch 1180 are operated step by step until this trunk line is selected. More particularly, when the wiper 1186 is moved into engagement with the contact terminating the conductor 12_c, the previously mentioned circuit is completed for energizing the test relay R1170, this circuit extending from ground at RA1153 by way of RA1167, the upper winding of R1170, the wiper 1186, the conductor 12_c, and the winding of R1603 to battery. When energized over this circuit, the relay R1170 operates to open at the "X" contacts associated with RA1171, the above-traced circuit for energizing the magnet 1189, thereby to arrest the stepping operation of the switch 1180. At RA1171 and its associated working contact, the relay R1170 completes a circuit for energizing its lower winding, this circuit extending from ground at RA1153 by way of the lower winding of R1170, RA1171, the armature 1190 and the winding of the magnet 1189 to battery. Due to the relatively high resistance of the lower winding of the relay R1170, the magnet 1189 does not operate when energized over the circuit just traced. After performing the circuit operations just described, the relay R1170 completes, at RA1172, a path, including the restored armature RA1167, for short-circuiting its upper winding, thereby to render itself slow to release. At RA1172, the relay R1170 also excludes its lower winding from the above-traced circuit extending through the winding of the relay R1603 embodied in the repeater 40. As a result the relay R1603 operates to prepare or complete, at RA1604, the previously traced chain circuit for energizing the all-trunks-busy relay R1165. After the relay R1170 has operated operation of the all-trunks-busy relay R1165 is without effect.

The relay R1170, upon fully operating, also completes, at RA1174 and RA1175, a loop circuit which extends from the repeating coil 1145 over the conductors of the selected trunk line 12 to

the repeater 40 at which this trunk line terminates. More particularly, this loop circuit extends from ground by way of the upper winding of R1610, the upper winding of R1630, RA1641, RA1651, the line conductor 12a, the wiper 1187, RA1174, the winding 1148, RA1155, the resistor 1179, the upper winding of R1140, the winding 1149, RA1175, the wiper 1188, the line conductor 12b, RA1652, RA1642, the lower winding of R1630 and the lower winding of R1610 to battery. The direction of current flow over this loop circuit is such that the polarized relay R1140 does not operate at this time. The line relay R1610 embodied in the repeater 40 operates in response to completion of the loop circuit just traced, thereby to initiate the operation of the repeater 40 to transmit an incoming call signal to the operator's position in the distant manual office No. 1, all in the manner explained previously in this section of the specification.

When the call is answered at the operator's position in the distant manual office No. 1, the control apparatus of the trunk circuit 45 cooperates with the control apparatus of the repeater 40 to reverse the direction of current flow over the established loop circuit extending from the repeater 40 and including the operating winding of the polarized back bridge relay 1140. In response to this current reversal, the relay R1140 operates to complete the operating circuit for the slow-to-release relay R1160, this circuit extending from ground by way of RA1153, RA1141, RA1124' and the winding of R1160 to battery. The relay R1160 now operates to complete a circuit for energizing the line switching relay R1110, this circuit extending from ground by way of RA1161, RA1139 and the winding of R1110 to battery. At RA1162', the relay R1160 completes an obvious shunt across the contact springs controlled by the operated armature RA1155, whereby the established loop circuit to the repeater 40 is not interrupted when the relay R1150 subsequently releases. The relay R1110 operating, completes at RA1111, its holding circuit and in so doing completes a holding circuit for the relay R1160, this latter holding circuit extending from ground by way of RA1161, RA1139 RA1111, RA1141, RA1124', and the winding of R1160 to battery. Obviously, ground potential is impressed upon the control conductor 28c over a portion of the circuit just traced. At RA1113, the relay R1110 opens the previously traced holding circuit for the relay R1150. The relay R1150 releasing opens further points in its operating and holding circuits and disconnects multiple ground from the control conductor 28c. At RA1155, the relay R1150 opens a point in the initially completed loop circuit extending to the repeater 40.

The relay R1110, in operating, also completes a circuit for projecting ringing current back over the calling line 10 to energize the signal device or ringer provided at the calling substation A. The path traversed by this current extends from the lower terminal of the ringing current source 555 by way of RA1137', the interrupter springs 556, RA1103, RA1116, the conductor 28b, one side of the loop extending to the substation A, the windings of the ringer provided at this substation, the other side of the loop extending to the substation A, the conductor 28a, RA1114, RA1102, the lower winding of R1100 and the exchange battery to the grounded terminal of the ringing current source 555. Signal voltage is also impressed upon the loop circuit extending to the repeater 40 over a path which includes the condenser 1105', RA1104, RA1117, RA1126, the repeater winding 1149, RA1175 and the trunk line conductor 12b. A portion of the current traversing this path is transmitted through the repeater 40 and the trunk circuit apparatus 45 to the subset in use at the operator's position in the manual office No. 1. Reproduction of this signal current serves to inform the operator handling the call that the call has been stored and that the calling subscriber's substation is being signaled.

Assuming that the call is answered at the calling substation A, a direct current loop circuit including the lower winding of the ring cut-off relay R1100 is completed. The relay R1100 now operates to complete, at RA1101 a holding circuit for itself, this holding circuit extending from ground at RA1161 by way of RA1139, RA1111, RA1141, RA1124', RA1162, RA1137, RA1101 and the upper winding of R1100 to battery. Following the completion of this circuit the relay R1100 completes, at RA1101', multiple holding circuits for itself, the relay R1110, and the relay R1160. At RA1101', the relay R1100 also completes an obvious multiple path for maintaining ground potential upon the control conductor 28c. At RA1104, the relay 1100 opens the above-traced path for transmitting signal current to the subset in use at the operator's position in the manual office No. 1. At RA1102 and RA1103 and their respective associated resting contacts, the relay R1100 opens two points in the above-traced ringing current circuit and in so doing opens two points in its own operating circuit. At these same armatures and their respective associated working contacts, the relay R1100 extends the calling loop circuit to the line terminals of the repeating coil 1145. The relay R1130 now operates to cause the sequential operation of the two relays R1138 and R1120 in the manner previously explained. The relay R1138 operating, opens the operating circuit for the relay R1110 and completes an obvious multiple holding circuit for the relay R1100. The relay R1120 operating, completes, at RA1124, another multiple holding circuit for the relay R1100; reprepares, at RA1122, the operating circuit for the relay R1150; connects the control conductor 28c to ground at RA1123; completes, at RA1126, an obvious path shunting the operated armature RA1162', thereby to hold the loop circuit extending to the repeater 40 completed following the release of the relay R1160; and opens, at RA1124', the operating circuit for the relay R1160. The relay R1160 now restores to open, at RA1162', the path shunting the operated armature RA1126; to open, at RA1162, a point in the initially completed holding circuit for the relay R1100; and to open, at RA1161, a further point in the operating circuit for the relay R1110. Following the relay operations just described, the desired talking circuit between the substation A and the operator's position in the manual office No. 1 is fully established. In this regard it will be noted that current for energizing the transmitter provided at the calling substation A is supplied over the calling loop circuit through the windings of the line relay R1130. The connection as thus routed to the operator's position in the manual office No. 1 may be extended to the desired substation in the usual manner.

The release of the connection is entirely under the control of the operator handling the call in this manual office, the arrangement of the call

storage circuit 35 being such that a disconnect signal is transmitted to the operator when the connection is released at the calling end thereof. More particularly, when the connection is released at the substation A, the calling loop circuit is interrupted to cause the deenergization and restoration of the line relay R1130. The relay R1130 releasing recompletes the operating circuit for the relay R1150, causing the latter relay partially to operate to close only the "X" contacts associated with RA1153 and RA1154. At this time, the relay R1110 is operated so that no holding circuit is provided for the relay R1150. At RA1131, the relay R1130 opens the operating circuit for the all-trunks-busy relay R1165, causing the latter relay to restore. At RA1132, the relay R1130 also opens the operating circuit for the relay R1138, thereby to cause the sequential release of the two relays R1138 and R1120. The relay R1138 releasing, reprepares the operating circuit for the relay R1110 and opens one of the holding circuits for the relay R1100. The relay R1120 releasing, opens, at RA1124, the only established holding circuit for the relay R1100; disconnects the control conductor 28c from the ground at RA1123; opens, at RA1122, the operating circuit for the relay R1150, causing the latter relay to restore; recompletes, at RA1124', the operating circuit for the slow-acting relay R1160 and opens, at RA1126, the loop circuit extending from the call storage circuit 35 to the repeater 40. When this loop circuit is opened, the lower winding of the relay R1140 is deenergized and this relay immediately restores to open, at RA1141, the operating circuit for the relay R1160, thereby to prevent the reoperation of the latter relay. At RA1141 and its associated resting contact, the relay R1140, in releasing, completes the operating circuit for the relay R1135. The relay R1100 releasing opens, at RA1101', another of the holding circuits for the relay R1110. At RA1101, the relay R1100 opens a further point in its own holding circuit. The relay R1135 in operating, opens, at RA1137, a further point in the initially completed holding circuit for the relay R1100, and interrupts, at RA1137', the previously traced circuit for projecting ringing current over the calling end of the established connection.

Since the repeater 40 is still operated, ground potential is held on the control conductor 12c over the previously traced path extending from ground at RA1763. Accordingly, the relays R1110 and R1170 are held energized over circuits including the grounded conductor 12c, and ground potential is maintained upon the control conductor 28c to hold the connector switch 25, the finder switch 20 and the line circuit 10a operated. With the relay R1110 operated, the slow-to-release relay R1135 is also held energized. Thus, the three relays R1110, R1135 and R1170 are held operated pending the release of the connection under the control of the operator handling the call in the manual office No. 1. It will be observed that with the apparatus in this condition, the extra control lead 12d extending from the repeater 40 is connected by way of the wiper 1185, the conductor 28d and the wiper 682 to the conductor C675. Thus, a circuit is prepared whereby booster battery meter control pulses may be transmitted under the control of the operator in the manual office No. 1 to the metering device 365 associated with the calling line 10. The manner in which this metering device is operated to make the proper number of registrations is exactly the same as previously explained.

When the connection is cleared out at the operator's position in the manual office No. 1, the trunk circuit apparatus 45 and the repeater 40 are released in the manner previously described. During the release of the repeater 40, ground potential is removed from the control conductor 12c. Accordingly, the relays R1110, R1135 and R1170 embodied in the call storage circuit 35 are deenergized and restore. Following the release of these three relays, the call storage circuit 35 is fully restored to normal. Ground potential is removed from the control conductor 28c when the conductor 12c is disconnected from ground. The connector switch 25, the finder switch 20 and the line circuit 10a are thus caused to release in the manner previously explained.

Provisions are made whereby the operator in the manual office No. 1 may release the operated switch train in the event the calling subscriber fails to respond to the recall operation which occurs when the call is released from storage. More specifically, if the operator fails to obtain a response from the calling subscriber within a reasonable time interval after she has answered the call, she may initiate the release of the trunk circuit apparatus 45 and the repeater 40 in the manner previously explained. Under the circumstances stated, only the relays R1110, R1140, R1160 and R1170 are operated in the call storage circuit 35. During the release of the repeater 40, the control conductor 12c is disconnected from ground and the direction of current flow through the operating winding of the relay R1140 is reversed. In response to this current reversal the relay R1140 restores. At RA1141, the relay R1140 opens the operating circuit for the relay R1160 and completes the operating circuit for the relay R1135. The relay R1135 operating, opens, at RA1137, the prepared holding circuit for the relay R1100, and, at RA1137', the ringing current circuit. The relay R1160, upon restoring, disconnects the control conductor 28c from ground; opens the holding circuit for the relay R1170 and interrupts the respective operating circuits for the two relays R1110 and R1135, causing the three last-enumerated relays to restore. Thus, the call storage circuit 35 is fully released. When ground potential is removed from the control conductor 28c, the connector switch 25, the finder switch 20 and the line circuit 10a are all released in the manner previously described.

It will be observed that the extra control contact engaged by the wiper 684 during the setting up of the connection just described and included in the contact set terminating the conductors of the trunk 28 is not wired. Accordingly, if a second call intended for the manual office No. 1 is routed by way of one of the connector switches in the automatic exchange No. 1 prior to the release of the call from storage, in the manner explained above, the connector switch occupied with the second call will, after testing all of the available interoffice trunks, be operated to the position corresponding to the trunk 28. Since at this time no further circuit is available for continuing the trunk hunting operation of the switch, operation of the switch is arrested and a busy tone signal is returned to the calling subscriber, all in the manner previously described.

III. *Trunk call—Substation A to manual office No. 2*

The manner in which a call originating at the substation A may be routed by way of the finder switch 20, the local connector switch 25, the trunk

line 13, the repeater 55, the trunk line 23 and the trunk circuit apparatus 60 to the operator's position in the manual office No. 2, is exactly the same as described in section II with reference to the call routed to the operator's position in the manual office No. 1. Further, the manner in which the connection as routed to the manual office No. 2 is released is in all respects identical with the release of the connection rounted to the manual office No. 1.

IV. *Trunk call—Substation A to manual office No. 3*

If the above-described call originating at the substation A is intended for a subscriber's line terminating at the manual office No. 3, the calling subscriber, upon initiating the call, dials the single digit designating the group of interoffice trunk lines extending to the manual office No. 3. At the end of the digit the connector switch 25 operates as described in Section II to search for an idle one of the trunk lines and to seize the first idle line tested. Assuming that the line 24, for example, is the first available idle line of the selected group, the local connector switch 25, upon testing the condition of the trunk line 14, operates to extend the calling loop circuit to the repeater 70. This loop circuit as extended over the trunk line 14 to the repeater 70 includes the windings of the two relays R1230 and R1240. The relay R1230 is differentially wound and, accordingly, does not operate at this time. The relay R1240, however, operates to complete, at RA1241, an obvious circuit for energizing the slow-acting hold relay R1270. The relay R1270, upon operating, completes a circuit for energizing the relay R1300, this circuit extending from ground at RA1241 by way of RA1274, RA1231, C1285 and the winding of R1300 to battery. At RA1273, the relay R1270 completes a circuit for energizing the relays R1305 and R1310 in parallel, this circuit extending from ground by way of RA1273, C1283, RA1324 and the parallel connected windings of R1305 and R1310 to battery. At RA1271 and RA1272, the relay R1270 connects the trunk line conductors 14_a and 14_b to the line terminals of the repeating coil 1340. The relay R1300, upon operating, prepares, at RA1302 and RA1303, a circuit traced hereinafter for energizing the two relays R1210 and R1260 in series. At RA1301, the relay R1300 completes an obvious path for impressing ground potential upon the control conductor 14_c whereby the preceding switches 20 and 25 are held operated. The relay R1305, upon operating, completes, at RA1306, a circuit for transmitting alternating ringing current over the two sides of the trunk line 24 for the purpose of energizing the drop 1360. More particularly, the circuit traversed by this ringing current extends from the ungrounded terminal of the ringing current generator, C1307, RA1306, the resistor 1345, the repeater windings 1343, 1344, 1351 and 1352 and the two sides of the trunk line 24, the switch springs 1365 and 1366, the jack springs 1361, 1357 and 1356, the condenser 1359 and the winding of the drop 1360 to ground. The resulting operation of the drop 1360 serves to indicate to the operator in the manual office No. 3 that an incoming call on the trunk line 24 should be answered.

When energized in parallel with the relay R1305, the relay R1310 attracts its armature 1312 into engagement with the associated weighted armature 1311, thereby to initiate vibratory movement of the latter armature in the usual manner. After the time interval required for vibration of the armature 1311 to cease, the two armatures 1311 and 1312 remain in engagement to hold completed an obvious circuit for energizing the slow-to-operate relay R1320. The relay R1320 operates after an interval to complete, at RA1323 and RA1324, a holding circuit for itself, this circuit extending from ground by way of RA1273, C1283, RA1324, RA1323 and the winding of R1320 to battery. At RA1324 and its associated resting contact, the relay R1320 opens the above-traced circuit for energizing the two relays R1305 and R1310 in parallel, causing both of these relays to restore. At RA1325, the relay R1320 opens a point in the operating circuit for the slow-acting relay R1330 and prepares an alternative holding circuit for itself. At RA1322, the relay R1320 completes an obvious multiple path for impressing ground potential upon the control conductor 14_c of the trunk line 14. At RA1321', the relay R1320 opens a point in the circuit for energizing the upper winding of the relay R1335. The relay R1305, upon restoring, opens, at RA1306 and its associated working contact, the above-traced circuit for transmitting ringing current over the trunk line 24 and through the winding of the drop 1360. At RA1306 and its associated resting contact, the relay R1305 reprepares the above-mentioned circuit for energizing the two relays R1210 and R1260 in series.

In order to answer the call, the operator in the manual office No. 3 inserts the plug terminating one end of her cord circuit in the call and answer jack 1355. In response to this operation, the jack springs 1356 and 1357 are disengaged to open a further point in the circuit for energizing the drop 1360, and the jack springs 1357 and 1358 are moved into engagement to complete the circuit for energizing the two relays R1210 and R1260. This circuit extends from ground at RA1371 through the winding of R1370 and by way of the jack springs 1357, 1358 and 1361, and the switch springs 1366 and 1365 to the junction point between the repeating coil windings 1351 and 1352; one branch extending from this point by way of the winding 1351, C1346, the winding 1343, the resistor 1345, RA1306, RA1303, RA1302, C1282, the lower winding of R1260, the lower winding of R1210, the upper winding of R1210 and the upper winding of R1260 to battery; and the other branch extending by way of the winding 1352, C1347, the winding 1344, the resistor 1345, RA1306, RA1303, RA1302, C1282, the lower winding of R1260, the lower winding of R1210, the upper winding of R1210 and the upper winding of R1260 to battery. Due to the relatively high resistance of the respective lower windings of the relays R1210 and R1260, the relays R1210 and R1370 do not operate when energized over the circuit just traced. The relay R1260, however, operates, to complete, at RA1263, the above-mentioned multiple holding circuit for the relay R1320, this circuit extending from ground by way of RA1263, C1284, RA1325 and the winding of R1320 to battery. At RA1261, the relay R1260 prepares the above-mentioned circuit for energizing the upper winding of R1335. At RA1262, the relay R1260 completes a circuit for energizing the battery reversing relay R1220, this circuit extending from ground by way of RA1262, RA1203 and the winding of R1220 to battery. At RA1221 and RA1222, the relay R1220, upon operating, reverses the direction of current flow over the loop circuit extending from the repeater 70 back to the calling substation A. This cur-

rent reversal is without effect in the present instance.

After the call is answered by the operator, the desired conversational circuit is fully established between the calling substation A and the operator's telephone set. Accordingly, the operator may converse with the calling party and ascertain the substation desired. After this information is received the operator may cause the connection to be forwarded to the desired substation in the manner conventionally followed in manual office practice.

The release of the connection as established between the substation A and the operator's position in the manual office No. 3 is under the control of the operator on duty at this position. More particularly, when the calling subscriber hangs up, the loop circuit extending from the substation A through the finder switch 20 and the local connector switch 25 to the repeater 70 is interrupted, causing the relays R1240 and R1270 sequentially to restore in the order named. The relay R1270, upon restoring, disconnects, at its armatures RA1271 and RA1272, the line conductors of the trunk line 14 from the line terminals of the repeating coil 1340, thereby to open a further point in the talking circuit extending from the calling substation to the operator's position in the manual office No. 3. At RA1273, the relay R1270 opens one of the multiple holding circuits for the relay R1320. At RA1274, the relay R1270 opens the above-traced operating circuit for the relay R1300, causing the latter relay to restore. Upon restoring, the relay R1300, at its armatures RA1302 and RA1303, excludes the high resistance lower windings of the relays R1210 and R1260 from the previously traced simplex circuit which extends to ground through the windings of the relay R1370. At RA1301, the relay R1300 opens one of the multiple paths for impressing ground potential upon the control conductor 14_c of the trunk line 14. When the lower windings of the relays R1210 and R1260 are excluded from the above-traced circuit serially including the winding of the relay R1370, the last-mentioned relay operates, to open, at RA1371, the path normally short-circuiting the winding of the signal device 1369. When this short-circuiting path is interrupted, the signal device 1369 is energized in series with the relay R1370 and the respective upper windings of the two relays R1210 and R1260 in an obvious manner. The resulting operation of this device serves to indicate to the operator that the connection has been released at the calling end thereof.

The operator, upon receiving the disconnect signal, may, by operating the key 1364 one or more times, cause the metering device 365 associated with the calling substation A to operate and register the proper charge for the call. For example, if the charge to be assessed for the call is represented by four operations of the metering device 365 the operator will momentarily actuate the key 1364 to its off-normal position four times, thereby to cause four operations on the part of the indicated metering device. When the key 1364 is operated to its off-normal position, the springs 1365 and 1367 are moved into engagement to include the booster battery current source 1368 in the above-traced circuit serially including the respective upper windings of the two relays R1210 and R1260. At the springs 1365 and 1366, the winding of the relay R1370 is excluded from this circuit in an obvious manner. When the booster battery current source 1368 is included in the circuit for energizing the two relays R1210 and R1260 the marginal relay R1210 operates to complete, at RA1211, an obvious circuit for energizing the slow-acting relay R1200. The relay R1200, upon operating, opens, at RA1203, the above-traced operating circuit for the relay R1220, causing the latter relay to restore to again reverse the direction of current flow over the calling loop circuit. In the present instance, this current reversal is without effect. At RA1201, the relay R1200 completes a circuit for energizing the metering device 365 associated with the substation A. This circuit extends by way of the grounded control conductor C488 through the finder switch 20, through the winding of the metering device 365 and by way of C305, C372, RA408', C477', RA654, the extra control wiper 682, C1207, RA1201 and the resistor 1204 to the negative terminal of the metering current source. When energized over this circuit, the metering device 365 operates to make one registration representing a unit charge. When the key 1364 is released by the operator, the contact springs 1365 and 1366 are again moved into engagement to recomplete the circuit for energizing the relay R1370 in series with the respective upper windings of the relays R1210 and R1260. Thereafter, the springs 1365 and 1367 are disengaged to exclude the booster battery current source 1368 from this circuit in an obvious manner. In response to the release of the key 1364, the marginal relay R1210 is insufficiently energized to remain operated and restores, to open, at RA1211, the operating circuit for the relay R1200. The relay R1200 restores after an interval to open, at RA1201, the above-traced circuit for energizing the metering device 365 and to recomplete, at RA1203, the above-traced operating circuit for the battery reversing relay R1220. During each succeeding operation of the key 1364, the relays R1210, R1200 and R1220 operate and restore in the exact manner just described. The relay R1200 functions to complete the circuit for energizing the metering device 365 each time the key 1364 is operated to its off-normal position. It is pointed out that the key 1364 should not be operated too rapidly since a sufficient time interval must be provided between each pair of operations to permit the above-described operating sequence of the relays R1210, R1200 and R1220.

After the call registering operation has been performed in the manner just described, the operator in the manual office No. 3 may initiate the release of the connection by withdrawing the plug terminating one end of her cord circuit from the jack 1355. In response to this operation, the jack springs 1357 and 1358 are disengaged to interrupt the above-traced circuit serially including the windings of the relay R1370 and the respective upper windings of the relays R1210 and R1260. Upon restoring, the relay R1260, opens, at RA1263, the holding circuit for the relay R1320, causing the latter relay to restore. At RA1262, the relay R1260 opens the operating circuit for the battery reversing relay R1220, whereby the last-mentioned relay is caused to restore. The relay R1320, upon restoring, disconnects the control conductor 14_c of the trunk line 14 from ground, thereby to cause the release of the connector switch 25, the finder switch 20 and the line circuit 10_a in the manner previously described. Following the restoration of the relay R1320, the repeater 70 and the trunk circuit 75

are fully released and are available for further use. In this regard it is pointed out that when ground potential is removed from the control conductor 14c battery potential is impressed upon this control conductor through the winding of the impedance element 1250, thereby to mark the repeater 70 as idle in the bank contacts of the connector switches having access thereto. When the connector switch 25, the finder switch 20 and the line circuit 10a are released, all of the apparatus utilized in routing the connection from the substation A to the manual office No. 3 is restored to normal and conditioned for further operation.

V. *Trunk Call—Substation A to tandem automatic exchange*

If the call originating at the substation A and routed to the link comprising the finder switch 20 and the connector switch 25 is intended for a substation terminating at the tandem automatic exchange or the manual office No. 4, the calling subscriber first dials the digit designating the group of trunk lines extending from the connector switch 25 to the distant tandem exchange. The arrangement of the local connector switch 25 is such that when the wipers 680 to 684, inclusive, are elevated to a position opposite the level of bank contacts terminating this group of trunk lines, the normal post springs 559 and 608 are respectively operated into engagement and the normal post springs 615 are disengaged. It will be recalled from the preceding explanation that at the time these operations occur, the relays R500 and R540 are operated. At the springs 615, the previously traced operating circuit for the relay R650 is interrupted. At the springs 559, a circuit is prepared for energizing the line switching relay R660. At the springs 608 a circuit is completed for energizing the relay R600, this circuit extending from ground at RA542 by way of C579, the springs 608 and the upper winding of R600 to battery. At the springs 608, a circuit is also completed for energizing the upper winding of R640 in series with the winding of R610, this circuit extending from ground by way of RA542, C579, the springs 608, C585, C490, RA545, C586, the upper winding of R640 and the winding of R610 to battery. The relay R600 operating, prepares, at RA607, the previously traced multiple path for impressing ground potential upon the release conductor C488. At RA604, the relay R600 opens a point in the previously traced operating circuit for the relay R630. At RA602, the relay R600 prepares the previously traced circuit for energizing the rotary magnet 670 in parallel with the relays R610 and R500. At RA603, the relay R600 prepares the holding circuit for the relay R640. At RA601, the relay R600 prepares its own holding circuit. The relay R640, upon operating, completes, at RA642, the holding circuit for R600. At RA643, the relay R640 opens a further point in the operating circuit for the line switching relay R650 and prepares a further point in its own holding circuit. At RA646, the relay R640 opens a point in the prepared circuit for energizing the line switching relay R660. At RA644 and RA645, the relay R640 further prepares the circuit for energizing the magnet 670 in parallel with the relays R610 and R500. Shortly following the operations just described, the relays R500 and R540 are caused to release in the manner previously explained. The relay R540, upon restoring, opens, at RA542, the above-traced operating circuit for the relay R600 and the above-traced circuit for energizing the upper winding of R640 in series with the winding of R610. The last-mentioned circuit is further opened at RA545 when the relay R540 restores. At RA542, the relay R540 completes the previously traced holding circuit for the busy test relay R640 and completes the previously traced circuit for energizing the magnet 670 in parallel with the relays R610 and R500. When energized in this manner, the magnet 670 operates to step the wipers 680 to 684, inclusive, into engagement with the first set of contacts of the selected level, thereby to select the first trunk in the group extending to the tandem automatic exchange. The magnet 670 further operates to open, at its armature 672, the previously traced holding circuit for the busy test relay R640, causing the last-mentioned relay to restore. Upon restoring, the relay R640 opens, at RA642, the holding circuit for R600 and, at RA643, a further point in its holding circuit. At RA644 and RA645, the relay R640 opens the circuit for energizing the magnet 670 in parallel with the relays R610 and R500. Due to their slow-to-release characteristics the relays R610 and R500 remain operated throughout the trunk hunting operation under consideration.

Assuming that the first trunk line of the selected group is busy, ground potential is present upon the control and extra control contacts of the contact set terminating this line. A holding circuit for the relay R600 is, therefore, completed immediately the wipers 680 to 684, inclusive, are stepped into engagement with the contact set terminating the first trunk. This holding circuit extends by way of the grounded wiper 684, C677, RA633, RA614 and the lower winding of R600 to battery. When, thereafter, the magnet 670 retracts its armature 672, the previously traced operating circuit for the busy test relay R640 and extending by way of the grounded control conductor 683 is also completed. Accordingly, the relay R640 is caused to reoperate. In reoperating, the relay R640 recompletes its holding circuit and recompletes the circuit for energizing the magnet 670 in parallel with the relays R610 and R500. From this point on, the manner in which the trunk hunting operation is continued until an idle trunk line of the selected group is found or until all of the trunk lines of the selected group have been tested and found to be in a busy condition, is exactly the same as described in section IA. The control and extra control contacts of the contact set terminating the conductors of the last trunk line in the group are not strapped together so that if all of the trunk lines are busy at the time the trunk hunting operation is initiated, the relay R600 is caused to restore when the last line of the group is tested and found to be busy. In such case the busy test relay R640 is locked in its operated position and the relay R610 is caused to restore to complete the previously traced circuit for transmitting busy tone current to the calling substation to inform the calling subscriber that the call cannot be completed.

An idle trunk line of the selected group is identified by the presence of battery potential upon the control and extra control contacts of the contact set at which the conductors of the line are terminated. Accordingly, if the wipers 680 to 684, inclusive, are moved into engagement with the contacts terminating an idle line of the selected group, the relays R600 and R640

are short-circuited and restore. The relay R600 functions to open, at RA602, a point in the above-traced circuit for energizing the magnet 670 in parallel with the relays R610 and R500, whereby the stepping of the wipers is arrested. At RA603, the relay R600 opens a point in the holding circuit for the relay R640. At RA601, the relay R600 opens a further point in its holding circuit as traced above. The busy test relay R640, upon restoring, opens, at RA644 and RA645, a further point in the circuit for energizing the magnet 670 in parallel with the relays R610 and R500, and completes, at RA646, the previously mentioned operating circuit for the relay R660. The last-mentioned circuit extends from ground by way of RA427, C481, the normal post springs 559, RA523', C583, RA606, RA646, the lower winding of R660, C676 and the wiper 683 to the negative terminal of the exchange battery as connected to the control contact of the contact set terminating the conductors of the selected trunk line. When energized over this circuit, the relay R660 first completes, at the "X" contacts associated with RA666, a holding circuit for itself, this holding circuit extending from ground at RA422 by way of C477, RA666 and the upper winding of R660 to battery. After this circuit is completed the relay R660 fully operates to complete, at RA667, an obvious path for short circuiting its lower winding, thereby to complete a path for applying ground potential directly to the control conductor of the selected trunk line. At RA668 the relay R660 opens a point in the operating circuit for the link release relay R550, thereby to prevent the operated link from being forcibly released. At RA665, the relay R660 further opens the above-traced circuit for energizing the rotary magnet 670, thereby to prevent this magnet from responding to further inpulses dialed at the calling substation. At its armatures RA661 to RA663, inclusive, the relay R660 completes a loop circuit extending by way of the selected trunk line to the repeater associated with this line. For example, if the trunk line 16 is seized during the trunk hunting operation of the connector switch, this loop circuit may partially be traced as extending by way of the line conductor 16a, the wiper 680, C468, RA661, C571, the repeater winding 567, C474, RA431, C475, the operating winding of the shunt field relay R620, RA663, C576, the repeater winding 569, C573, RA662, C470 and the wiper 681 to the line conductor 16b. When this loop circuit is completed, the repeater 85 associated with the trunk lines 16, 21 and 26 is conditioned to repeat the impulses of further digits dialed at the calling substation to the automatic switching apparatus 90 provided in the distant tandem exchange. At RA663 and RA664, the relay R660, upon operating, opens two points in the previously traced circuit for energizing the back bridge relay R520. At RA669, the relay R660 prepares a circuit for energizing the relay R516.

During further operation of the calling device provided at the calling substation A, the relays R435, R430 and R516 function to repeat the impulses over the loop circuit established between the connector switch 25 and the repeater 85. The control apparatus of the repeater 85, in turn, operates to repeat the impulses to the automatic switching apparatus 90 provided in the distant tandem exchange. Thus, each time the line relay R435 restores, it opens, at RA437, the holding circuit for the relay R430. The relay R430 restoring, opens, at RA431, a point in the above-traced loop circuit extending to the repeater 85. At RA432, the relay R430 completes the previously traced circuit for energizing the relay R500. Thus, the relays R600, R630 and R610 are caused sequentially to operate and are held operated throughout the series of impulses. With the line switching relay R660 operated, a circuit is also completed for energizing the relay R516 when the relay R430 releases during the open circuit period of each impulse. This circuit extends from ground by way of RA432, RA412, C479, C585', RA669, C586' and the lower winding of R516 to battery. Since the upper winding of the relay R516 is normally short-circuited, this relay is slow to operate. The relay R516 operates, after an interval, to open, at RA518, the path normally short-circuiting its upper winding and to prepare, at RA517, the circuit for energizing the relay R430. When thereafter the relay R435 reoperates at the conclusion of the open circuit period of the impulse, the last-mentioned circuit is completed, this circuit extending from ground by way of RA517, C486, RA437 and the winding of R430 to battery. The relay R430 reoperating completes, at RA431, the loop circuit to the repeater 85 and opens, at RA432, the above-traced operating circuit for the relay R516, thus causing the latter relay to restore. The interrelated operation of the three relays R435, R430 and R516 occurs during each succeeding impulse transmitted to the connector switch 25, the relay R430 functioning to repeat the impulses to the selected repeater 85. At the end of each series of impulses, the relays R500, R630 and R610 are caused sequentially to restore in the manner previously explained.

The impulses as repeated through operation of the repeater 85 to the automatic switching apparatus 90 provided in the tandem automatic exchange cause a connection to be routed through this automatic switching apparatus to the desired line in the usual manner. For example, if the call is intended for a substation line terminating at the tandem automatic exchange, the connection may be routed directly to this line through operation of the automatic switching apparatus 90. On the other hand, if the call is intended for a substation terminating at the manual office No. 4, the connection may be routed by way of the trunk line 27, for example, to an operator's position in this manual office in the usual manner. The answering operator in the manual office No. 4 may, in turn, direct the call to the desired substation in the manner conventionally followed in manual office practice. In either case, when the call is answered, either at a substation associated with a line terminating at the tandem automatic exchange or at an operator's position in the manual office No. 4, the control apparatus of the automatic switching equipment 90 and of the repeater 85 functions to cause the current traversing the loop circuit including the operating winding of the shunt field relay R620 to be reversed. In response to this current reversal, the relay R620 operates to complete, at RA621, an obvious circuit for impressing ground potential upon the zone metering lead C492, whereby certain operations on the part of the zone metering circuit are initiated in the manner explained hereinafter.

The manner in which the local connector switch 25 is released during the release of the connection is substantially similar to the release of this switch as described previously with ref-

erence to the local call routed to the substation B. In this connection it will be apparent that the relay R420 is held energized from ground on the private wiper 683 until the connection is cleared out at the called end thereof. Also in this case, the ring cut-off relay R530 is not operated and, accordingly, no circuit is completed for energizing the meter control relay R400 during the release of the switch. In any event, when the connection is cleared out at both the calling and called ends thereof, the five relays R435, R430, R425, R420 and R410 are caused to restore to perform the functions previously described. During the release of these relays the locking circuit for the line switching relay R660 is opened, at RA422, in response to the release of the hold relay R420. Aside from the operating differences just mentioned, the connector switch 25 is released in the manner previously described.

ZONE METERING

As indicated previously, the zone metering circuit 30 associated with the local connector switch 25 may be utilized for the purpose of metering trunk calls routed by way of this connector switch to substations located in either one or two digit zones. Thus, in initiating the above-described call routed to the tandem automatic exchange No. 2, the first digit dialed by the calling subscriber at the substation A designates the zone to which the call is to be routed. In the specific arrangement described only a single digit is required to cause the local connector switch 25 to select the group of trunks interconnecting the automatic exchange No. 1 with the automatic exchange No. 2. This local connector switch is, however, arranged for two digit trunk selection and accordingly the zone metering circuit 30 is arranged to be controlled by impulses transmitted to the switch 25 and comprising either the first digit or the first and second digits of the dialed directory number.

When any one of the local connector switches embodied in the automatic exchange No. 1 is operated to select a group of trunks requiring zone metering, ground potential is impressed upon the timer start conductor C865 to complete an obvious circuit for energizing the relay R860. With the start conductor C865 grounded the relay R820 is energized over a circuit extending by way of the normally closed off-normal spring 847 of the switch 892 and the winding of R820 to battery. With the conductor C865 grounded, the pulsing cam 859, which is continuously driven in any desired manner, operates intermittently to complete the circuit for energizing the pulsing relay R845. More specifically, the speed of rotation of the cam 859 is such that current pulses are delivered to the relay R845 at .655 second intervals. Each time the relay R845 is energized it functions to complete, at RA846, an obvious circuit for energizing the magnet 897 of the rotary switch 892. The magnet 897 in operating disconnects the multipled contacts of the four contact sets 893 to 896, inclusive, from ground and conditions the associated ratchet and pawl mechanism to advance the wipers 866 to 869, inclusive, one step. When subsequently deenergized, the magnet 897 retracts its armature 898 to connect the multipled contacts of the switch 892 to ground at RA823, and, in cooperation with its associated ratchet and pawl mechanism, advances the wipers 866 to 869 one step. Thus, the wipers of the switch 892 are continuously driven at a predetermined rate so long as ground potential is maintained upon the start conductor C865. When these wipers are advanced to engage their associated eleventh contacts, the normally engaged off-normal springs 847 are disengaged to open the previously traced circuit for energizing the relay R820. The relay R820 now restores to complete, at RA821, an obvious path for grounding the pulsing lead C754 and, at RA822, a path extending from ground at RA865 for impressing ground potential upon the pulsing lead C755. Each time the wipers 866 to 869, inclusive, are advanced from engagement with their associated eleventh contacts into engagement with their associated first contacts the off-normal springs 847 are again engaged to complete the operating circuit for the relay R820, whereby the two pulsing conductors C754 and C755 are disconnected from ground. During each interval when the relay R820 is operated the multipled contacts of the switch 858 are also disconnected from ground at RA823. From the foregoing explanation it will be apparent that ground pulses are transmitted over the pulsing leads C754 and C755 at the end of each cycle of operation of the rotary switch 892.

Assuming that the zone metering circuit 30 is arranged to control the metering of a call routed from the automatic exchange No. 1 to the automatic exchange No. 2, operation of the circuit is initiated in response to seizure of the link comprising the finder switch 20 and the local connector switch 25. More specifically, when the calling loop circuit is extended to the connector portion of the link from the substation A, for example, to cause the sequential operation of the five relays R435, R430, R425, R420 and R410, a circuit is completed for energizing the start relay R710 when the slow-acting relay R425 of the local connector switch operates, this circuit extending from ground by way of RA428, C495 and the winding of R710 to battery. The relay R710 operating, completes, at RA712, a circuit for energizing the pulsing relay R750, this circuit extending from ground at RA434 by way of C496, the winding of R750 and RA712 to battery. The relay R750 operating, completes, at RA751, an obvious circuit for energizing the slow-acting relay R770. The relay R770 now operates to complete, at RA771, a circuit for energizing the slow-acting relay R730, this circuit extending from ground by way of the off-normal springs 891, C734, RA771 and the lower winding of R730 to battery. The relay R730 in operating prepares, at RA732, a circuit for energizing the operating magnet 878 of the zone selecting switch 870 in parallel with the upper winding of the relay R730. Following the relay operations just described, the zone metering circuit 30 is conditioned to respond to the first series of impulses dialed at the calling substation A. In this regard it will be apparent that the pulsing relay R430 operates to repeat the dialed pulses to the pulsing relay R750 over the pulsing lead C496. When the relay R750 restores at the beginning of the first impulse, it completes the circuit for energizing the magnet 878 in multiple with the upper winding of the relay R730, this circuit extending from ground by way of RA751, RA732 and RA772 to C735 where it divides; one branch extending through the upper winding of R730 to battery and the other branch extending through the winding of the magnet 878 to battery. When energized over this circuit, the magnet 878 operates to advance the wipers 874 to 876,

inclusive, into engagement with their respective associated first contacts. When the wipers of the switch 870 are thus moved off-normal, the off-normal springs 891 are disengaged to interrupt the above-traced operating circuit for the relay R730. This relay, due to its slow-to-release characteristic, remains operated until the series of impulses is terminated. Similarly, the relay R770, due to its slow-to-release characteristic, remains operated during impulsing. At the end of the open circuit period of the first impulse, the relays R430 and R750 are caused sequentially to reoperate in an obvious manner, whereby the operating circuit for the relay R770 is recompleted and the circuit for energizing the magnet 878 in parallel with the upper winding of the relay R730 is interrupted. During each succeeding impulse of the first digit, a current pulse is transmitted to the magnet 878, whereby the wipers 874 to 876, inclusive, are operated step by step and at the end of the digit are left standing in engagement with the contacts corresponding to the number of impulses dialed. Assuming, for example, that the digit designating the group of trunks extending from the automatic exchange No. 1 to the automatic exchange No. 2 is the digit two, the wipers of the zone selecting switch 870 are left standing in engagement with their respective associated second contacts when the digit is terminated. During the inter-digit pause between the first and second digits dialed at the calling substation, the pulsing relay R750 remains operated. Accordingly, the relay R730 restores, to open, at RA732, the above-traced circuit for delivering pulses to the operating magnet 878. With the relay R730 occupying its restored position, further impulses dialed at the calling substation A will have no effect upon the zone metering circuit 30. At RA731, the relay R730 completes a circuit extending by way of C733 and the wiper 874 for energizing the upper winding of the relay R840. The relay R840 operating, prepares, at RA841', a circuit for energizing the relay R800. In the present assumed case wherein the first digit determines the zone to which the call is to be routed, the relay R800 is not energized. At RA841, the relay R840 completes a holding circuit for itself, this holding circuit extending from ground by way of RA714, the hold conductor C736, RA841 and the lower winding of R840 to battery. At its remaining bracketed armatures, the relay R840 prepares predetermined cross connecting paths extending between the contacts of the contact set 873 and the wipers of the meter pulsing switch 892.

The manner of cross connecting the contacts of the contact set 873 with the wipers of the switch 892 depends upon the particular charge to be assessed for a call to a particular zone. For example, in the present case if four registrations on the part of the metering device 365 associated with the calling line 10 are required to assess the minimum charge against the calling subscriber, the cross connecting paths just mentioned are so arranged that the No. 2 contact of the contact set 873 will be connected to the wiper 868 of the switch 892 when the relays R850 and R860 are operated. In this regard, it will be understood that the bracketed contact springs controlled by the four zone selecting relays R825, R830, R835 and R840 are all multipled to the ten contacts in the contact set 873. It will further be apparent that by cross connecting the contact points associated with these armatures to the four upper armatures controlled by the relay R840 in different manners, any desired number of metering pulses may be obtained for any particular zone.

Following the operation of the relay R840, no further relay operations occur in the zone metering circuit 30 until the call is answered at the called substation. In the event the call is abandoned before it is answered, no metering pulses are transmitted to the metering device 365 associated with the calling line. In such case, the zone metering circuit 30 is released in response to restoration of the hold relay R425. More specifically, when the relay R425 restores, it opens the previously traced operating circuit for the relay R710. The relay R710 releasing, opens, at RA712, the operating circuit for the relay R750 and completes, at RA715, a circuit for energizing the release magnet 879. The latter circuit extends from ground by way of RA715, C737, the off-normal springs 890 and the winding of the magnet 879 to battery. When this circuit is completed, the magnet 879 operates to release the wipers 874 to 876, inclusive, in the usual manner. When these wipers are returned to normal, the off-normal springs 891 are moved into engagement to reprepare the operating circuit for the relay R730 and the off-normal springs 890 are disengaged to interrupt the operating circuit for the release magnet 879. The relay R710 releasing, also opens, at RA714, the previously traced holding circuit for the operated zone selecting relay R840, permitting the latter relay to release when the wipers of the switch 870 are moved out of engagement with their associated second contacts. Following the operations just described the zone metering circuit 30 is fully released.

In the event the call is answered at the called substation the shunt field relay R620 is caused to operate in the manner previously explained. This relay in operating, completes, at RA621, a circuit for energizing the relay R700, this circuit extending from ground by way of RA621, C492, RA713 and the winding of R700 to battery. At RA702, the relay R700, in operating, completes an obvious holding circuit for itself. At RA703, the relay R700 prepares a circuit for energizing the relay R850. At RA704, the relay R700 prepares the operating circuit for the motor magnet 787 of the minor switch 780. The operating circuit for the relay R850 is completed at the end of the next cycle of operation of the rotary switch 892 when the relay R820 is caused to restore in the manner previously explained, this circuit extending from ground by way of RA865, RA822, C755, RA703, C752, RA813, RA855, RA814 and the upper winding of R850 to battery. When the relay R820 releases following operation of the relay R700, a circuit is also completed for energizing the motor magnet 787 of the minor switch 780, this circuit extending by way of the grounded start conductor C865, RA821, the pulsing lead C754, RA717, RA704 and the winding of the magnet 787 to battery. When energized over this circuit the magnet 787 attracts its armature 788 to disconnect the wiper 784 from ground, and, in cooperation with its associated ratchet and pawl mechanism, advances the wipers 784 to 786, inclusive, into engagement with their associated first contacts. When these wipers are moved off-normal, the off-normal springs 790 are engaged to prepare the operating circuit for the release magnet 789. When energized over the circuit traced above, the relay R850 partially operates to complete, at the "X"

contacts associated with RA856, an obvious path for short-circuiting its lower winding. At the end of the ground pulse transmitted over each of the conductors C754 and C755, the path short-circuiting the lower winding of the relay R850 is interrupted and the magnet 787 retracts its armature 788 to connect the wiper 784 to ground. The relay R850 now completes its operation to prepare, at RA855, the operating circuit for the relay R810. At its armatures RA851 to RA854, inclusive, the relay R850 connects the bracketed contacts controlled by the zone relays R825, R830, R835 and R840 to the wipers 866 to 869, inclusive, in a predetermined manner determined by the wiring of these contacts. In the present assumed case wherein the wiper 876 engages its associated second contact, this wiper is connected over one of the cross connecting paths to the wiper 868 only. Following the operation of the relay R850 and during continued operation of the switch 892, four current pulses are delivered to the pulsing relay R775. More specifically, when the wiper 868 is operated to engage its associated fifth contact, the relay R775 is energized over a circuit extending from ground by way of RA823, the armature 898, the multipled fifth to eighth contacts of the contact set 895, the wiper 868, RA863, RA853, RA842, the second contact of the contact set 873, the wiper 876, C738 and the winding of R775 to battery. This circuit is interrupted at the armature 898 when the motor magnet 897 is subsequently energized in response to the next operation of the pulsing relay R845. Since the fifth to eighth contacts of the contact set 895 are multipled together it will be apparent that three additional current pulses are transmitted to the pulsing relay R775 over the circuit just traced during movement of the wipers 866 to 869, inclusive, over their associated contacts numbered from one to eleven, inclusive.

Each time the pulsing relay R775 operates it completes a circuit for energizing the metering device 365 associated with the calling line 10, this circuit extending by way of the grounded conductor C488, the winding of the device 365, C305, C372, RA701, RA711, RA776 and the resistor 777 to battery. Thus, the metering device is caused to make four registrations representing the minimum charge for the call, immediately following the completion of the connection to the substation desired by the calling party at the substation A. From a consideration of the bank wiring of the rotary switch 892 it will be evident that the number of metering pulses transmitted by the relay R775 is determined by the one of the wipers 866 to 869, inclusive, over which the current pulses are transmitted to the relay R775. The one of these wipers over which the current pulses are transmitted to the relay R775 is, in turn, determined by the manner of cross connecting the bracketed contact springs of the zone selecting relays R825 to R840, inclusive, to the enumerated wipers. For example, had the armature RA842 been arranged for connection to the wiper 866, three current pulses would be delivered to the pulsing relay R775 during the cycle of operation of the switch 892 under consideration. Alternatively, had the No. 2 contact of the contact set 873 been arranged for connection over one of the cross connecting paths to the wiper 867, only a single current pulse would be delivered to the relay R775. Following the operations just described and when the wipers of the switch 892 are operated to engage their associated eleventh contacts, the relay R820 is again de-energized and releases to again transmit a current pulse to the operating magnet 787 of the switch 780, whereby the wipers of the latter switch are advanced a sceond step. The relay R820 upon restoring also completes the previously mentioned circuit for energizing the relay R810, this circuit extending by way of the grounded conductor C755, RA703, C752, RA813, RA855 and the lower winding of R810 to battery. When thus energized, the relay R810 operates to complete, at the "X" contacts associated with RA811, a circuit for energizing its upper winding, this circuit extending from ground by way of RA714, RA762, C739, RA811 and the upper winding of R810 to battery. After the circuit just traced is completed, the relay R810 opens, at RA813, a point in the common portion of the operating circuits for itself and the relay R850, respectively. At RA814, the relay R810 further opens the operating circuit for the relay R850. At RA815, the relay R810 interrupts the holding circuit for the relay R850 causing the latter relay to restore. The relay R850 releasing, opens, at RA853, the completed path extending between the wiper 876 and the wiper 868, thereby to prevent further current pulses from being transmitted to the relay R775 during further operation of the rotary switch 892.

Following the relay operations just described, a current pulse is transmitted to the operating magnet 787 of the timing switch 780 at the end of each cycle of operation of the rotary switch 892 in the manner previously explained. When the wipers of the switch 780 have been advanced to engage their associated tenth contacts, a circuit is completed for energizing the lower winding of R720 in multiple with the release magnet 789; one branch of this circuit extending from ground by way of the armature 788, the wiper 784, RA724 and the lower winding of R720 to battery, and the other branch extending by way of the grounded wiper 784, the wiper 785, the off-normal springs 790 and the winding of the magnet 789 to battery. When its lower winding is thus energized, the relay R720, which is of the two-step type, partially operates to complete at the "X" contacts associated with RA722 a path for short-circuiting its upper winding, this path extending by way of the grounded wiper 784, RA724, the upper winding of R720, RA722 and RA742 back to ground at RA714. At the "X" contacts associated with RA725, the relay R720 completes an obvious mutiple circuit for energizing the release magnet 789. When the release magnet 789 is energized, it operates to release the wipers 784 to 786, inclusive, whereby these wipers are restored to their respective normal positions and the off-normal springs are disengaged. During the release of the switch 780 and when the wiper 785 is restored to normal, the path short-circuiting the upper winding of the relay R720 is interrupted, permitting the two windings of this relay to be energized in series. The relay R720 now completes its operation to prepare, at RA723 and RA724, a circuit for energizing the relay R740. At RA721, the relay R720 opens the alternative circuit for energizing the magnet 789. The wipers of the switch 780, following the release thereof, are again stepped off normal and advanced step by step under the control of the relay R820. After ten steps, these wipers are again operated to engage their associated tenth contacts at which time the lower

winding of R740 is energized in multiple with the release magnet 789 over a circuit extending from ground by way of the armature 788, the wiper 784, RA724, RA723, RA744, and the lower winding of R740 to battery. The relay R740 now operates to complete, at the "X" contacts associated with RA743, a path for short-circuiting its upper winding, this path extending by way of the grounded wiper 784, RA724, RA723, RA744, the upper winding of R740, RA743 and RA764 back to ground at RA714. At the "X" contacts associated with RA746, the relay completes an obvious multiple circuit for energizing the release magnet 789. When the release magnet 789 is energized, the wipers of the switch 780 are again restored to normal and during the release thereof the path short-circuiting the upper winding of the relay R740 is interrupted permiting the two windings of this relay to be energized in series. The relay R740 now completes its operation further to open its operating circuit at RA744 and to prepare at RA745 a circuit for energizing the relay R760. At RA747, the relay opens the multiple circuit for energizing the magnet 789. At RA741 and RA742, the relay R740 interrupts the holding circuit for the relay R720, causing the latter relay to restore. At RA748, the relay R740 prepares a path for transmitting a warning tone signal current over the established connection to the calling and called substations.

As pointed out above, when the release magnet 789 is energized, the wipers of the timing switch 780 are again normalized but the stepping operation thereof is immediately continued under the control of the relay R820. During the third half-revolution of these wipers and when the wiper 786 is operated to engage its associated third contact, the above-mentioned warning tone signal current path is completed, this path extending from one terminal of the warning tone current source, not shown, by way of C791, the wiper 786, RA748, the condenser 707, C467 and over one side of the established connection to the receivers respectively provided at the calling and called substations. A return path to the opposite terminal of the signal current source is provided over the other side of the established connection. This current path is interrupted at the wiper 786 when the wipers of the switch 780 are advanced out of engagement with their respective associated third contacts. Thereafter and when the wipers are advanced into engagement with their associated fifth contacts, the operating circuit for the relay R760 is completed, this circuit extending from ground by way of the armature 788, the wiper 784, RA745, RA766 and the lower winding of R760 to battery. When thus energized the relay R760 partially operates to complete, at RA765, a path extending from ground at RA714 for short-circuiting its upper winding. At the "X" contacts associated with RA767, the relay R760 completes an obvious alternative circuit for energizing the release magnet 789. The wipers of the switch 780 are thus restored to normal. During the release of these wipers the path short-circuiting the upper winding of the relay R760 is interrupted at the wiper 784 and its associated fifth contact, permitting the two windings of this relay to be energized in series. The relay R760 now completes its operation to open, at RA768, the alternative operating circuit for the release magnet 789. At RA764, the relay R760 interrupts the holding circuit for the relay R740, causing the last-mentioned relay to release. At RA762 and its associated resting contact, the relay R760 interrupts the previously traced holding circuit for the relay R810, causing the latter relay to restore. At RA766, the relay R760 opens its operating circuit and prepares a circuit for energizing the relay R520'. At RA765', the relay R760 completes an obvious circuit for energizing the slow-to-operate relay R770'. The relay R770' operates following the release of the relay R810 to prepare, at RA771', an obvious holding circuit for the latter relay.

The purpose of impressing the warning signal voltage upon the established talking circuit is to indicate to the calling subscriber that unless the connection is promptly released an additional charge will be assessed for the call. Such a charge is assessed following the release of the relay R810. More specifically, the relay R810, upon releasing, reprepares the operating circuit for the relay R850. This operating circuit is recompleted in the manner previously explained at the end of the cycle of operation of the rotary switch 892 which is in progress. Following the operation of the relay R850, four additional current pulses are transmitted to the relay R775 during continued operation of the rotary switch 892 and, hence, four metering pulses are transmitted to the metering device 365, all in the manner previously explained. Following the transmission and registration of these metering pulses, the relay R810 is again operated to open the holding circuit for the relay R850 and thus causes the release of the latter relay. The relay R810, upon operating the second time, locks to ground at RA771'.

If the parties conversing over the established connection fail to release the connection within a predetermined time interval after the second charge is assessed for the call, the connection is forcibly released. More specifically, the switch 780 continues to operate under the control of the pulsing relay R820 to measure a further time interval. When the wipers of this switch are operated to engage their associated tenth contacts following transmission of the second set of metering pulses, the switch is released and the relay R720 is caused to operate, all in the manner previously described. At the end of another ten steps on the part of the switch 780 the switch is again released and the relay R740 is caused to operate. Following the second operation of the relay R740 and when the wipers of the switch 780 are again operated to engage their associated third contacts, the previously traced circuit for transmitting a warning tone signal current over the established connection is again completed. The parties conversing over the connection are thus informed that the connection is about to be forcibly released. Thereafter, and when the wipers of the switch 780 are operated to engage their associated fifth contacts, the operating circuit for the relay R520' is completed, this circuit extending from ground by way of the armature 788, the wiper 784, RA745, RA766, C493 and the winding of R520' to battery. The relay R520' now operates to open, at RA521' and RA522', two points in the established loop circuit extending through the windings of the line relay R435. At RA523' the relay R520' opens the holding circuit for the relay R420. As a result, the relays R435, R430, R425, R420 and R410 are caused sequentially to restore in the order named, thereby to cause the release of the connector switch 25 and the finder switch 20 in the manner previously explained. During the release of the connector

switch 25, ground potential is removed from the conductors C492, C495 and C496 in response to the release of the relays R620, R425 and R430 respectively. Thus, the relays R710 and R750 are deenergized and restore. The relay R750 releasing opens the operating circuit for the relay R770. The relay R710 releasing disconnects ground from the hold conductor C736, thereby to deenergize the operated relays R700, R720, R740, R760 and R840. At RA715, the relay R710 completes the previously traced circuit for energizing the release magnet 879, whereby the wipers of the zone selecting switch 870 are restored to normal. At RA716, the relay R710 completes an obvious alternative circuit for energizing the release magnet 789, whereby the wipers of the switch 780 are restored to normal. The relay R760 releasing opens, at RA765', the operating circuit for the relay R770', causing the latter relay to restore and open, at RA771, the holding circuit for the relay R810. The relays R740 and R760 releasing open two points in the above-traced operating circuit for the relay R520', causing the latter relay to restore. Following the release of the relay R810, the zone metering circuit 30 is fully restored to normal.

As pointed out previously for those zones requiring two-digit trunk selection, two-digit control of the zone metering circuit 30 is utilized. More specifically, if the first two digits of a directory number designating a particular substation of a particular zone are seven and five, respectively, the lead C874' is connected to the seventh contact of the contact set 871. If a first digit of seven impulses is dialed at a calling substation and the impulses are transmitted to the local connector switch 25, the wipers of the zone selecting switch 870 are operated to engage their associated seventh contacts in the manner previously explained. At the end of the digit the relay R730 restores to complete a circuit extending by way of RA731, C733 and the wiper 874 for energizing the zone selecting relay R830. This relay operating locks to ground at RA831, and completes, at RA831', a circuit for energizing the lower winding of R800, this circuit extending from ground at RA731 by way of C733, the wiper 874 and its associated seventh contact, C874', RA831' and the lower winding of R800 to battery. A branch of this circuit extends by way of RA801, the wiper 875, the multipled contacts of the set 872, the off-normal springs 890 and the winding of the magnet 879 to battery. When its lower winding is thus energized the relay R800, which is of the two step type, partially operates to complete, at the "X" contacts associated with RA802, an obvious path for short-circuiting its upper winding. At the "X" contact associated with RA803, the relay R800 completes an obvious multiple circuit for energizing the release magnet 879. The wipers of the switch 870 are thus restored to normal. When these wipers are returned to normal, the off-normal springs 891 are closed to complete the previously traced operating circuit for the relay R730. In addition, the path short-circuiting the upper winding of R800 is interrupted at the wiper 875 and its associated first contact permitting the two windings of the relay R800 to be energized in series. The relay R800 now completes its operation to open, at RA801 and RA804, further points in the operating circuit for the release magnet 879.

With the relay R730 operated the zone selecting switch 870 responds to the impulses of the second digit dialed at the calling substation, the wipers thereof being operated to the position corresponding to the numerical value of the digit. In the case under consideration these wipers are operated to engage their associated fifth contacts so that at the end of the digit when the relay R730 restores, a circuit extending by way of the grounded wiper 874 is completed for energizing the relay R835. This relay in operating locks to ground at RA836, and at one of its lower ten armatures completes a pulsing path extending between the fifth contact of the contact set 873 and the relay armature carried by the relay R850 which corresponds to the charge to be assessed for the call. For example, if the zone is one for which three operations of the metering device associated with the calling line represent the minimum charge, the completed path extends from the fifth contact of the contact set 873 by way of the fifth armature of the bracketed armatures controlled by the relay R835 to the armature RA851. In the particular case under consideration, the fifth one of the bracketed armatures controlled by the relay R830 is not connected to any of the armatures controlled by the relay R850. Hence, only one path for transmitting current pulses to the meter pulsing relay R775 is completed through the bracketed armatures controlled by the zone selecting relays. From this point on the manner in which the zone metering circuit operates and is released is exactly the same as set forth above in describing one-digit zone selection.

When a local call is routed by way of the local connector switch 25, the zone metering circuit 30 is not effective to cause the operation of the metering device associated with the calling line. To this end those contacts in the contact set 871 which correspond to the levels of the connector switch 25 terminating subscribers' lines, are not wired. With this arrangement none of the zone selecting relays R825, R830, R835 and R840 are operated in response to the impulses comprising first digits which correspond to levels of the connector switch 25 terminating only subscribers' lines. Obviously, if a dialed first digit designates a level terminating both subscribers' lines and trunk lines extending to a particular zone, whereby two-digit zone selection is utilized, one of the zone selecting relays is operated at the end of the first digit. When, however, the connector switch 25 is utilized in establishing local call connections the shunt field relay R620 is not caused to operate. Accordingly, the relay R700 of the zone metering circuit 30 is not energized. Hence, operation of the timing switch 780 is not initiated and the relays R850 and R810 cannot operate. Normally, therefore, only the relays R710, R750 and R770 and possibly one of the zone selecting relays are operated at the time a local call connection routed by way of the connector switch 25 is released. In addition, the wipers of the switch 870 occupy an off-normal position determined by the numerical value of the first digit of the directory number designating the called local substation. During the release of the local connection the relays R710 and R750 are deenergized and restore in response to the release of the relays R435 and R430 respectively. The relay R710 functions to complete the circuit for energizing the release magnet 879 in the manner previously described whereby the wipers of the switch 870 are restored to normal and any operated zone selecting relay is deenergized. Obviously, the relay R770 is deenergized and restores

in response to the release of the pulsing relay R750.

In the event a connection occupied with a trunk call, metered through operation of the zone metering circuit 30, is released prior to the forcible release of the connection in the manner explained above, the zone metering circuit is restored to normal in response to release of the local connector switch 25, the release of this circuit being accomplished in response to release of the relays R750 and R710 in the exact manner previously described.

VI. *Forcible release of the local connector switch*

In order to prevent the local connector switch 25 and its associated finder switch 20 from being held operated due to faults occurring on the lines having access thereto or to the failure of a calling subscriber to complete a calling operation after it is started, the relays R510 and R550 are arranged respectively to be controlled by the timing devices 696 and 695. These timing devices may be of any conventional construction. More specifically, the arrangement of the timing device 695, for example, is such that ground potential is momentarily applied to the start timing conductor C695' at predetermined spaced time intervals and the time cut-off conductor C697 is normally grounded. A predetermined time interval after each ground pulse is applied to the start timing conductor C695', the time cut-off lead C697 is disconnected from ground. The timing device 696 is of similar arrangement, ground pulses being impressed upon the start timing lead C517 at spaced intervals, ground potential normally being maintained upon the time cut-off lead C516 and the latter lead being disconnected from ground a predetermined time interval after each ground pulse is applied to the lead C517.

If a permanent condition arises on one of the subscriber's lines arranged for loop operation, either due to a fault or to the inadvertent initiation of a call at one of the associated substations, the link comprising the finder switch 20 and the connector switch 25 may be seized in the manner previously explained. Under the conditions assumed, no dial impulses are transmitted to the connector portion of the link and accordingly only the relays R435, R430, R425, R420, R410 and R540 are operated. After the connector switch 25 is thus seized, the timing device 695 operates to impress ground potential upon the start timing conductor C695', thereby to energize the relay R550 over a circuit extending by way of the grounded conductor C695', RA552, C484, RA423, C485, RA668, RA657, C584 and the winding of R550 to battery. When energized over this circuit the relay R550 operates to complete a holding circuit for itself, this holding circuit extending from ground by way of RA551, RA552, C484, RA423, C485, RA668, RA657, C584 and the winding of R550 to battery. After this circuit is completed the relay R550 opens its operating circuit in an obvious manner. At RA553 and RA554, the relay R550 connects the control conductor C488 to the grounded time cut-off conductor C697 over a path including C585 and RA659'. After this holding path is completed the conductor C488 is disconnected from ground at RA554 and its associated resting contact.

A predetermined time interval after the relay R550 operates, the time cut-off conductor C697 is disconnected from ground, thereby to deenergize the operated relays of the finder switch 20 and to cause the release of this switch. During the release of the finder switch 20 the loop circuit extending to the connector portion of the link is interrupted, thereby to cause the sequential release of the relays R425, R430, R425, R420, R410 and R540 in the order named. The relay R420 releasing opens the previously traced operating circuit for the relay R550, causing the latter relay to restore. Thus, the link comprising the finder switch 20 and the connector switch 25 is fully released.

When the control conductor C488 is disconnected from ground the cut-off relay R350 is deenergized and restores, assuming that the line 10 is the line upon which the calling condition exists. The relay R350 releasing recompletes the operating circuit for the line relay R360. The relay R360 operating, completes, at RA364, an obvious holding circuit for the operated slow-acting lockout relay R340. Thus, the relays R360 and R340 associated with the line 10 are held operated until the calling condition present on this line is terminated. With the relay R360 operated, the private conductor C303 is connected to ground to mark the line 10 as busy in the bank contacts of the connector switches having access thereto. With the relay R340 operated, the path for impressing ground potential upon the distributor start conductor C306 is held open at RA343 and its associated resting contact. Obviously, the two relays R360 and R340 are caused sequentially to restore when the calling condition present on the line 10 is terminated.

In the event the operation of the link release relay R550 is due to a delay in dialing and the dialing operation is completed to cause the operation of one of the two line switching relays R650 and R660 prior to the disconnection of the time cut-off lead C697 from ground, the link is not forcibly released. More specifically, when either of the two enumerated line switching relays operates, the previously traced holding circuit for the link release relay R550 is interrupted at RA657 or RA668. The relay R550 is thus deenergized. In releasing, the relay R550 again connects the control conductor C488 to ground at RA554 and its associated resting contact, following which, this control conductor is disconnected from the time cut-off lead C697. From the foregoing explanation it will be apparent that in any case where a calling subscriber fails to complete a dialing operation the link comprising the finder switch 20 and the local connector switch 25 is forcibly released under the control of the timing device 695.

In the event the line 10, for example, is arranged for magneto operation and a seizing pulse of alternating current is transmitted by way of this line to cause the seizure of the finder switch 20 and the local connector switch 25, in the manner previously explained, the link is released under the control of the timing device 696 if the calling subscriber fails to complete the initiation of the call. Under the circumstances stated, the relay R600 is the only relay which is operated in the connector switch 25. In operating, the relay R600 prepares a circuit for energizing the relay R510 when a ground pulse is thereafter impressed upon the start timing conductor C517. This circuit, when completed, extends by way of the grounded conductor C517, RA513, C581, RA605, C478' and the winding of R510 to battery. The relay R510, upon operating, completes a holding circuit for itself, this holding circuit extending from ground by way of RA512, RA513,

C581, RA605, C478' and the winding of R510 to battery. At RA514 and RA515, the relay R510 completes an alternative holding circuit for the operated relay R600, this circuit extending by way of the grounded time cut-off conductor C516, RA514, RA515, the off-normal springs 517', C489', RA607, C487, RA405, RA416, RA406', C490, C585 and the lower winding of R600 to ground. Ground potential is obviously impressed on the control conductor C488 over a portion of the circuit just traced. After this holding circuit is completed, the relay R510 opens, at RA515 and its associated resting contact, the initially completed holding circuit for the relay R600 and the initially completed path for impressing ground potential upon the control conductor C488. In the event a simplex loop circuit is not established by way of the calling line 10 and the windings of the relay R435 before the time cut-off lead C516 is disconnected from ground, the link is released. More specifically, when the lead C516 is disconnected from ground, the finder switch 20 and the line circuit 10_a are both released in the manner previously explained. Further, the relay R600 is deenergized and restores. This relay upon restoring opens, at RA605, the previously traced holding circuit for the relay R510, causing the latter relay to restore. Thus, the line circuit 10_a, the finder switch 20 and the connector switch 25 are all released and conditioned for further operation.

In the event a simplex loop circuit is established by way of the calling line 10 to cause the operation of the relays R435, R430, R425, R420 and R410 prior to disconnection of the conductor C516 from ground, in the manner just explained, the link is held operated independently of the relay R510 and the timing device 696. Under these circumstances, ground potential is impressed upon the conductor C488 over a path including RA554, C489, RA415 and RA416, when the relay R410 operates. Hence, the presence or absence of ground potential upon the conductor C516 is without effect upon the connector switch 25 following operation of the relay R410.

It will be recalled from the preceding explanation that when a call is initiated on a line arranged for magneto operation to cause the operation of the relay R600 in the local connector switch 25, for example, the simplex loop circuit is completed through removal of the receiver at the calling substation from its supporting hook or cradle. If no dialing operation is thereafter performed at the calling substation, the timing device 695 in cooperation with the link release relay R550 functions to cause the release of the connector switch 25 and the associated finder switch 20 in the exact manner just explained.

VII. Trunk call—*Manual office No. 1 to substation A*

If a call originating on a line terminating at the manual office No. 1 and intended for the substation A is routed to the position of the operator assigned to handle calls routed over the trunk line 22, this operator may forward the connection by seizing the trunk line 22 and dialing the digits of the directory number designating the called substation A. To seize the trunk line 22, the operator inserts the plug terminating one end of her cord circuit in the call and answer jack 2150. In response to this operation, the jack springs 2151 and 2152 are moved into engagement to complete the previously traced circuit for energizing the relay R2005. Upon operating, the relay R2005, opens, at RA2006 and RA2007, respectively, points in the previously traced operating circuits for the relays R1930 and R1950, respectively. At RA2006 and its associated working contact, the relay R2005 completes the operating circuit for the slow-to-release relay R2020. The relay R2020 in operating completes, at RA2021, the previously mentioned circuit for energizing the supervisory lamp 2156, this circuit extending from ground by way of RA2021, RA2032, C2083, RA2107 and the filament of the lamp 2156 to battery. At RA2022, the relay R2020 prepares the previously traced operating circuit for the relay R1970. At RA2023, the relay R2020 opens a point in the operating circuit for the relay R2030 and prepares the previously traced operating circuit for the relay R2105. At RA2024, the relay R2020 completes the previously traced circuit for energizing the busy signal lamp 2158 and in so doing prepares the holding circuits for the two relays R2105 and R2120. At RA2024, the relay R2020 also completes one of the operating circuits for the relay R1920, this circuit extending from ground by way of RA2024, C1988, RA1974, RA1901 and the winding of R1920 to battery. Upon operating, the relay R1920 completes, at RA1921 and RA1923, respectively, the previously traced operating circuits for the relays R1930 and R1950, respectively, causing both of these relays to operate. The relay R1930, upon operating, connects the conductors of the trunk line 22 to the terminals of the alternating current source and, completes, at RA1933, the operating circuit for the relay R1910. The relay R1950, upon operating, disconnects the conductors of the trunk line 22 from the terminals of the repeating coil 2073. The relay R1910 operating, completes the operating circuit for the relay R1900 and the latter relay interrupts the operating circuit for the relay R1920. Thus, the relays R1920, R1910 and R1900 are caused sequentially to restore in the order named. During the interval when the relay R1910 is operated, the previously traced circuit is completed for energizing the relay R1970. The relay R1970, upon operating, completes its holding circuit and, opens, at RA1974, a point in the above-traced operating circuit for the relay R1920. Thus, the relays R1920, R1910 and R1900 remain in their respective restored positions after one cycle of operation thereof. The relay R1930, upon restoring, disconnects the conductors of the trunk line 22 from the alternating current source and, opens, at RA1933, a further point in the operating circuit for the relay R1910. The relay R1950, upon restoring, connects the conductors of the trunk line 22 to the line terminals of the repeating coil 2073. From the foregoing explanation it will be apparent that when the trunk circuit apparatus 45, illustrated in Figs. 19, 20 and 21, is seized, the control equipment embodied therein functions to transmit a seizing pulse of alternating current over the trunk line 22 to the repeater 40, illustrated in Figs. 16 to 18, inclusive.

The relay R1760 responds to the seizing pulse of alternating current transmitted over the trunk line 22 by operating to complete, at RA1762, a circuit for energizing the relay R1720. This circuit extends from ground by way of RA1762, C1617, RA1674, C1616, RA1725 and the upper winding of R1720 to battery. When its upper winding is energized over this circuit, the relay R1720 only partially operates to complete, at the "X" contacts associated with RA1727, a path for short-circuiting its lower winding, this path ex-

tending from ground by way of RA1727, RA1713, the lower winding of R1720, RA1725, C1616, RA1674, C1617 and RA1762 back to ground. When the seizing pulse of alternating current is ended the relay R1760 is deenergized and restores, to open the short-circuiting path just traced. When this path is interrupted, the two windings of the relay R1720 are energized in series and this relay fully operates, to complete, at its armatures RA1721, RA1722 and RA1723, a loop circuit including the link line 17 and extending through the windings of the line relay R1500 embodied in the toll connector switch 50, illustrated in Figs. 14 and 15. This loop circuit may be traced as extending from ground by way of the lower winding of R1500, the lower winding of R1510, RA1523, the repeater winding 1571, RA1534, the conductor 17_a, RA1721, the repeater winding 1546, the upper winding of R1750, the resistor 1736, RA1722, C1771, RA1861, C1770, the repeater winding 1747, RA1723, the conductor 17_b, RA1536, the repeater winding 1572, RA1524, the upper winding of R1510 and the upper winding of R1500 to battery. At RA1724, the relay R1720 completes a path for impressing ground potential upon the connected control conductors 12_c and 17_c of the trunk line 12 and the link line 17, respectively, this path extending from ground at RA1724 by way of C1615 and RA1606 to each of the two conductors 12_c and 17_c. When this path is completed the repeater 40, illustrated in Figs. 16 to 18, inclusive, is marked as busy in the bank contacts of the connector switches having access thereto. At RA1725, the relay R1720 opens a further point in its operating circuit and prepares a locking circuit for the relay R1710. At RA1726, the relay R1720 completes an obvious circuit for energizing the polarizing winding of the back bridge relay R1750. The last-mentioned relay is so poled that it only operates when its lower winding is energized and its upper winding is energized by current of a particular polarity. The direction of current flow over the loop circuit as traced above is the reverse of that required to cause the operation of the relay R1750. At RA1726, the relay R1720 also completes a circuit for energizing the upper winding of the relay R1830, this circuit extending from ground by way of RA1726, C1771', RA1852 and the upper winding of R1830 to battery.

The relay R1830, upon operating, initiates the cyclic operation of the three relays R1810, R1800 and R1820 and the operation of the timing switch 1680 in the manner previously explained in section II. The purpose of initiating the operation of the three indicated relays and the timing switch at this time is to forcibly release the repeater 40 in the event no dial pulses are transmitted thereto within a predetermined time interval after the repeater is seized. The manner in which the repeater is thus released is described in detail hereinafter. At RA1728, the relay R1720 completes a circuit for energizing the slow-to-release relay R1870, this circuit extending from ground by way of RA1728, C1778, RA1883, RA1856 and the winding of R1870 to battery. At RA1729, the relay R1720 prepares certain operating and holding circuits specifically referred to hereinafter. The relay R1870 operating, opens, at RA1871, a point in one of the operating circuits for the relay R1830. At RA1872, the relay R1870 opens a point in the previously traced path for impressing ground potential upon the wiper 1683 of the timing switch 1680. At RA1873, the relay R1870 prepares a holding circuit for itself. Finally, at RA1874, the relay R1870 prepares an operating circuit for the relay R1850. Following the relay operation just described, the control apparatus embodied in the repeater 40 is conditioned to respond to pulses of alternating current transmitted thereto over the trunk line 22 from the trunk circuit apparatus 45 as a result of dial operation.

When the above-traced loop circuit extending through the windings of the two relays R1500 and R1510 is completed, the relay R1500 operates, to complete a circuit for energizing the slow-acting hold relay R1450, this circuit extending from ground by way of RA1532, RA1501, C1478 and the winding of R1470 to battery. The relay R1510 is differentially wound and, accordingly, does not operate when its two windings are energized in series with the windings of the line relay R1500 over the above-traced loop circuit. The relay R1450 in operating, completes a circuit for energizing the upper winding of R1440, this circuit extending from ground by way of RA1451, the off-normal springs 1426 and the upper winding of R1440 to battery. At RA1452, the relay R1450 prepares certain operating and holding circuits described subsequently. At RA1453, the relay R1450 opens a point in the operating circuit for the release magnet 1537. At RA1454, the relay R1450 prepares a circuit for energizing the vertical magnet 1423 in parallel with the lower winding of R1440 during the first series of impulses transmitted to the toll connector switch 50. The relay R1440, upon operating, further prepares the last-mentioned circuit at RA1443. At RA1441, the relay R1440 prepares a circuit for energizing the relays R1420 and R1460 in series. At RA1444, the relay R1440 completes a circuit for conducting dial tone signal current through the winding 1574 of the repeating coil 1570. This circuit extends from the ungrounded terminal of the dial tone current source, not shown, by way of RA1444, C1484, the condenser 1502, the winding 1574, RA1562, the upper winding of R1520 and the exchange battery to the grounded terminal of the current source. Due to the alternating character of the current traversing this circuit a corresponding voltage is induced in the repeater winding 1572, which voltage is transmitted by way of the repeater 40 and the trunk circuit apparatus 45 to the receiver embodied in the operator's cord circuit. The operator is thus informed that the dialing operation may be started. Following the relay operations just described, the connector switch 50 is conditioned to respond to impulses repeated thereto through operation of the control apparatus embodied in the repeater 40.

In order to transmit to the connector switch 50 the impulses of the directory number designating the called substation A, the operator inserts the dialing plug 2163 in the dial jack 2153 and then dials the digits of the directory number. Each time the dial of the calling device 2160 is moved off-normal, the shunt springs 2162 are engaged to complete a circuit for energizing the slow-to-release relay R2100, this circuit extending from ground by way of the shunt springs 2162, the ring contact of the plug 2163, the ring contact of the jack 2153 and the winding of R2100 to battery. Upon operating, the relay R2100, completes, at RA2102 and RA2101, an alternative circuit for energizing the relay R2005, this circuit extending from ground by way of the pulsing springs 2161, the tip contact of the plug 2163, the tip contact of the jack 2153, RA2102, RA2101, C2085, RA2043 and the

winding of R2005 to battery. After this alternative circuit is completed the initially completed operating circuit for the relay R2005 is interrupted at RA2101 and its associated resting contact. During each return movement of the dial embodied in the calling device 2160, the pulsing springs 2161 are opened and closed a number of times determined by the numerical value of the digit dialed. For example, if the directory number designating the substation A is the number 45, the first digit dialed will comprise four impulses so that the above-traced alternative operating circuit for the relay R2005 is opened and closed four times. Each time the dial of the calling device 2160 is returned to its normal position, the shunt springs 2162 are disengaged to open the operating circuit for the relay R2100. This relay restores after an interval, to recomplete, at RA2101 and its associated resting contact, the initially completed operating circuit for the relay R2005; following which it interrupts, at RA2101 and RA2102, the above-traced alternative circuit for energizing the relay R2005.

Upon restoring at the beginning of the open circuit period of the first impulse transmitted thereto, the relay R2005 recompletes, at RA2007, the previously traced operating circuit for the slow-acting relay R1950. At RA2006, the relay R2005 opens the operating circuit for the relay R2020 and recompletes the previously traced operating circuit for the relay R1930. The relay R1950, upon operating, disconnects the conductors of the trunk line 22 from the repeating coil 2073. Due to their slow-to-release characteristics, the relays R1950 and R2020 remain operated throughout each series of impulses transmitted to the relay R2005. The relay R1930, upon operating at the beginning of the open circuit period of each impulse, connects the conductors of the trunk line 22 to the alternating current source. This relay also releases at the end of the open circuit period of each impulse in response to the release of the relay R2005. Thus, the relay R1930 follows the impulses resulting from operation of the calling device 2160 and functions to transmit corresponding alternating current impulses over the trunk line 22 to the repeater 40. At the end of each series of impulses, the relay R2005 remains in its restored position so that the relay R2020 is held energized and the relays R1930 and R1950 are caused sequentially to restore to reconnect the conductors of the trunk line 22 to the line terminals of the repeating coil 2073. After the dialing operation has been performed in the manner just described, the dial plug 2163 may be withdrawn from the dial jack 2153.

The control apparatus in the repeater 40 functions to convert the alternating current pulses transmitted thereto over the trunk line 22 into direct current impulses which are transmitted over the loop circuit comprising the link line 17 to the pulsing relay R1500 embodied in the toll connector switch 50. More particularly, the relay R1760 operates at the beginning of each pulse of alternating current transmitted over the trunk line 22 and restores at the end of each pulse. Upon operating at the beginning of the first received alternating current pulse, the relay R1760 completes a circuit for energizing the relays R1730 and R1880 in parallel. This circuit extends from ground by way of RA1762, C1617, RA1674, C1616, RA1725 and C1772 to RA1864 where it divides, one branch extending through the lower winding of R1880 to battery and the other branch extending by way of C1665 and the winding of R1730 to battery. The relay R1730, upon operating, completes, at RA1731, an obvious path shunting the upper winding of R1750 in series with the resistor 1736 and the repeater winding 1746. At RA1732, the relay R1730 completes an obvious path for short-circuiting the repeater winding 1747. Thus, the resistance of the circuit elements 1736, 1746, 1747 and the upper winding of R1750 is excluded from the pulsing circuit over which the impulses are transmitted to the toll connector switch 50. Due to its slow-to-release characteristic, the relay R1730 remains operated during each series of impulses transmitted to the repeater 40. The relay R1880, upon operating at the beginning of the first alternating current impulse transmitted to the relay R1760, completes, at RA1882, a path for short-circuiting the upper winding of R1860, this path extending from ground at RA1728 by way of C1778, RA1882, the upper winding of R1860, RA1864, C1772, RA1725, C1616, RA1674, C1617 and RA1762 back to ground. At RA1881, the relay R1880 prepares a holding circuit for itself. At RA1883, the relay R1880 opens the operating circuit for the relay R1870 and completes a circuit for energizing the relay R1850, this circuit extending from ground at RA1728 by way of C1778, RA1883, RA1874 and the winding of R1850 to battery. The relay R1850, upon operating, completes a holding circuit for itself, this circuit extending from ground at RA1728 by way of C1778, RA1855 and the winding of R1850 to battery. At RA1853, the relay R1850 further prepares the holding circuit for the relay R1870. At RA1851, the relay R1850 prepares one of the operating circuits for the relay R1830 and in so doing prepares circuits for energizing the relays R1640 and R1650. At RA1856, the relay R1850 further opens the above-traced operating circuit for the relay R1870. At RA1852, the relay R1850 interrupts the previously traced operating circuit for the relay R1830, whereby the latter relay is caused to restore during the portion of the next operating cycle of the three relays R1800, R1810 and R1820 when the first two thereof are restored. Upon restoring, the relay R1830, opens, at RA1832 and RA1833, the previously traced operating circuits for the relays R1810 and R1800, respectively, whereby the two last-named relays and the relay R1820 are prevented from reoperating. The relay R1830 also completes, at RA1834, the previously traced operating circuit for the release magnet 1686, whereby the wipers 1683 and 1684 are restored to normal in the manner previously described. When these wipers are restored to normal, the off-normal springs 1687 are opened to interrupt the operating circuit for the release magnet 1686. At RA1831, the relay R1830 further prepares the above-mentioned operating circuits for the relays R1640 and R1650.

At the end of the first alternating current pulse transmitted over the trunk line 22 to the repeater 40, the relay R1760 releases to open, at RA1762, the above-traced path short-circuiting the upper winding of the relay R1860, permitting this winding to be energized in series with the lower winding of R1880 over a circuit which extends from ground at RA1728 by way of C1778, RA1882, the upper winding of R1860 and the lower winding of R1880 to battery. Upon restoring, the relay R1760 also completes the above-mentioned holding circuit for the relay R1870,

this circuit extending from ground by way of RA1762, C1775, RA1853, RA1873 and the winding of R1870 to battery. The relay R1860 operates when its upper winding is energized in series with the lower winding of R1880 and completes, at RA1862, a circuit extending by way of RA1881 for energizing the upper winding of R1880. At RA1863, the relay R1860 completes an obvious path for short-circuiting its lower winding, thereby to render itself slow to release. At RA1864, the relay R1860 further opens the previously traced operating circuit for the relay R1880 and the above-traced path for short-circuiting its upper winding. At RA1861, the relay R1860 opens a point in the above-traced loop circuit extending by way of the link line 17 through the windings of the line relay R1500 embodied in the toll connector switch 50. Thus, the open circuit period of the first impulse dialed at the operator's position in the manual office No. 1 is repeated to the relay R1500. The relay R1880 is differentially wound so that when its upper winding is energized in response to operation of the relay R1860, it restores, to open, at RA1882, the circuit serially including its upper winding and the upper winding of R1860. At RA1881, the relay R1880 opens a point in the circuit for energizing its upper winding. At RA1883, the relay R1880 opens the previously traced operating circuit for the relay R1850. The relay R1860 restores a short time interval following the release of the relay R1880, this interval being determined by the release period of the first-mentioned relay. Upon restoring, the relay R1860, reprepares, at RA1864, the operating circuit for the relay R1880 and interrupts, at RA1863, the path short-circuiting its lower winding. At RA1861, the relay R1860 recompletes the loop circuit extending by way of the link line 17 through the windings of the line relay R1500. Following the release of the relay R1860, the impulse correcting network comprising this relay and the relay R1880 is conditioned to respond to the second operation of the alternating current relay R1760, which second operation occurs when the second alternating current pulse is transmitted over the trunk line 22 to the repeater 40. Upon operating at the beginning of the second pulse, the relay R1760, opens, at RA1762, the previously traced holding circuit for the relay R1870. At RA1762, the relay R1760 also recompletes the operating circuit for the relay R1880, causing the last-mentioned relay to reoperate and recomplete the path for short-circuiting the upper winding of R1860. At the end of the second alternating current pulse when the relay R1760 again restores, the path short-circuiting the upper winding of R1860 is again interrupted permitting this winding to be energized in series with the lower winding of R1880. Accordingly, the relay R1860 is caused to reoperate to again complete the circuit for energizing the upper winding of R1880 and to again interrupt, at RA1861, the loop circuit extending by way of the link line 17 to the toll connector switch 50. Following the reoperation of the relay R1860, the relays R1880 and R1860 are caused sequentially to restore in the exact manner described above. During each succeeding alternating current impulse transmitted over the trunk line 22 to the repeater 40, the relays R1760, R1880 and R1860 interact in the exact manner just described and the last-mentioned thereof functions to repeat the impulses to the line relay R1500 of the tool connector switch 50. Due to slow-to-release characteristics thereof, the relays R1870 and R1730 remain operated during each series of impulses. At the end of each series of impulses, the relay R1760 remains in its restored position for an interval sufficiently long to permit the release of the slow-acting relay R1730. This relay, upon restoring, opens, at RA1731, the path shunting the repeater winding 1746, the upper winding of R1750 and the resistor 1736. At RA1732, the relay R1730 opens the path short-circuiting the repeater winding 1747. Obviously, the relay R1730 remains in its restored position after the two digits of the directory number designating the called substation A have been dialed at the operator's position.

The line relay R1500 follows the impulses of the first digit and functions to transmit these impulses to the vertical magnet 1423. More particularly, when the line relay R1500 restores at the beginning of the open circuit period of the first impulse, it opens, at RA1501, the above-traced operating circuit for the slow-to-release hold relay R1450. At RA1501 and its associated resting contact, the relay R1500 completes the circuit for energizing the magnet 1423 in parallel with the lower winding of the relay R1440. This circuit extends from ground by way of RA1532, RA1501, C1477 and RA1454 to RA1443 where it divides, one branch extending through the winding of the magnet 1423 to battery, and the other branch extending through the lower winding of R1440 to battery. When energized over this circuit, the magnet 1423 operates to elevate its wipers 1405 to 1409, inclusive, one step in the vertical direction. In response to this first step of the enumerated wipers, the off-normal springs 1426 are opened to interrupt the previously traced operating circuit for the relay R1440. The last-mentioned relay, due to its slow-to-release characteristic, remains operated during the first series of impulses transmitted to the connector switch 50. The off-normal springs 1538 are also moved into engagement in response to the first vertical step taken by the wipers 1405 to 1409, inclusive. During the open circuit period of each succeeding impulse of the first series, the vertical magnet 1423 is again energized to step the indicated wipers one step. Accordingly, at the end of the first digit the wipers are left standing in a position opposite the level of bank contacts terminating the subgroup of subscribers' lines which includes the called line 10. In the present case wherein the line 10 is assumed to be the fifth line of the fourth group of lines, the wipers of the connector switch 50 are left standing in a position opposite the fourth level of bank contacts at the end of the first series of impulses. During the interdigit pause between the first and second digits, the line relay R1500 is held operated for a time interval sufficiently long to permit the release of the relay R1440. This relay in releasing, opens, at RA1443 and its associated working contact, the above-traced circuit for energizing its lower winding in parallel with the winding of the magnet 1423. At RA1443 and its associated resting contact, the relay R1440 prepares a circuit for energizing the relay R1400 in parallel with the rotary magnet 1417 during the second series of impulses transmitted to the switch.

At the beginning of the first impulse of the second digit, the line relay R1500 restores to complete the circuit for energizing the relay R1400 and the magnet 1417 in parallel, this circuit extending from ground by way of RA1532,

RA1501, C1477, RA1454 to RA1415 where it divides, one branch extending through the winding of R1400 to battery and the other branch extending by way of RA1422, C1476, RA1546, C1475 and the winding of the magnet 1417 to battery. When energized over this circuit, the relay R1400 operates, to shunt the restored armature RA1415 of the busy test relay R1410, thereby to prevent the above-traced pulsing circuit from being interrupted in response to operation of the busy test relay occasioned by movement of the wipers 1405 to 1409, inclusive, over contacts terminating busy lines. At RA1402, the relay R1400 prepares a path for short-circuiting the upper winding of R1420 and completes a circuit for energizing the slow-to-release relay R1460, this circuit extending from ground by way of RA1402, the resistor 1404 and the winding of R1460 to battery. At RA1401, the relay R1400 opens a point in the trunk hunting test circuit, traced hereinafter, over which the busy test relay R1420 is energized during trunk hunting operations on the part of the connector switch. The relay R1460, upon operating, prepares, at RA1463, a circuit for energizing the busy test relay R1410.

The rotary magnet 1417 operates to step the wipers 1405 to 1409, inclusive, one step in the rotary direction in response to each operation of the pulsing relay R1500. At the end of the second digit, therefore, the indicated wipers are left standing in engagement with the conductors terminating the called line 10. Immediately the line 10 is selected in this manner it is tested to determine the idle or busy condition thereof. In this regard it will be recalled from the foregoing explanation, that if the line 10 is idle, battery potential is impressed upon the private conductor C303 through the winding of the cut-off relay R350. On the other hand, if the line 10 is busy, ground potential is impressed upon the indicated control conductor. Assuming that the line 10 is idle at the time it is thus selected, the busy test relay R1410 is short-circuited and does not operate. Shortly following the end of the second digit, the relay R1400 restores, to open the above-traced operating circuit for the relay R1460. The relay R1460 restores after an interval to complete a circuit for energizing the slow-to-operate line switching relay R1540, this circuit extending from ground by way of RA1452, RA1414, C1472, the lower winding of R1540, C1471, RA1463, C1467, the private wiper 1406, C303, RA362 and the winding of R350 to battery. When energized over this circuit, the relay R1540 first operates, to complete, at the "X" contacts associated with RA1545 a holding circuit for itself, this holding circuit extending from ground by way of RA1452, C1473, RA1545 and the upper winding of R1540 to battery. After this circuit is completed, the relay R1540 fully operates, to open, at RA1544, the above-mentioned test circuit including the winding of the busy test relay R1410. At RA1542, the relay R1540 completes a path for connecting the private conductor C303 of the called line 10 to ground, this path extending from ground by way of RA1452, C1473, RA1542, C1467 and the private wiper 1406 to the private conductor C303. When the private conductor C303 is thus grounded the called line 10 is marked as busy in the bank contacts of the connector switches having access thereto and the cut-off relay R350 is energized over a circuit extending by way of this conductor, RA362 and the winding of R350 to battery. When thus energized the relay R350 operates to disconnect the windings of the line relay R360 from the conductors of the line 10 and thus clear the called line of the impedance represented by the line relay windings. Assuming that the "Y" wiring, illustrated in Fig. 1, is used, the cut-off relay R350, upon operating, also completes, at RA353 and RA354, an obvious circuit for energizing the metering device 365. The resistance of the resistor 356 included in this circuit is such that the indicated metering device does not operate when thus energized.

The operation of the connector switch 50 is different depending upon whether the called line 10 is arranged for loop or simplex operation. Assuming that this line is arranged for loop operation such that the "Y" wiring, illustrated in Fig. 3, is used, the extra control contact of the contact set terminating the conductors of this line is connected to ground. Hence, the relay R1540, upon operating in the manner described above, completes a circuit for energizing the relay R1430. This circuit extends by way of the grounded extra control contact of the contact set terminating the conductors of the line 10, the wiper 1407, the winding of R1430, C1469 and RA1543 to battery. The relay R1430 in operating prepares a circuit whereby the two windings of the back bridge relay R1520 may be energized in series over the loop circuit which is established between the connector switch 50 and the called substation A when the call is answered. In the event the called line 10 is arranged for simplex operation, such that the "X" wiring, illustrated in Fig. 3, is used, the extra control contact in the bank associated with the wiper 1407 and included in the contact set terminating the conductors of this line is not connected to ground and, accordingly, the above-traced operating circuit of the relay R1430 is not completed in response to operation of the line switching relay R1540. With the relay R1430 restored, a circuit is prepared, at RA1431, for energizing the back bridge relay R1520 over the simplex circuit which is established between the connector switch 50 and the called substation A when the call is answered.

The relay R1540, upon operating, also opens, at RA1546, the above-traced circuit for energizing the rotary magnet 1417, thereby to prevent this magnet from responding to further impulses inadvertently transmitted to the pulsing relay R1500. At RA1547 and RA1548, the relay R1540 further prepares the desired talking circuit between the operator's position and the called substation A, and completes a circuit for transmitting ringing current over the called line to energize the signal device provided at the called substation. The path traversed by this current may be traced as extending from the ungrounded terminal of the ringing current source 555 by way of the interrupter springs 556, RA1552, RA1547, RA1533, C1482, the wiper 1408, C301, the signal device bridged across the conductors of the line 10 at the called substation, C302, the wiper 1409, C1483, RA1535, RA1548, RA1553, the lower winding of R1550 and the exchange battery to the grounded terminal of the ringing current source. Ringing current is also by-passed through the repeater winding 1574 of the repeating coil 1570 over a circuit extending from the ungrounded terminal of the generator by way of the interrupter springs 556, the condenser 1543, RA1549, RA1554, the winding 1574, RA1562, the upper winding of R1520 and the exchange battery to the grounded terminal of the generator 555. The current traversing this circuit is transmitted by induction through the repeater 40, over

the trunk line 22 and through the trunk circuit apparatus 45 to the operator's telephone set so that the operator is informed that the called substation is being signaled. Due to the circuit interrupting action of the springs 556 controlled by the cam 557, the ringing current circuit just traced is only intermittently completed.

When the call is answered at the called substation, a direct current bridge is connected across the conductors of the line 10 so that the lower winding of the ring cut-off relay R1550 is energized over a circuit substantially similar to that traced above and traversed by the ringing current. When energized over this circuit, the relay R1550 first operates, to complete at the "X" contacts associated with RA1551, a holding circuit for itself. This holding circuit extends from ground by way of RA1451, C1466, RA1551 and the upper winding of R1550 to battery. After this circuit is completed, the relay R1550 completes its operation to open, at RA1552 and RA1553, two points in the above-traced circuit by way of which ringing current is transmitted over the called line. At these same armatures, the relay R1550 also opens two points in its operating circuit. At RA1554 and its associated resting contact, the relay R1550 interrupts the above-traced circuit over which ringing current is bypassed through the coil 1574 of the repeating coil 1570, thereby to terminate the ring-back tone signal being transmitted to the calling operator's position. At RA1552 and RA1553 and their respective associated working contacts, the relay R1550 connects the link line conductors C1482 and C1483 to the line terminals of the repeater coil windings 1573 and 1574, thereby to complete the desired talking circuit between the called substation and the calling operator's position. When the relay R1550 operates it also completes the above-mentioned circuit for energizing the back bridge relay R1520. In the event the called line 10 is arranged for loop operation, this circuit extends from ground by way of the lower winding of R1520, RA1563, C1479, RA1431, C1480, the winding 1573, RA1552, RA1547, RA1533, C1482, the wiper 1408, C301, the bridge connected across the conductors of the line 10 at the called substation, C302, the wiper 1409, C1483, RA1535, RA1548, RA1553, RA1554, the winding 1574, RA1562 and the upper winding of R1520 to battery. Current for energizing the transmitter provided at the substation A is supplied over the circuit just traced. In the event the called line is arranged for simplex operation, such that the relay R1430 occupies its restored position, one branch of the circuit for energizing the relay R1520 extends from battery by way of the upper winding of R1520, RA1562, the winding 1574, RA1554, RA1553, RA1548, RA1535, C1483, the wiper 1409, C302 and through certain of the apparatus provided at the substation A to ground. The other branch of this circuit extends from battery through the upper winding of R1520 and by way of RA1562, C1481, RA1431, C1480, the winding 1573, RA1552, RA1547, RA1533, C1482, the wiper 1408, C301 and through certain of the apparatus provided at the substation A to ground. If the line 10 is arranged for simplex operation a battery for supplying energizing current to the transmitter is provided locally at the substation A. When energized over either of the two circuits traced above, the relay R1520 operates, to complete, at RA1521, an obvious multiple holding circuit for the ring cut-off relay R1550. At its armatures RA1522 to RA1525, inclusive, the relay R1520 reverses the direction of current flow over the loop circuit extending from the connector switch by way of the link line 17 and through the upper winding of the polarized relay R1750.

When the polarity of the current traversing the operating winding of the relay R1750 is thus reversed, this relay operates to complete an alternative circuit for energizing the relay R1810, this alternative circuit extending from ground by way of RA1762, RA1751, C1637, RA1643, RA1678, C1636, RA1821 and the winding of R1810 to battery. Upon operating, the relay R1810, completes, at RA1811 and RA1813, the previously traced operating circuits for the relays R1840 and R1765. The two relays R1830 and R 1840 now operate in the manner previously explained to disconnect the conductors of the trunk line 22 from the line terminals of the repeating coil 1745 and to connect these conductors to opposite terminals of the alternating current source, whereby a pulse of alternating current is transmitted over the trunk line 22 to the trunk circuit apparatus 45. The relay R1840, upon operating also completes the previously traced operating circuit for the relay R1800, thereby to cause the sequential operation of the last-named relay and the relay R1820. When the relay R1800 operates, the previously mentioned circuit is completed for energizing the relay R1640, this circuit extending from ground by way of RA1851, RA1831, RA1801, C1618, RA1645 and the lower winding of R1640 to battery. At RA1802, the relay R1800 prepares the previously traced circuit for energizing the relays R1670 and R1705. When its lower winding is energized over the circuit just traced, the relay R1640 partially operates, to complete, at the "X" contacts associated with RA1644, a path for short circuiting its upper winding, this path extending from ground by way of RA1729, RA1701, RA1708, C1646, RA1644, the upper winding of R1640, RA1645, C1618, RA1801, RA1831 and RA1851 back to ground. Since the relay R1640 is of the two-step type it does not fully operate until this short-circuiting path is broken. The relay R1820, upon operating, opens, at RA1821, the above-traced alternative operating circuit for the relay R1810, thereby to cause the sequential release of the three relays R1810, R1800 and R1820 in the order named. The relay R1810 releasing, opens the completed operating circuit for the relays R1765 and R1840, causing these relays to restore and terminate the alternating current pulse being transmitted over the trunk line 22. The relay R1800 releasing, opens, at RA1801, the above-traced path short circuiting the upper winding of R1640, permitting the two windings of the latter relay to be energized in series over a circuit extending from ground at RA1729 by way of RA1701, RA1708, C1646, RA1644 and the two windings of R1640 in series to battery. The relay R1640 now fully operates, to open, at RA1643 and its associated resting contact, a point in the above-traced alternative operating circuit for the relay R1810. Thus, further cyclic operation of the three relays R1810, R1800 and R1820 is prevented. At RA1643 and its associated working contact, the relay R1640 prepares another circuit for energizing the relay R1810. At RA1645, the relay R1640 opens a point in its operating circuit and prepares a circuit for energizing the two-step relay R1650.

At RA1641 and RA1642, the relay R1640 reversely connects the trunk line conductors 12_a and 12_b to the windings of the differentially wound relay R1630, but this operation is without effect on a call of the character under consideration.

The relay R2000 operates at the beginning of the alternating current pulse transmitted to the trunk circuit apparatus 45 when the call is answered at the called substation and restores when this pulse is ended. Upon operating, the relay R2000 completes, at RA2002, the previously traced circuit for energizing the upper winding of the relay R2105. When its upper winding is energized the relay R2105 partially operates to short circuit its lower winding. When the relay R2000 restores at the end of the alternating current pulse, it opens at RA2002 the path short-circuiting the lower winding of the relay R2105, permitting the two windings of the latter relay to be energized in series. The relay R2105 now completes its operation to interrupt, at RA2107, the circuit for energizing the supervisory lamp 2156. At RA2109, the relay R2105 opens a point in its operating circuit and prepares the circuit for energizing the upper winding of the relay R2120. When the supervisory lamp 2156 is extinguished in response to operation of the relay R2105, the operator supervising the connection is informed that the call has been answered and may complete the connection between the calling and called substation in the manner conventionally followed in manual office practice. The manner in which the connection when thus fully completed is released at the end of the conversation is explained in detail hereinafter.

In the event the called line 10 is busy at the time it is selected, the control apparatus embodied in the connector switch 50 operates in a substantially conventional manner to transmit to the calling operator's position the usual busy tone signal. In such case, the above-mentioned test circuit, including the winding of the busy test relay R1410, is completed at the end of the second digit dialed at the calling operator's position and immediately the wipers 1405 to 1409, inclusive, are operated into engagement with the contacts terminating the conductors of the called line. This circuit extends by way of the grounded private conductor C303, the private wiper 1406, C1467, RA1463, C1470, RA1544, C1468 and the winding of R1410 to battery. When energized over this circuit, the relay R1410 operates, to prepare a circuit for energizing the trunk hunting control relay R1420 and to prepare, at RA1413, a holding circuit for itself. This holding circuit is completed in response to the subsequent sequential release of the two relays R1400 and R1460 and extends by way of the grounded private wiper 1406, RA1413, RA1462, C1470, RA1544, C1468 and the winding of R1410 to battery. At RA1414, the relay R1410 opens a point in the previously traced operating circuit for the line switching relay R1540. At RA1415, the relay R1410 opens a point in the previously traced circuit for energizing the relay R1400 and the rotary magnet 1417 in parallel during the impulses of the second digit. At RA1411, the relay R1410 prepares a circuit for energizing the line switching relay R1560. At RA1416, the relay R1410 prepares a circuit for conducting busy tone signal current through the winding 1574 of the repeating coil 1570. The last-mentioned circuit is completed when the relay R1460 restores and extends from the ungrounded terminal of the busy tone signal current source, not shown, by way of RA1566, C1485, RA1463', RA1416, C1484, the condenser 1502, the winding 1574, RA1562, the upper winding of R1520 and the exchange battery to the grounded terminal of the busy tone current source. Due to the alternating character of the current traversing this circuit, a corresponding induced voltage is developed in the repeater winding 1572, which voltage is transmitted by way of the repeater 40 and the trunk circuit apparatus 45 to the telephone set embodied in the operator's cord circuit. The operator, upon failing to receive the usual answer signal within a reasonable time interval, may monitor the connection routed by way of the trunk circuit apparatus 45, the repeater 40 and the connector switch 50 to the called line 10, in which case she hears the busy signal and is informed that the called line is busy.

After receiving the busy signal, the operator may release the connection in the manner more fully described hereinafter, or she may cause a connection to be established to the busy called line and offer the call to the party conversing at the called substation. In order to establish a connection to the busy called line, the ringing key embodied in the operator's cord circuit is momentarily operated thereby to connect a source of ringing current across the tip and ring contacts of the jack 2150. In response to this operation the relay R2010 is energized over a circuit extending from one side of the ringing current source by way of the tip contact of the jack 2150, RA2121, C2078, RA2101, the winding 2076, the condenser 2004, the winding of R2010, the winding 2077, C2079, RA2122 and the ring contact of the jack 2150 to the opposite terminal of the ringing current source. This circuit is interrupted when the ringing key embodied in the operator's cord circuit is restored to normal. The relay R2010 operates when energized over the above-traced circuit and completes a circuit for energizing the relay R1960, this circuit extending from ground by way of RA1978, C1991, RA2011, C1994, RA1902 and the upper winding of R1960 to battery. Upon operating, the relay R1960 completes a holding circuit for itself, which circuit extends from ground by way of RA1978, RA1964 and the upper winding of R1960 to battery. At RA1965, the relay R1960 prepares a circuit for energizing its lower winding. At RA1963, the relay R1960 completes a circuit extending by way of RA1976 for energizing the relay R1940. At RA1961 and RA1962, the relay R1960 completes the previously traced operating circuits for the two relays R1930 and R1950. The two last-mentioned relays, upon operating, disconnect the conductors of the trunk line 22 from the repeating coil 2073 and connect these conductors to the alternating current source. The relay R1940, upon operating, initiates the cyclic operation of the three relays R1910, R1900 and R1920 in the manner previously explained. At RA1943 the relay R1940 prepares the previously traced holding circuit for itself and the previously traced operating circuit for the magnet 2070. With the relay R1940 operated, the circuit for energizing the magnet 2070 is completed once during each cycle of operation of the three relays R1910, R1900 and R1920. As a result, the wipers 2068 and 2069 are operated at the rate of one step for each cycle of operation of the three indicated relays. When these wipers are stepped to the first off-normal position, the off-normal springs 2072 are engaged to prepare the operating circuit for the release magnet 2071. When the

wipers 2068 and 2069 have been operated two steps, the above-mentioned circuit is completed for energizing the lower winding of R1960, this circuit extending from ground at RA1965 by way of C1993, the wiper 2068 and its associated second contacts, C1992 and the lower winding of R1960 to battery. The relay R1960 is differentially wound and, accordingly, when its lower winding is energized in the manner just explained it restores, to open, at RA1964, its previously traced holding circuit. Since the relay R2010 is now restored, the relay R1960 is not caused to reoperate. At RA1961 and RA1962, the relay R1960 interrupts the respective operating circuits for the relays R1930 and R1950, causing these two relays to restore to terminate the alternating current pulses being transmitted over the trunk line 22 and to reconnect the conductors of this trunk line to the repeating coil 2073. At RA1963, the relay R1960 interrupts the operating circuit for the relay R1940. When the relays R1910 and R1920 restore following the release of the relay R1960 the previously traced holding circuit for the relay R1940 is interrupted and this relay restores, to open, at RA1941, the operating circuit for the relay R1910, whereby the cyclic operation of the three relays R1910, R1900 and R1920 is arrested. The relay R1940, upon restoring, also completes, at RA1943, the above-traced operating circuit for the release magnet 2071, whereby the wipers 2068 and 2069 are returned to normal and the off-normal springs 2072 are disengaged to deenergize the release magnet. From the foregoing explanation it will be apparent that the momentary operation of the alternating current relay R2010 causes an alternating current pulse of medium length to be transmitted from the trunk circuit apparatus 45 over the trunk line 22 to the repeater 40. More particularly, the duration of this pulse is primarily determined by the time interval required for the wipers of the switch 2065 to be operated two steps.

The relay R1760 operates at the beginning of this alternating current pulse and restores at the end of the pulse. Upon operating, the relay R1760 completes, at RA1762, the previously traced circuit for energizing the lower winding of R1880 in parallel with the slow-acting relay R1730, causing both of these relays to operate. At RA1762 and its associated resting contact, the relay R1760 interrupts the previously traced holding circuit for the relay R1870. The interval during which the relay R1760 is operated is sufficient to permit the release of the slow-to-release relay R1870. The relay R1880, upon operating, prepares the circuit for energizing its upper winding and, completes, at RA1882, the previously traced path short circuiting the upper winding of R1860. The relay R1730, upon reoperating, completes, at RA1731 and RA1732, the shunt paths for excluding the repeater windings 1746 and 1747, the upper winding of R1750 and the resistor 1736 from the loop circuit extending by way of the link line 17 to the connector switch 50. The relay R1870, upon restoring, prepares, at RA1873, a path for impressing ground potential upon both conductors of the link line 17. At RA1871, the relay R1870 completes one of the operating circuits for the relay R1830, this circuit extending from ground at RA1851 by way of RA1871 and the upper winding of R1830 to battery. The relay R1830, upon operating, initiates the cyclic operation of the three relays R1810, R1900 and R1820 in the manner previously explained and, prepares, at RA1834, the previously traced operating circuit for the magnet 1685. During each cycle of operation of these three relays, the holding circuit for the relay R1830 is completed when either of the two relays R1800 and R1810 is operated. During each cycle of operation of the three enumerated relays, the operating circuit for the magnet 1685 is also completed when the relay R1820 is operated.

When the relay R1760 restores at the end of the alternating current pulse, the above-mentioned path is completed for impressing ground potential upon the conductors 17_a and 17_b of the link line 17, this path extending from ground by way of RA1762, C1775, RA1853, RA1873, C1776 to RA1733 where it divides, one branch extending by way of RA1732 and RA1723 to the line conductor 17_b and the other branch extending by way of C1770, RA1861, C1771, RA1722, RA1731 and RA1721 to the opposite line conductor 17_a. When this path is completed the lower winding of the differentially wound relay R1510 is deenergized causing this relay R1510 to operate.

The relay R1760, upon restoring at the end of the alternating current pulse, also opens the above-traced operating circuit for the relay R1730 and the previously traced path short circuiting the upper winding of the relay R1860, whereby the last-mentioned relay is caused to operate. Upon operating, the relay R1860 opens the ground path extending to the conductor 17_a, and initiates the sequential release of the relay R1880 and itself in the manner previously explained. The relay R1730, upon restoring, opens, at RA1733 and its associated working contact, the path for impressing ground potential upon the two conductors of the line 17, whereby both windings of the differentially wound relay R1510 are again energized and the latter relay reoperates. At RA1733 and its associated resting contact, the relay R1730 completes an alternative circuit for energizing the slow-to-release relay R1870, this circuit extending from ground at RA1762 by way of C1775, RA1853, RA1873, C1776, RA1733, C1777, RA1856 and the winding of R1870 to battery. Upon operating, the relay R1870 recompletes its holding circuit and opens, at RA1871, the operating circuit for the relay R1830. When the two relays R1810 and R1800 restore, following the reoperation of the relay R1870, the holding circuit for the relay R1830 is interrupted. The relay R1830 releasing opens points in the operating circuits for the relays R1800 and R1810. Thus, the cyclic operation of the relays R1810, R1800 and R1820 is arrested. Upon restoring, the relay R1830 also recompletes the previously traced circuit for energizing the release magnet 1686, whereby the wipers 1683 and 1684 are restored to normal and the off-normal springs 1687 are disengaged to deenergize the release magnet 1686. The wipers of the switch 1680 are only operated two steps during the relay operations just described, and with the relay R1720 operated, the operating circuit for the relay R1620 is open at RA1729'. Accordingly, the operation and subsequent release of the switch 1680 are without effect in the present instance.

The relay R1510, upon operating in the manner explained above, completes, at RA1511, the operating circuit for the relay R1560, this circuit extending from ground at RA1451 by way of C1466, RA1511 and the winding of R1560 to battery. The relay R1560, upon operating, completes a holding circuit for itself, this holding

circuit extending from ground at RA1451 by way of C1466, RA1541, C1465, RA1411, C1464, RA1561 and the winding of R1560 to battery. Thus, the relay R1560 is held operated after its operating circuit is opened in response to the release of the relay R1510. At RA1564 and RA1565, the relay R1560 bridges the repeating coil windings 1573 and 1574 across the conductors of the busy called line, thereby to complete a connection over which the operator may converse with the party using the telephone set provided at the called substation A. The branch of this talking circuit which extends from the called line to the repeating coil 1570 extends from the line conductor C301 by way of the wiper 1408, C1482, RA1533, RA1547, RA1564, the winding 1573, the condenser 1574', the winding 1574, RA1565, RA1548, RA1535, C1483 and the wiper 1409 to the opposite conductor C302 of the called line 10. At RA1562 and RA1563, the relay R1560 disconnects the windings of the back bridge relay R1520 from the talking bridge just traced, thus preventing battery potential from being impressed on the established connection involving the busy called line 10. After the bridging path traced above is completed the operator may break in upon the conversation being held over the previously established connection and offer the call to the party using the telephone set provided at the substation A. If this party accepts the offered toll call, the two parties using the previously established connection are instructed to hang up. During the release of the previously established connection, ground potential is removed from the private conductor C303 of the line 10, thereby to interrupt the previously traced holding circuit for the busy test relay R1410. When ground potential is removed from the private conductor C303, battery potential is impressed upon this conductor through the winding of the cut-off relay R350 embodied in the line circuit 10_a. The relay R1410 in releasing completes, at RA1414, the previously traced circuit for energizing the lower winding of the line switching relay R1540 in series with the winding of the cut-off relay R350. The relay R1540, upon operating, completes its holding circuit and performs the other functions previously described. From this point on, the manner in which the called substation is signaled and the desired talking circuit is completed when the call is answered at the called substation A, is exactly the same as previously described. Also, the manner in which the control apparatus embodied in the repeater 40 cooperates with the control apparatus embodied in the trunk circuit apparatus 45 to cause the supervisory lamp 2156 to be deenergized when the call is answered at the called substation is the same as set forth above.

The release of the connection as routed from the operator's position in the manual office No. 1 to the subscriber's line 10 is under the control of the operator who indicates the call regardless of whether the desired connection is obtained or the called line is found to be busy and the switch train is released without offering the call to the called subscriber. In the event the call is answered at the called substation A, the operator ordinarily will not release the connection until she receives the usual disconnect signal. This signal is received when the connection is cleared out at the called substation. More particularly, when the called subscriber hangs up, the loop circuit extending between the connector switch 50 and the called substation is interrupted. The back ridge relay R1520 is thus deenergized and restores. Upon restoring, this relay opens, at RA1521, the multiple holding circuit for the ring cut-off relay R1550 and, at its armatures RA1522 to RA1525, inclusive, reverses the direction of current flow over the loop circuit extending by way of the link line 17 and including the operating winding of the relay R1750. In response to this operation, the polarized relay R1750 restores to complete the previously traced operating circuit for the relay R1810. The relay R1810 operating, completes the operating circuits for the relays R1765 and R1840 and prepares the operating circuit for the relay R1800. The relays R1765 and R1840 operating, disconnect the conductors of the trunk line 22 from the repeating coil 1745 and connect the indicated trunk line conductors to the alternating current source. The relay R1800, upon operating, completes the operating circuit for the relay R1820. At RA1801, the relay R1800 completes a circuit for energizing the relay R1650, this circuit extending from ground by way of RA1851, RA1831, RA1801, C1618, RA1645, C1647, RA1709, C1648 and the lower winding of R1650 to battery. When energized over this circuit the relay R1650 only partially operates to complete, at the "X" contacts associated with RA1654, a path for short circuiting its upper winding, this path extending by way of the grounded conductor C1648, the upper winding of R1650, RA1654, C1639, RA1701 and RA1729 back to ground. The relay R1820, upon operating, opens, at RA1821, the operating circuit for the relay R1810, thereby to cause the sequential release of the relays R1810, R1800 and R1820. When the relay R1800 restores, it opens, at RA1801, the path short circuiting the upper winding of R1650, permitting the two windings of the latter relay to be energized in series. The relay R1650 now completes its operation to prepare, at RA1655, a circuit for energizing the relay R1660. At RA1653, the relay R1650 completes a circuit for energizing the relay R1700, this circuit extending from ground at RA1706 by way of C1628, RA1653, C1632 and the winding of R1700 to battery. The relay R1700 operates, after an interval, to open, at RA1701, the previously traced circuits for energizing the two operated relays R1640 and R1650, causing both of these relays to restore. The relay R1650, upon restoring, opens, at RA1653, the above-traced operating circuit for the relay R1700, and the latter relay, upon releasing, reprepares, at RA1701, the operating circuits for the relays R1640 and R1650. The relay R1640, upon restoring, opens, at RA1643, the previously traced operating circuit for the relay R1810, thus preventing the relays R1810, R1800 and R1820 from reoperating after the first cycle of operation thereof is completed. When the relay R1810 restores in response to the operation of the relay R1820, it opens the respective operating circuits for the relays R1765 and R1840, causing both of these relays to restore. The relay R1840, upon restoring, disconnects the conductors of the trunk line 22 from the alternating current source, thereby to terminate the supervisory pulse of alternating current which is transmitted over the indicated trunk line to the trunk circuit apparatus 45. When the relay R1765 restores, it reconnects the conductors of the trunk line 22 to the line terminals of the repeating coil 1745. The relays R2000, R2120, R2115 and R2110 respond to the supervisory pulse of alternating current to transmit a disconnect signal to the

operator handling the call in the exact manner previously described in Section II.

In order to release the connection, the operator withdraws the plug terminating one end of her cord circuit from the call and answer jack 2150. The manner in which the trunk circuit apparatus 45 operates in response to this operation is exactly the same as described in section II with reference to the release of the connection routed to the operator's position in the manual office No. 1 from the substation A. During the release of this apparatus, a relatively long release pulse of alternating current is transmitted over the trunk line 22 to the repeater 40. The relay R1760 operates at the beginning of this pulse and remains operated until the pulse is ended. Upon operating, this relay completes, at RA1762, the previously traced circuit for energizing the lower winding of the relay R1880 in parallel with the relay R1730, causing both of these relays to operate. At RA1762 and its associated resting contact, the relay R1760 opens the previously traced holding circuit for the slow-to-release relay R1870. The relay R1870 restores after an interval, to complete, at RA1871, the operating circuit for the relay R1830. The relay R1830, upon operating, initiates the cyclic operation of the three relays R1810, R1800 and R1820 and the step by step operation of the timing switch 1680 in the manner previously explained. When the wipers 1683 and 1684 are stepped into engagement with their respective associated third contacts, a circuit is completed for energizing the relay R1710, this circuit extending from ground at RA1762 by way of C1617, RA1674, C1616, RA1725, C1772, RA1684, C1665, the wiper 1684, C1666 and the winding of R1710 to battery. When energized over this circuit, the relay R1710 operates to complete a holding circuit for itself, this holding circuit extending from ground at RA1762 by way of C1617, RA1674, C1616, RA1725, RA1711 and the winding of R1710 to battery. At RA1712 and RA1713, the relay R1710 completes an alternative holding circuit for the relay R1720, this alternative circuit extending from ground at RA1762 by way of C1617, RA1674, C1616, RA1725, RA1711, RA1712, RA1713 and the two windings of R1720 to battery. Following the completion of this circuit, the relay R1710 interrupts, at RA1713 and its associated resting contact, the initially completed circuit for energizing the two windings of R1720 in series. When the release pulse of alternating current transmitted over the trunk line 22 is ended the relay R1760 restores, to open, at RA1762, the above-traced holding circuits for the relays R1710 and R1720 and the above-traced operating circuits for the relays R1730 and R1880. The relay R1720 immediately restores, to open, at RA1727, a further point in the initially completed circuit for energizing its two windings in series. At RA1726, the relay R1720 interrupts the circuit for energizing the polarizing winding of the relay R1750 and opens a point in one of the operating circuits for the relay R1830. At RA1725, the relay R1720 opens a further point in the previously traced circuit for energizing the lower winding of the relay R1880 and the relay R1730 in parallel and reprepares its own operating circuit. At RA1724, the relay R1720 opens one of the multiple paths for impressing ground potential upon the control conductors 12_c and 17_c of the lines 12 and 17, respectively. At RA1728, the relay R1720 interrupts the holding circuit for the relay R1850, causing the last-mentioned relay to restore. At RA1728, the relay R1720 also opens a point in the previously traced circuit for energizing the lower winding of R1880 in series with the upper winding of R1860, causing these two relays to restore, if operated. At its armatures RA1721 to RA1723, inclusive, the relay R1720 interrupts the loop circuit extending by way of the line 17 and through the windings of the relays R1510 and R1500, thereby to initiate the release of the operated connector switch 50. The relay R1710 restores shortly following the release of the relay R1720 and, upon restoring, reprepares, at RA1713 and its associated resting contact, the circuit for energizing the two windings of R1720 in series. The relay R1850, upon restoring, opens, at RA1853, a point in the holding circuit for the relay R1870. At RA1852, the relay R1850 reprepares one of the operating circuits for the relay R1830. At RA1851, the relay R1850 interrupts the completed operating circuit for the last-mentioned relay. The relay R1730 restores shortly following the release of the relay R1760. Following the release of the relay R1850 and when the two relays R1800 and R1810 restore, the relay 1830 is deenergized. Upon restoring, the relay R1830 opens the respective operating circuits for the two relays R1800 and R1810, thereby to prevent further cyclic operation of these two relays and the relay R1820. At RA1834, the relay R1830 completes the previously traced circuit for energizing the release magnet 1686, whereby the wipers 1683 and 1684 are restored to normal and the off-normal springs 1687 are disengaged. When these springs are moved out of engagement, the circuit for energizing the release magnet 1686 is interrupted. Following the release of the timing switch 1680 all of the control equipment embodied in the repeater 40 is fully released and this repeater is conditioned for further use.

When the relay R1720 restores to open the loop circuit extending to the operated connector switch 50, the line relay R1500 is deenergized and restores momentarily to recomplete, at RA1501 and its associated resting contact, the circuit for energizing the relay R1400, whereby the last-mentioned relay and the relay R1460 are caused to reoperate. At RA1501 and its associated working contact, the relay R1530 opens the operating circuit for the hold relay R1450. The relay 1450, upon restoring, opens, at RA1454, the completed operating circuit for the relay R1400, thereby to cause the sequential release of the relays R1400 and R1460. The momentary reoperation of the two last-mentioned relays is without effect. At RA1451, the relay R1450 interrupts the holding circuit for the ring cut-off relay R1550, causing the latter relay to restore. At RA1452, the relay R1450 opens the holding circuit for the relay R1540, whereby the last-mentioned relay is caused to restore. The relay R1540, upon restoring, opens, at RA1543, the previously traced operating circuit for the relay R1430, causing the latter relay to restore, if operated. At RA1452, the relay R1450 also disconnects the control conductors 17_c and 12_c from ground, whereby the repeater 40 is marked as idle in the bank contacts of the connector switches having access thereto. At RA1453, the relay R1450 completes a circuit for energizing the release magnet 1537, this circuit extending from ground by way of RA1453, C1474, the off-normal springs 1538, RA1531 and the winding of the magnet 1537 to battery. The release magnet 1537 now operates to cause the wipers 1405 to 1409, inclusive, to be returned to rotary and ver-

tical normal in the usual manner. When these wipers are restored to normal, the off-normal springs 1538 are disengaged to interrupt the above-traced circuit for energizing the release magnet 1537, and the off-normal springs 1426 are moved into engagement to reprepare the previously traced operating circuit for the relay R1440. During the release of the connector switch 50 and when the hold relay R1450 restores to remove ground potential from the private wiper 1406, the cut-off relay R350 embodied in the line circuit 10a is deenergized and restores, whereby the line 10 is marked as idle in the bank contacts of the connector switches to which it is accessible. After the wipers 1405 to 1409, inclusive, are returned to normal, the connector switch 50 is fully released and is conditioned for further operation.

In the event the call as routed to the line 10 is not answered or this line is busy at the time it is selected by the connector switch 50, the trunk circuit apparatus 45 and the repeater 40 are released in the exact manner just described when the operator withdraws the call and answer plug terminating one end of her cord circuit from the jack 2150. During the release of the repeater 40, the loop circuit extending to the connector switch 50 is interrupted in response to the release of the relay R1720. The manner in which the connector switch 50 releases when this loop circuit is opened is slightly different from the release of this switch as described above. Thus, if the call is not answered at the called substation A in response to the ringing current transmitted over the line 10, the ring cut-off relay R1550 is not operated and, accordingly, is not released in response to the release of the hold relay R1450. If the called line 10 is busy at the time it is selected by the connector switch 50, neither of the two relays R1540 and R1550 are operated at the time the connection is released. The busy test relay R1410, on the other hand, is operated. The holding circuit for the last-mentioned relay is interrupted in response to the restoration of the wipers 1405 to 1409, inclusive, to their respective home positions. Aside from the differences noted, the connector switch 50 is released in the manner described above.

If the above-described call, routed by way of the operator's position in the manual office No. 1, the trunk circuit apparatus 45 and the repeater 40 to the connector switch 50, is intended for one of the private branch exchange trunk lines to which this connector switch has access, the operator dials the two digits of the directory number designating the first trunk line of the group. The manner in which the impulses are repeated through operation of the relay R1860 to the loop circuit extending to the connector switch 50 is exactly the same as set forth above. The arrangement of the connector switch 50 is such that this switch operates automatically to select an idle trunk line of the group after the wipers thereof have been positioned in engagement with the contacts terminating the first line of the group. To this end, the private contact and the extra control contact in the bank associated with the wiper 1405 of each contact set terminating one of the trunk lines, except those of the contact set terminating the last line of the group, are strapped together so that when one of the trunk lines is busy ground potential is impressed upon the private and extra control contacts of the contact set at which the line is terminated, whereas if the line is idle, battery potential is impressed upon the indicated contacts. The extra control contact of the contact set terminating the last line of the group is left open circuited. With this arrangement if the wipers 1405 to 1409, inclusive, are, during the rotary movement thereof, positioned in engagement with the contacts terminating the first line of the group and this line is busy, the previously traced circuit is completed for energizing the busy test relay R1410. This relay upon operating, prepares, at RA1413, the previously traced holding circuit for itself, opens the operating circuit for the relay R1540 and, opens, at RA1415, the operating circuit for the rotary magnet 1417. At RA1412, the relay R1410 prepares a circuit for energizing the relay R1420. The last-mentioned circuit is completed in response to the release of the relay R1400 which occurs shortly following the end of the second digit. This circuit extends by way of the grounded extra control contact individual to the selected trunk line, the wiper 1405, RA1401, RA1412, RA1461, the armature 1418 and the lower winding of R1420 to battery. Upon operating, the relay R1420 completes a holding circuit for itself, this holding circuit extending from ground at RA1452 by way of RA1442, RA1421, the armature 1418 and the lower winding of R1420 to battery. At RA1422, the relay R1420 completes a circuit for energizing the rotary magnet 1417 in parallel with the slow-to-release relay R1460, this circuit extending from ground at RA1452 by way of RA1442, RA1422, C1476 and RA1546 to C1475 where it divides, one branch extending through the winding of the magnet 1417 to battery and the other branch extending by way of RA1402, the resistor 1404 and the winding of R1460 to battery. Thus, the relay R1460 is held operated until the trunk hunting operation is ended. When the rotary magnet 1417 is energized over the circuit just traced, it operates to step the wipers 1405 to 1409, inclusive, into engagement with the contacts of the contact set terminating the second trunk line of the selected group. At its armature 1418, the magnet 1417 opens the previously traced holding and operating circuits for the relay R1420, causing the last-mentioned relay to restore. Upon restoring, the relay R1420, opens, at RA1421, a further point in its holding circuit and interrupts, at RA1422, the above-traced circuit for energizing the rotary magnet 1417 and the relay R1460 in parallel. If the second trunk line is also busy so that ground potential is present upon the control and extra control contacts of the contact set at which it is terminated, the previously traced operating circuit for the relay R1420 is recompleted in response to the deenergization and release of the rotary magnet 1417, which occurs shortly following the release of the relay R1420. Further, the operating circuit for the relay R1410 is not interrupted. When the relay R1420 reoperates it functions to recomplete its holding circuit and to recomplete the above-traced circuit for energizing the rotary magnet 1417 and the relay R1460 in parallel. Thus, the rotary magnet is energized and operates to step the wipers 1405 to 1409, inclusive, another step and to again open the holding and operating circuits for the relay R1420. The relay R1420 and the rotary magnet 1417 continue to interact in the manner just described until an idle line of the selected group is found or until all of the lines have been tested and found to be busy. Assuming that all of the trunk lines of the group are busy, the wipers

1405 to 1409, inclusive, are operated into engagement with the contacts of the set terminating the last line of the group. With the wipers in this position the circuit for energizing the relay R1420 is interrupted. This is true for the reason pointed out above, i. e., the extra control contact engaged by the wiper 1405 and included in the contact set terminating the last trunk line of the group is open circuited. Accordingly, when the last trunk line is selected, the relay R1420 remains in its restored position so that the circuit for energizing the rotary magnet 1417 and the relay R1460 is not recompleted. Shortly following the selection of the last line of the group, the relay R1460 restores to complete the previously traced holding circuit for the busy test relay R1410. At RA1463' the relay R1460 completes the previously traced circuit for impressing the voltage of the busy tone current source upon the talking circuit extending from the connector switch 50 back to the operator's position in the manual office No. 1. The manner in which the connection is released under the control of the operator attending this position is exactly the same as described above.

Assuming that one of the trunk lines of the selected group is idle, the busy test relay R1410 and the lower winding of the relay R1420 are short-circuited when the wipers 1405 to 1409, inclusive, are stepped into engagement with the contacts of the set terminating the idle line. Accordingly, the relay R1420 remains in its restored position and the relays R1410 and R1460 restore shortly after the line is selected. Upon restoring, the relay R1460 completes, at RA1463, the previously traced operating circuit for the line switching relay R1540. From this point on, the manner in which the desired talking circuit is established between the operator's position in the private branch exchange and the operator's telephone set in the manual office No. 1 is exactly the same as described above with reference to the call routed to the substation A. Further, the connection is released under the control of the operator in the manual office No. 1 in the exact manner explained above with reference to the call forwarded to the substation A.

VIII. *Trunk call—Manual office No. 1 to manual office No. 2*

If the above-described call, routed from the operator's position in the manual office No. 1 by way of the trunk circuit apparatus 45 and the repeater 40 to the toll connector switch 50, is intended for a substation associated with a line terminating at the manual office No. 2, the operator, after initiating the call, dials the single digit designating the group of trunk lines extending to the manual office No. 2. The manner in which the impulses of this digit are repeated through operation of the relay R1860 to the loop circuit extending by way of the link line 17 to the toll connector switch 50, is the same as described in section VII. During the vertical movement of the wipers 1405 to 1409, inclusive, and when these wipers are positioned opposite the level of bank contacts terminating the group of trunk lines extending to the manual office No. 2, the normal post springs 1425 and 1539 and the off-normal springs 1538 are respectively operated into engagement. At the springs 1539, a circuit is prepared for energizing the relay R1530. At the normal post springs 1425, a circuit extending from ground at RA1441, is completed for energizing the upper winding of R1420 in series with the winding of R1460. The relay R1420 now operates to prepare its holding circuit and to prepare the previously traced circuit for energizing the rotary magnet 1417 in parallel with the winding of R1460. The relay R1460, upon operating, prepares the previously traced operating circuit for the busy test relay R1410, opens the holding circuit for the busy test relay, prepares the previously traced circuit for energizing the relay R1420 during the trunk hunting operation, and opens the previously traced operating circuit for the line switching relay R1540. Shortly following the end of the single digit dialed at the operator's position in the manual office No. 1, the relays R1400 and R1440 both restore. Upon restoring, the relay R1440, completes, at RA1442, the holding circuit for the relay R1420 and the circuit for energizing the rotary magnet 1417 and the relay R1460 in parallel. When the rotary magnet 1417 is energized in this manner, it operates to rotate the wipers 1405 to 1409, inclusive, into engagement with the first set of contacts in the selected level. If the trunk line terminating at this first set of contacts is busy, a trunk hunting operation on the part of the connector switch 50 is initiated. The manner in which the trunk lines of the selected group are successively tested until an idle line is found or until all of the lines of the group have been tested is exactly the same as described in the preceding section with reference to the call routed from the operator's position in the manual office No. 1 to one of the private branch exchange trunk lines accessible to the connector switch 50. When an idle line of the selected group is found, the trunk hunting operation is arrested and the relays R1410, R1420 and R1460 are caused to restore. Upon restoring, the relay R1460 completes the previously traced operating circuit for the line switching relay R1540, and the latter relay, upon partially operating, completes, at the "X" contacts associated with RA1545, the above-mentioned circuit for energizing the relay R1530. This circuit extends from ground by way of RA1452, C1473, RA1545, the normal post springs 1539 and the winding of R1530 to battery. A branch circuit for energizing the two relays R1530 and R1540 in parallel is also completed when the relay R1540 partially operates, this branch circuit extending from ground at RA1724 by way of C1615, RA1606, the control conductor 17_c to RA1545 where it divides, one branch extending through the upper winding of R1540 to battery and the other branch extending by way of the normal post springs 1539 and the winding of R1530 to battery. The completion of this branch circuit prevents the relays R1530 and R1540 from being deenergized after the line and hold relays R1500 and R1450 are caused to restore in the manner pointed out below. Upon operating, the relay R1530, further opens, at RA1531, the previously traced operating circuit for the release magnet 1537. At RA1532, the relay R1530 opens the above-traced operating circuit for the hold relay R1450, causing the last-mentioned relay to restore. At its armatures RA1533 to RA1536, inclusive, the relay R1530 disconnects the link line conductors C1482 and C1483 from the armatures RA1547 and RA1548 controlled by the line switching relay R1540 and connects these link line conductors to the conductors 17_a and 17_b, respectively, of the line 17 extending to the repeater 40.

At RA1534 and RA1536 and their respective associated resting contacts, the relay R1530 opens two points in the above-traced loop circuit ex-

tending through the windings of the relays R1510 and R1500, causing the relay R1510 to restore. The release of the relays R1500 and R1450 is without effect.

If it be assumed, for example, that the trunk line 13 extending to the repeater 55 is the trunk line seized by the connector switch 50 during the trunk hunting operation thereof, the relay R1530, upon operating to perform the functions described above, establishes an uninterrupted loop circuit between the two repeaters 40 and 55, which loop circuit includes the operating winding of the polarized relay R1750. When seized in this manner the repeater 55 operates to impress ground potential upon the private wiper 1406, thereby to complete a branch circuit extending by way of C1467, RA1542 and RA1545 for holding the relays R1540 and R1530 energized until the repeater 55 is released. The repeater 55 also operates to transmit a seizing pulse of alternating current over the trunk line 23 to the trunk circuit apparatus 60 provided in the manual office No. 2. The manner in which the control apparatus of the repeater 55 operates to transmit this pulse and the manner in which the control apparatus of the trunk circuit 60 responds to the received pulse to signal the operator in the manual office No. 2 that an incoming call is present on the trunk line 23, are exactly the same as described previously in section II with reference to the call routed from the substation A by way of the repeater 40 and the trunk circuit apparatus 45 to the operator's position in the manual office No. 1. When the call is answered by the operator in the manual office No. 2, the trunk circuit apparatus 60 operates to transmit a supervisory pulse of alternating current back over the trunk line 23 to the repeater 55. The control apparatus of this repeater responds to the received alternating current pulse by operating to reverse the direction of current flow over the loop circuit extending back through to the connector switch 50 and the trunk line 17 to the operating winding of the polarized relay R1750. The resulting operation of the relay R1750 initiates the operation of the control apparatus embodied in the repeater 40 to transmit a supervisory pulse of alternating current over the trunk line 22 to the trunk circuit apparatus 45. The relays R2000 and R2105 respond to this alternating current pulse and cause the deenergization of the supervisory lamp 2156. When this lamp is deenergized, the operator in the manual office No. 1 is informed that the call has been answered at the operator's position in the manual office No. 2. The operator who answers the call in the manual office No. 2 may cause the connection to be forwarded to the desired called substation in the manner conventionally followed in manual office practice.

During the release of the connection, the operator in the manual office No. 1 may desire to signal the operator in the manual office No. 2 and provisions are made whereby this may be accomplished. To this end, the operator handling the call in the manual office No. 1 momentarily actuates the ringing key embodied in her cord circuit to connect the tip and ring contacts of the jack 2150 to the source of ringing current provided in the manual office No. 1 and, thereby, energize the alternating current relay R2010. The relays R1960, R1950, R1930, R1920, R1910, R1900 and R1940 together with the minor switch 2065, respond to the operation of the relay R2010 by causing an alternating current pulse of medium length to be transmitted over the trunk line 22 to the repeater 45 in the manner described in section VII with reference to the offering of a toll call to a called subscriber at a time when the line extending to the called subscriber's substation is busy. The length of this alternating current pulse is determined by the time required for the wipers of the minor switch 2065 to be operated two steps.

The relays R1760, R1830, R1870, R1740, R1810, R1800 and R1820 respond to the alternating current pulse transmitted thereto over the trunk line 22 from the trunk circuit apparatus 45 by operating to unbalance the loop circuit extending by way of the link line 17, the operated connector switch 50 and the trunk line 13 to the repeater 55 in the manner previously explained in section VII with reference to the operation of the connector switch 50 to establish a toll offering connection to a busy called line. When the loop circuit extending between the repeaters 40 and 55 is unbalanced, the repeater 55 operates to transmit an alternating current pulse to the trunk circuit apparatus 60 in the manual office No. 2 in the manner explained in section IX with reference to a call routed from the manual office No. 2 to the manual office No. 1. The trunk circuit apparatus 60 responds to the received alternating current pulse by operating to cause the energization of a supervisory lamp embodied in the operator's cord circuit, whereby the operator in the manual office No. 2 is informed that the connection is ready to be released.

If the operator in the manual office No. 2 desires to signal the operator in the manual office No. 1 before the connection is released, she may do so by operating the ringing key embodied in her cord circuit, thereby to cause the control apparatus embodied in the trunk circuit 60 to transmit an alternating current pulse over the trunk line 23 to the repeater 55. The repeater 55 responds to this alternating current pulse by operating to reverse the direction of current flow over the loop circuit extending by way of the trunk line 13, the operated connector switch 50, the link line 17 and through the operating winding of the relay R1750. In response to this current reversal, the relay R1750 restores. Upon restoring, the relay R1750, in cooperation with the relays R1810, R1800, R1820, R1840, R1765, R1650, R1700 and R1640 causes an alternating current pulse to be transmitted over the trunk line 22 to the trunk circuit apparatus 45 in the manner previously explained in section VII with reference to the operations which occur when the established connection routed to the substation A is released at this substation. The relays R2000, R2120, R2115 and R2110 respond to this alternating current pulse in the manner previously described to cause the energization of the supervisory lamp embodied in the operator's cord circuit provided in the manual office No. 1.

The manner in which the trunk circuit apparatus 45 and the repeater 40 are released, is substantially the same as described in section VII. During the release of the repeater 40 and when the relay R1720 restores, the loop circuit extending to the repeater 55 is interrupted and one of the multiple paths for impressing ground potential upon the control conductors 12_c and 17_c is interrupted. When the loop circuit extending to the repeater 55 is opened, this repeater in cooperation with the trunk circuit apparatus 60 transmits a disconnect signal to the operator handling the call in the manual office No. 2.

The release of the portion of the connection which comprises the trunk circuit apparatus 60, the repeater 55 and the connector switch 50 is under the control of the operator in the manual office No. 2, the manner in which the switching units 60 and 55 are released being substantially similar to the release of the corresponding units 40 and 45 terminating the respective ends of the interoffice trunk line 22. During the release of the repeater 55, the private wiper 1406 and the control conductors 12c and 17c are disconnected from ground, whereby the relays R1540 and R1530 are deenergized and restore. The relay R1530, upon restoring, completes, at RA1531, the previously traced operating circuit for the release magnet 1537, whereby the wipers 1405 to 1409, inclusive, are restored to rotary and vertical normal in the usual manner. When these wipers are returned to their respective home positions, the normal post springs 1539 and 1425 are disengaged and the off-normal springs 1538 are opened to interrupt the operating circuit for the release magnet 1537. Thus, the connector switch 50 is fully released.

IX. *Trunk call—Manual office No. 2 to manual office No. 1*

In view of the foregoing explanation with reference to calls originating at the operator's position in the manual office No. 1, it is believed that the manner in which calls may be routed from the operator's position in the manual office No. 2 by way of the trunk circuit apparatus 60, the trunk line 23, the repeater 55, the link line 18 and the toll connector switch 65 to any desired subscriber's line terminating at the automatic exchange No. 1 will be clearly apparent without further explanation. Further, the manner in which a call may be routed from the operator's position in the manual office No. 2 by way of the trunk circuit apparatus 60, the trunk line 23, the repeater 55, the toll connector switch 65, the trunk line 12, the repeater 40, the trunk line 22 and the trunk circuit apparatus 45 to the operator's position in the manual office No. 1, is substantially similar to the mode of completing a connection between the two operators' positions as described in the preceding section. After the connection is set up between the two operators' positions as a result of a call originating in the manual office No. 2, either operator may signal the other operator before the connection is released. Thus, if the calling operator in the manual office No. 2 desires to signal the operator in the manual office No. 1, she operates the ringing key embodied in her cord circuit, thereby to cause the control apparatus of the trunk circuit 60 to transmit an alternating current pulse of medium length over the trunk line 23 to the repeater 55. The repeater 55 responds to this pulse of alternating current by operating momentarily to unbalance the loop circuit extending by way of the toll connector switch 65 and the trunk line 12 to the repeater 40. When this loop circuit is unbalanced, the differentially wound relay R1630 operates, to complete, at RA1631, a circuit for energizing the lower winding of the relay R1620, this circuit extending from ground at RA1679 by way of C1656, RA1822, C1649, RA1631 and the lower winding of R1620 to battery. The relay R1620, upon operating, completes, at RA1623, an obvious holding circuit for itself. Immediately after this holding circuit is completed the control apparatus embodied in the repeater 55 operates to restore the balance of the loop circuit extending from this repeater through the toll connector switch 65 to the repeater 40, causing the differentially wound relay R1630 to reoperate and interrupt the operating circuit for the relay R1620. At RA1625, the relay R1620 completes a circuit extending by way of C1663 and RA1729' for energizing the relay R1870. At RA1624, the relay R1620 completes a circuit for energizing the lower winding of R1830, this circuit extending from ground by way of RA1624, C1657, RA1757, C1658, RA1679', C1659 and the lower winding of R1830 to battery. At RA1621, the relay R1620 completes a circuit for energizing the relay R1840, this circuit extending from ground at RA1621 by way of RA1676, C1629, RA1741, C1773 and the winding of R1840 to battery. At RA1622, the relay R1620 completes the operating circuit for the relay R1765, this circuit extending from ground by way of RA1622, RA1677, C1633, RA1742 and the winding of R1765 to battery. The relays R1765 and R1840, upon operating, disconnect the conductors of the trunk line 22 from the repeating coil 1745 and connect them to the alternating current source. The relay R1870, upon operating, prepares its holding circuit at RA1873, prepares, at RA1874, the operating circuit for the relay R1850 and opens, at RA1872, the previously traced path for impressing ground potential upon the wiper 1683 of the timing switch 1680. The relay R1830, upon operating, initiates the cyclic operation of the three relays R1810, R1800 and R1820, and the step by step operation of the timing switch 1680 in the manner previously explained. When the wipers 1683 and 1684 of the switch 1680 have been stepped two steps a circuit is completed for energizing the upper winding of the relay R1620, this circuit extending from ground by way of RA1625, the wiper 1682 and the upper winding of R1620 to battery. The relay R1620 is differentially wound. Accordingly, when its upper winding is energized, this relay restores to open the previously traced operating circuits for the relays R1870, R1840, R1830 and R1765. When the two relays R1800 and R1810 restore, following the release of the relay R1620, the holding circuit for the relay R1830 is interrupted. Accordingly, the relay R1830 restores to open the respective operating circuits for the relays R1810 and R1800, whereby further cyclic operation of these two relays and the relay R1820 is prevented. At RA1834, the relay R1830 completes the previously traced circuit for energizing the release magnet 1686, whereby the wipers 1683 and 1684 are restored to normal and the off-normal springs 1687 are disengaged to deenergize the release magnet. The relays R1840 and R1765, upon restoring in response to the release of the relay R1620, again connect the conductors of the trunk line 22 to the repeating coil 1745. Thus, the apparatus embodied in the repeater 40 is restored to the condition which prevailed prior to operation of the differentially wound relay R1620.

From the foregoing explanation it will be apparent that an alternating current pulse is transmitted over the trunk line 22 to the trunk circuit apparatus 45 for a period substantially coincident with the time interval required for the wipers 1683 and 1684 of the timing switch 1680 to be operated two steps. The relay R2000 operates at the beginning of this alternating current pulse and remains operated until the pulse is ended. This relay, in cooperation with the three relays

R2120, R2115 and R2110, functions to cause a splash of ringing current to be transmitted by way of the tip and ring contacts of the jack 2150 to the operator's cord circuit whereby the supervisory signal lamp embodied in this cord circuit is either energized or deenergized to signal the operator. From the foregoing explanation, it will be apparent that the calling operator in the manual office No. 2 may repeatedly signal the called operator in the manual office No. 1 if she so desires.

In order to signal the calling operator in the manual office No. 2, the operator in the manual office No. 1 operates the ringing key in her cord circuit to impress the voltage of the ringing current source provided in the manual office No. 1 across the tip and ring contacts of the jack 2150 and thus energize the alternating current relay R2010. The control apparatus embodied in the trunk circuit 45 responds to the operation of the relay R2010 by operating to transmit an alternating current of medium length over the trunk line 22 to the repeater 40 in the manner described in section VII with reference to the call routed from the operator's position in the manual office No. 1 to the substation A. The relay R1760 responds to the alternating current pulse and, upon operating, completes the previously traced operating circuit for the relay R1830. The relay R1830 operating, initiates the cyclic operation of the three relays R1810, R1800 and R1820, and the operation of the timing switch 1680 in the manner previously explained. Shortly after the wipers 1683 and 1684 of the switch 1680 have been stepped into engagement with their respective associated second contacts, the alternating current pulse being transmitted to the repeater 40 over the trunk line 22 is terminated, causing the relay R1760 to restore. Upon restoring, the relay R1760 opens the operating circuit for the relay R1830 and completes a circuit for energizing the lower winding of the relay R1650, this circuit extending from ground at RA1762 by way of RA1751 RA1707, C1634, RA1608, C1635, RA1872, C1688, the wiper 1683 and its associated second contact, RA1655 and the lower winding of R1650 to battery. When this circuit is completed, the relay R1650 partially operates to complete, at the "X" contacts associated with RA1654, a path for short-circuiting its upper winding. This path extends from ground by way of RA1679, C1656, RA1701, C1639, RA1654, the upper winding of R1650 and RA1655 to the grounded wiper 1683. When the relays R1810 and R1800 restore following the release of the relay R1760, the holding circuit for the relay R1830 is interrupted at RA1804 and RA1814. The relay R1830 now restores to open the respective operating circuits for the relays R1810 and R1800 and thus prevent further cyclic operation of these two relays and the relay R1820. At RA1834, the relay R1830 completes the previously traced circuit for energizing the release magnet 1686, whereby the wipers 1683 and 1684 are restored to normal and the off-normal springs 1687 are disengaged to deenergize the release magnet 1686. During the release of the timing switch 1680 and when the wiper 1683 is disengaged from its associated second contact, the above-traced path short-circuiting the upper winding of R1650 is interrupted, permitting the two windings of this relay to be energized in series. The relay R1650 now completes its operation. Upon fully operating, the relay R1650, at its armatures RA1651 and RA1652, reverses the direction of current flow over the loop circuit extending by way of the trunk line 12 and the operated connector switch 65 to the repeater 55. At RA1653, the relay R1650 prepares the previously traced operating circuit for the relay R1700. At RA1655, the relay R1650 opens a point in its operating circuit and prepares a circuit for energizing the lower winding of R1660.

When the direction of current flow over the loop circuit extending to the repeater 55 is reversed the control apparatus of this repeater operates to transmit an alternating current pulse to the trunk circuit apparatus 60. Certain of the control relays embodied in the trunk circuit apparatus respond to this alternating current pulse by causing the operation of the supervisory signal device provided in the operator's cord circuit which is being used by the operator handling the call in the manual office No. 2.

In the event the called operator in the manual office No. 1 signals the calling operator in the manual office No. 2 a second time, such that a second control pulse is transmitted over the trunk line 22 to the repeater 40, the relay R1760 again operates to cause the reoperation of the relay R1830, whereby the cyclic operation of the three relays R1810, R1800 and R1820, and the operation of the timing switch 1680 is again initiated. Shortly after the wipers 1683 and 1684 have been stepped into engagement with their respective associated second contacts, the alternating current pulse is ended and the relay R1760 restores, to open the operating circuit for the relay R1830 and to complete the above-mentioned circuit for energizing the lower winding of the relay R1660. The last-mentioned circuit extends from ground by way of RA1762, RA1751, RA1707, C1634, RA1608, C1635, RA1872, C1688, and the wiper 1683 and its associated second contact, RA1655 and the lower winding of R1660 to battery. When energized over this circuit, the relay R1660 partially operates, to complete, at the "X" contacts associated with RA1662, a path for short-circuiting its upper winding, this path extending from ground at RA1679 by way of C1656, RA1701, C1639, RA1662, the upper winding of R1660 and RA1655 to the grounded wiper 1683. Shortly after this path is completed, the relays R1810, R1800, R1830 and R1840 restore in the order named. The relay R1830, upon restoring, recompletes the operating circuit for the release magnet 1686, whereby the timing switch 1680 is restored to normal. During the release of this switch and when the wiper 1683 is moved out of engagement with its associated second contact, the above-traced path short-circuiting the upper winding of R1660 is interrupted, permitting the two windings of this relay to be energized in series. The relay R1660 now fully operates, to complete, at RA1661, the operating circuit for the slow-to-operate relay R1700. The relay R1700, upon operating, opens, at RA1701, the respective holding circuits for the relays R1650 and R1660, causing both of these relays to restore. The relay R1660, upon restoring, opens, at RA1661, the operating circuit for the relay R1700, whereby the last-mentioned relay is caused to restore, to reprepare, at RA1701, the previously traced holding circuits for the relays R1650 and R1660. The relay R1650 in releasing, opens, at RA1654, an additional point in its operating circuit and, at RA1653, a point in the prepared operating circuit for the relay R1700. At RA1655, the relay R1650 opens a point in the above-traced circuit for energizing the lower winding of R1660 and prepares the circuit for energizing its own

lower winding. At RA1651 and RA1652, the relay R1650 again reverses the direction of current flow over the loop circuit extending over the trunk line 12 and through the operated connector switch 65 to the repeater 55. The control apparatus of the repeater 55 responds to the current reversal by operating to transmit a pulse of alternating current to the trunk circuit apparatus 60. The trunk circuit 60, in turn, responds to the received alternating current pulse by causing the operation of the supervisory signal device embodied in the operator's cord circuit in use by the operator handling the call in the manual office No. 2.

From the foregoing explanation it will be apparent that the called operator in the manual office No. 1 may signal the calling operator in the manual office No. 2 any desired number of times. It will further be apparent that the relay R1650 may or may not be operated at the time the connection is released, depending upon the number of times the called operator in the manual office No. 1 has signaled the calling operator in the manual office No. 2. The manner in which the trunk circuit apparatus 60 and the repeater 55 are released when the connection is cleared out at the operator's position in the manual office No. 2 will be apparent from the previous explanation in section VII pertaining to the release of the connection routed from the operator's position in the manual office No. 1 to the substation A. During the release of the repeater 55 the loop circuit extending to the repeater 40 is opened, causing a disconnect signal to be transmitted to the operator handling the call in the manual office No. 1. The manner in which the repeater 40, the trunk circuit apparatus 45 and the connector switch 65 are released when the connection is cleared out at the operator's position in the manual office No. 1 is substantially similar to the release of the connection considered in the preceding section. During the release of the repeater 40, the relay R1650, if operated, is deenergized and restores in response to the release of the relay R1670.

X. *Trunk call—Manual office No. 1 to manual office No. 3*

A call originating at the operator's position in the manual office No. 1 and intended for a substation associated with a line terminating at the manual office No. 3 may be routed by way of the trunk circuit apparatus 45, the trunk line 22, the repeater 40 and the toll connector switch 50 to an idle one of the group of trunk lines extending to the manual office No. 3 in the exact manner described in sections VII and VIII. Assuming that the interoffice trunk line 24 is the first idle trunk line of the selected group, the connector switch 50 operates to establish a loop circuit including the line 14 and extending between the repeaters 40 and 70. When this loop circuit is completed, the control apparatus of the repeater 70 operates to transmit a splash of ringing current over the trunk line 24 to the trunk circuit apparatus 75, thereby to energize the drop 1360 in the manner previously explained in section IV with reference to the call originating at the substation A and routed to the manual office No. 3. When the call is answered at the operator's position in the manual office No. 3 the relay R1220 operates to reverse the direction of current flow over the loop circuit extending to the repeater 40. The relay R1750 embodied in the repeater 40 responds to this current reversal by causing a pulse of alternating current to be transmitted over the trunk line 22 to the trunk circuit apparatus 45 in the manner previously explained. The trunk circuit apparatus 45 responds to the received alternating current pulse by deenergizing the supervisory lamp 2156, thus indicating to the operator in the manual office No. 1 that the call has been answered.

After the connection is established between the two operators' positions, the operator in the manual office No. 3 may signal the operator in the manual office No. 1 by operating the key 1364 to complete, at the contact springs 1365 and 1367, an obvious path for impressing the voltage of the booster battery source 1368 upon the simplex circuit extending by way of the two sides of the trunk line 24 through the respective high resistance lower windings of the relays R1210 and R1260. The marginal relay R1210 operates when the current flow over the trunk line 24 is thus increased. Upon operating, the relay R1210, completes, at RA1211, an obvious circuit for energizing the slow-acting relay R1200. The relay R1200 in operating opens the operating circuit for the battery reversing relay R1220 and performs other functions which have no effect at this time. The relay R1220, upon restoring, reverses the direction of current flow over the loop circuit extending from the repeater 70 through the operating winding of the relay R1750. When the key 1364 is released and allowed to return to its normal position, the springs 1365 and 1367 are disengaged to open the path over which booster battery potential is impressed upon the simplex circuit including the two sides of the trunk line 24. The relays R1210 and R1200 are thus caused sequentially to restore. Upon restoring, the relay R1200 recompletes the operating circuit for the relay R1220, causing the latter relay to operate and again reverse the direction of current flow over the loop circuit extending from the repeater 70 through the operating winding of the relay R1750.

The polarized relay R1750 restores in response to the release of the relay R1220 and reoperates in response to the reoperation of the battery reversing relay R1220. When the relay R1750 restores, the relays R1810, R1800, R1820, R1840, R1765, R1650 and R1700 cooperate in the manner previously explained in section VII to cause an alternating current pulse to be transmitted over the trunk line 22 to the trunk circuit apparatus 45. During the operation of the enumerated relays, the relay R1700 is caused momentarily to operate in response to the operation of the relay R1650. The relay R1700 operating interrupts the holding circuits for the two relays R1650 and R1640, causing both of these relays to restore. Thus, the relay R1640 is conditioned for reoperation in response to the reoperation of the polarized relay R1750. More particularly, when the relay R1750 reoperates, it completes, at RA1751, the previously traced operating circuit for the relay R1810. The relay R1810, upon operating, completes the operating circuit for the relay R1800. The relay R1800, in turn, recompletes, at RA1801, the previously traced circuit for energizing the lower winding of the relay R1640. The relay R1810 also completes the respective operating circuits for the relays R1765 and R1840 whereby a second pulse of alternating current is transmitted over the trunk line 22 to the trunk circuit apparatus 45. The relay R1640 partially operates to short-circuit its upper winding when its lower winding is again energized. Thereafter and when the relays R1810 and R1800

sequentially restore, the path short-circuiting the upper winding of the relay R1640 is interrupted and this relay fully operates to open the operating circuit for the relay R1810. Thus, the relays R1810, R1800 and R1820 are prevented from re-operating and the relays R1765 and R1840 are caused to restore to terminate the alternating current pulse transmitted over the trunk line 22.

The relays R2000, R2120, R2115 and R2110 cooperate in the manner previously explained to cause ringing current to be transmitted by way of the tip and ring contacts of the jack 2150 in response to each of the two alternating current pulses transmitted to the trunk circuit apparatus 45 over the trunk line 22. Thus, the signal device embodied in the operator's cord circuit in use in the manual office No. 1 is caused to operate to inform the operator handling the call that she is being recalled by the operator handling the call in the manual office No. 3.

If the calling operator in the manual office No. 1 desires to signal the called operator in the manual office No. 3, she operates the ringing key of her cord circuit, whereby an alternating current pulse of medium length is transmitted from the trunk circuit apparatus 45 over the trunk line 22 to the repeater 40. Certain of the control relays embodied in the repeater 40 operate in the manner previously explained in section VII momentarily to unbalance the loop circuit extending between the repeater 40 and the repeater 70 in response to the received alternating current pulse. When this loop circuit is unbalanced, the upper winding of the differentially wound relay R1230 is deenergized. The relay R1230 now operates to open, at RA1231, the operating circuit for the relay R1300. Upon restoring, the relay R1300 completes an alternative simplex circuit for energizing the two relays R1210 and R1260 in series with the relay R1370. This alternative circuit extends from ground by way of RA1371, the winding of R1370, the jack springs 1358, 1357 and 1361 and the switch springs 1366 and 1365 to the midpoint connection between the repeating windings 1351 and 1352 where it divides, one branch extending by way of the winding 1351, C1436, the coil 1343, the resistor 1345, RA1306, RA1303, C1281, the upper winding of R1210 and the upper winding of R1260 to battery, and the other branch extending by way of the winding 1352, C1347, the winding 1344, the resistor 1345, RA1306, RA1303, C1281, the upper winding of R1210 and the upper winding of R1260 to battery. After this circuit is completed, the initially completed circuit for energizing the relays R1210, R1260 and R1370 is interrupted at RA1302 and RA1303. When the high resistance lower windings of the relays R1210 and R1260 are thus excluded from the above-traced circuit, the marginal relay R1370 is sufficiently energized to operate. Upon operating, this relay opens, at RA1371, the path normally short circuiting the winding of the signal device 1369, whereby this winding is serially included in the circuit including the winding of R1370 and the respective upper windings of the relays R1210 and R1260. The resulting operation of the signal device 1369 serves to inform the operator in the manual office No. 3 that she is being recalled by the operator in the manual office No. 1.

Since the loop circuit extending between the repeaters 40 and 70 is only momentarily unbalanced, the relay R1230 restores shortly following its operation, to recomplete the operating circuit for the relay R1300. The relay R1300, upon operating again, includes the high resistance lower windings of the relays R1210 and R1260 in the circuit for energizing these two relays in series with the relay R1370. In response to this operation, the relay R1370 restores to again short circuit the winding of the signal device 1369. Obviously, the operations just described will be repeated each time the operator handling the call in the manual office No. 1 operates the ringing key of the cord circuit in use in this office.

The manner in which the trunk circuit apparatus 45 and the repeater 40 are released under the control of the operator in the manual office No. 1 is the same as described in section VII with reference to a call routed to the substation A from the operator's position in the manual office No. 1. During the release of the repeater 40 and when the loop circuit extending between this repeater and the repeater 70 is broken, a disconnect signal is transmitted to the operator handling the call in the manual office No. 3 in the manner previously explained in section IV.

The manner in which the repeater 70 and the trunk circuit apparatus 75 are released under the control of the operator in the manual office No. 3 is the same as described in section IV with reference to a call originating at the substation A and routed to the operator's position in the manual office No. 3. During the release of the repeater 70 ground potential is removed from the private wiper 1406 to initiate the release of the connector switch 50 as described in section VIII.

XI.—*Trunk call—Manual office No. 3 to substation A*

If a call originating on a line terminating at the manual office No. 3 and intended for the substation A is routed to the operator's switchboard in this office, the operator may forward the connection to the desired substation by inserting the plug terminating the calling end of her cord circuit in the jack 1355 to seize the trunk line 24. In response to this operation, the jack springs 1357 and 1358 are engaged to complete the previously traced simplex circuit for energizing the relay R1370 in series with the relays R1210 and R1260. Only the relays R1260 and R1370 operates when this circuit is completed. Upon operating, the relay R1260, completes, at RA1262, the previously traced operating circuit for the battery reversing relay R1220. The resulting operation of the relay R1220 is without effect. At RA1262 and its associated resting contact, the relay R1260 opens a point in the circuit for energizing the slow-to-release relay R1300'. At RA1263, the relay R1260 prepares the previously traced holding circuit for the relay R1320 and completes a circuit for energizing the slow-acting relay R1330, this latter circuit extending from ground by way of RA1263, C1284, RA1325 and the winding of R1330 to battery. At RA1261, the relay R1260 prepares a loop circuit which, when completed, extends from the repeating coil 1340 to the toll connector switch 80.

The relay R1330, upon operating, completes, at RA1334, an obvious path for impressing ground potential upon the control conductor 14_c of the trunk line 14, thereby to mark the repeater 70 as busy in the bank contacts of the connector switches having access thereto. At RA1334', the relay R1330 prepares the above-mentioned operating circuit for the relay R1300'. At RA1332, the relay R1330 completes an obvious circuit for energizing the polarizing winding of the back bridge relay R1335. At RA1331 and RA1333, the

relay R1330 completes the above-mentioned loop circuit extending to the toll connector switch 80. This loop circuit may partially be traced as extending by way of the line conductor C1286, RA1333, the winding 1342, the upper winding of R13335, RA1321', C1277, RA1261, C1276, the winding 1341 and RA1331 to the opposite line conductor C1287. This loop circuit extends through the windings of the line relay embodied in the toll connector switch 80, whereby the indicated line relay is caused to operate to condition the control apparatus of the connector switch 80 to respond to the impulses of the directory number designating the called substation A. The direction of the current traversing this loop circuit is such that the polarized relay R1335 does not operate at this time.

In order to direct the wipers 1223 into engagement with the set of contacts terminating the conductors of the desired line 10, the operator inserts the dial plug 1363 in the dialing jack 1361 and operates the dial of the calling device 1362 in accordance with the digits of the directory number designating the called substation. When the dial plug is inserted in the jack 1361 an auxiliary circuit extending to ground through the pulsing springs of the calling device 1362 is completed for holding the relay R1260 operated. After this auxiliary circuit is completed, the springs of the jack 1361 are disengaged to exclude the winding of the relay R1370 from the simplex circuit extending to the repeater 70. When the dialing operation is completed, the dial plug is withdrawn from the jack 1361 so that the winding of the relay R1370 is again energized in series with the respective upper windings of the relays R1210 and R1260 and the relay R1370 is caused to reoperate to open the path short circuiting the signal device 1369. Each time the dial of the calling device 1362 is moved off-normal and released, the pulsing springs embodied therein are opened and closed a number of times determined by the numerical value of the digit dialed, thereby intermittently to interrupt the above-traced circuit for energizing the relay R1260. When this relay restores at the beginning of the open circuit period of the first impulse, it opens, at RA1262, the operating circuit for the relay R1220. At RA1262 and its associated resting contact, the relay R1260 completes the above-mentioned circuit for energizing the slow-to-release relay R1300', this circuit extending from ground by way of RA1262, C1288, RA1334' and the winding of R1300' to battery. The relay R1300', upon operating, completes, at RA1301', an obvious path for short circuiting the repeater winding 1341. At RA1302', the relay R1300' completes a path including the conductor C1278 for excluding the windings of the relay R1210 and the lower winding of the relay R1260 from the circuit for energizing the last-mentioned relay. In response to this operation, the resistance of the circuit over which the impulses are delivered to the relay R1260 is materially reduced, whereby the relay R1260 is rendered more faithfully responsive to the dialed impulses. Due to its slow-to-release characteristic, the relay R1300' remains operated throughout each series of impulses and only restores shortly following the end of each digit. Each time the relay R1260 restores during the open circuit period of an impulse transmitted thereto it also functions to open, at RA1261, the previously traced loop circuit extending to the toll connector switch 80. Thus, the impulses dialed at the operator's position in the manual office No. 3 are repeated to this toll connector switch. This switch responds to the impulses of the first digit by elevating its wipers to a position opposite the level of bank contacts terminating the group of ten lines including the called line 10. In response to the impulses of the second digit, the wipers 1223 of the connector switch 80 are rotated into engagement with the set of contacts terminating the conductors of the called line 10. The manner in which the line 10 is tested to determine the idle or busy condition thereof; ringing current is transmitted over the line to energize the signal device provided at the called substation, in the event the line tests idle or busy tone current is returned over the connection to the operator's telephone set in the event the called line is busy, is exactly the same as described previously in section VII in considering the operation of the toll connector switch 50. Assuming that the called line 10 is idle at the time it is selected, the desired conversational circuit between the operator's telephone set and the called substation is completed when the call is answered. In response to this operation, the back bridge relay embodied in the connector switch 80 operates to reverse the direction of current flow over the loop circuit extending through the operating winding of the polarized relay R1335. The relay R1335 now operates to complete, at RA1336, an obvious circuit for energizing the relay R1300. The relay R1300, upon operating, completes, at RA1301, a multiple path for impressing ground potential upon the control conductor 14c. At RA1302 and RA1303, the relay R1300 includes the high resistance lower windings of the relays R1210 and R1260 in the above-traced simplex circuit which extends through the winding of the relay R1370. When this occurs, the relay R1370 is insufficiently energized to remain operated and restores, to recomplete, at RA1371, the path for short circuiting the signal device 1369. The resulting operation of the signal device serves to inform the operator that the call has been answered.

In the event the line 10 is busy at the time it is selected, whereby the usual busy signal is returned to the calling operator, the operator may cause a talking circuit to be set up between her telephone set and the called substation by momentarily operating the key 1364 to its off-normal position, thereby to include the booster battery current source 1368 in the above-traced simplex circuit which includes the upper windings of the relays R1210 and R1260. The increased current flow over this circuit causes the marginal relay R1210 to operate and complete, at RA1211, the operating circuit for the slow-acting relay R1200. The relay R1200, upon operating, completes, at RA1202, a path extending by way of C1280 and RA1321 for impressing ground potential upon both sides of the loop circuit extending to the operated toll connector switch 80, one branch of this path extending through the winding 1342 and RA1333 to the link line conductor C1286 and the other branch extending through the upper winding of R1335 and by way of RA1321', C1277, RA1261, C1276, the winding 1341 and RA1331 to the link line conductor C1287. Thus, the loop circuit extending to the operated connector switch 80 is unbalanced. When the key 1364 is released, the booster battery current source 1368 is excluded from the simplex circuit including the windings of the relays R1210 and R1260, whereby the relays

R1210 and R1200 are caused sequentially to restore. The relay R1200, upon restoring, opens the above-traced path for impressing ground potential upon the two sides of the calling loop circuit whereby the balanced condition of this loop circuit is restored. The manner in which the control apparatus of the connector switch 80 responds to the unbalanced condition of the loop circuit extending thereto to establish a dry talking circuit to the called line 10 is exactly the same as described in section VII with reference to the operation of the toll connector switch 50. After this talking circuit is set up, the operator may converse with the party using the called substation and offer the toll call to the called subscriber. If the call is accepted, the parties conversing over the previously established connection extending to the substation A are instructed to hang up. When the previously established connection is fully released, ringing current is projected over the called line to signal the called substation in the usual manner, and when the call is answered at the called substation the desired talking circuit between the operator's telephone set and the telephone instrument provided at the called substation is fully completed.

The release of the connection as established between the operator's position in the manual office No. 3 and the substation A is entirely under the control of the operator attending this position. More particularly, when the connection is released at the called end thereof, the back bridge relay embodied in the toll connector switch 80 operates to again reverse the direction of current flow over the loop circuit extending through the operating winding of the polarized relay R1335. Accordingly, the relay R1335 restores, to open, at RA1336, the operating circuit for the relay R1300. The relay R1300 releasing, excludes the high resistance lower windings of the relays R1210 and R1260 from the simplex circuit extending through the winding of the relay R1370. Accordingly, the relay R1370 again operates, to open, at RA1371, the path short circuiting the signal device 1369. The resulting operation of this signal device serves to inform the operator that the connection has been released in the called substation. In order to release the operated switch train, the operator withdraws the plug terminating one end of her cord circuit from the jack 1355. In response to this operation, the jack springs 1357 and 1358 are disengaged to interrupt the circuit for energizing the relays R1210, R1260 and R1370 in series. The relay R1260, upon restoring, opens at RA1261, the loop circuit extending to the operated connector switch 80. At RA1262, the relay R1260 opens the operating circuit for the battery reversing relay R1220 and momentarily recompletes the operating circuit for the relay R1300'. The resulting restoration of the relay R1220 and operation of the relay R1300' are without effect. At RA1263, the relay R1260 opens the operating circuit for the relay R1330. The relay R1330, upon restoring, opens, at RA1334', the operating circuit for the relay R1300', causing the latter relay to restore. At RA1331 and RA1333, the relay R1330 opens two additional points in the loop circuit extending to the toll connector switch 80. At RA1334, the relay R1330 disconnects the control conductor 14_c from ground whereby the repeater 70 is marked as idle in the bank contacts of the connector switches to which it is accessible. At RA1332, the relay R1330 opens the circuit for energizing the polarizing winding of the relay R1335. Thus, the trunk circuit apparatus 75 and the repeater 70 are fully released. When the loop circuit extending to the operated connector switch 80 is opened in the manner just described, this connector switch and the line circuit 10_a associated with the called line 10 are released in the manner previously explained in section VII with reference to the operation of the toll connector switch 50.

XII. *Trunk call—Manual office No. 3 to manual office No. 1*

If the above-described call initiated at the opeartor's position in the manual office No. 3 and routed over the trunk line 24 and through the repeater 70 to the toll connector switch 80 is intended for a substation associated with a line terminating at the manual office No. 1, the calling operator dials the single digit designating the group of trunk lines including the trunk line 12. Assuming that the line 12 is seized by the connector switch 80 during the trunk hunting operation thereof, a loop circuit is established between the repeaters 70 and 40. When this loop circuit is completed the control apparatus of the repeater 40 operates to transmit a seizing pulse of alternating current over the trunk line 22 to the trunk circuit apparatus 45. The trunk circuit apparatus 45 responds to the pulse of alternating current by completing the operating circuit for the answer lamp 2155, whereby the operator attending the position in the manual office No. 1 is informed that a call is present on the line 22 which should be answered. When the call is answered the trunk circuit apparatus 45 operates to transmit a pulse of alternating current over the trunk line 22 to the repeater 40. The control apparatus of the repeater 40 responds to this alternating current pulse by operating to reverse the direction of current flow over the loop circuit extending between the repeaters 40 and 70. In response to this current reversal, the relays R1335 and R1300 sequentially operate and the relay R1370 restores to short-circuit the signal device 1369. The deenergization of this signal device serves to inform the operator in the manual office No. 3 that the call has been answered. Following the operations just described, a talking circuit is established between the two operators' positions whereby the calling operator may inform the called operator as to the particular substation desired by the calling party. The manner in which the repeater 40 and the trunk circuit apparatus 45 operate during the sequence of operations just described is exactly the same as explained in section II with reference to a call routed to the operator's position in the manual office No. 1 from the substation A. The manner in which the repeater 70 operates during the sequence of operations just described is exactly the same as described in section XI with reference to the call routed from the operator's position in the manual office No. 3 to the substation A.

If the called operator in the manual office No. 1 desires to signal the calling operator in the manual office No. 3, she momentarily operates the ringing key embodied in her cord circuit, whereby an alternating current pulse of medium length is transmitted from the trunk circuit apparatus 45 over the trunk line 22 to the repeater 40 in the manner previously ex-

plained in section VII. The repeater 40 responds to this alternating current pulse by reversing the direction of current flow over the loop circuit extending between this repeater and the repeater 70. In response to this current reversal, the relays R1335 and R1300 are caused sequentially to restore in the manner pointed out above. When the relay R1300 restores, it excludes the high resistance lower windings of the two relays R1210 and R1260 from the simplex circuit extending through the winding of the relay R1370. The relay R1370 now operates to interrupt the path short-circuiting the signal device 1369. The resulting operation of this device serves to inform the operator in the manual office No. 3 that she is being recalled by the operator in the manual office No. 1. Subsequent operations of the ringing key embodied in the operator's cord circuit in use in the manual office No. 1 cause the polarity of the current traversing the loop circuit extending between the repeaters 40 and 70 alternately to be changed from one polarity to the reverse polarity. Accordingly, the relays R1335, R1300 and R1370 follow the operations of the ringing key embodied in the operator's cord circuit in use in the manual office No. 1 so that the signal device 1369 is alternately energized and deenergized.

If the operator in the manual office No. 3 desires to signal the operator in the manual office No. 1, she operates the key 1364 to include the booster battery current source 1368 in the circuit serially including the windings of the three relays R1210, R1260 and R1370. The relays R1210 and R1200 now operate to unbalance the loop circuit extending through the operated toll connector switch 80 and by way of the trunk line 12 to the repeater 40. When this loop circuit is unbalanced, the differentially wound relay R1630 operates. Upon operating, this relay initiates the operation of certain of the other control elements embodied in the repeater 40 to transmit an alternating current pulse over the trunk line 22 to the trunk circuit apparatus 45. The manner in which this alternating current pulse is transmitted to the trunk circuit apparatus 45 is the same as described in section IX. The trunk circuit apparatus 45 responds to the received pulse of alternating current by operating to energize or deenergize the signal device embodied in the cord circuit in use in the manual office No. 1, thereby to inform the operator supervising the call that she is being recalled by the operator in the manual office No. 3. The manner in which the relays R1210 and R1200 are caused to restore when the key 1364 is released and allowed to return to its normal position will be apparent without further explanation in view of the foregoing description. The relay R1200, upon restoring, opens, at RA1202, the path for impressing ground potential upon the two sides of the loop circuit extending to the repeater 40, whereby the balanced condition of this loop circuit is restored and the differentially wound relay R1630 is released.

The release of the connection established between the manual office No. 3 and the manual office No. 1 is under the joint control of the two operators supervising the calling and called ends of the connection. In this regard it is pointed out that the operator in the manual office No. 1 does not attempt to release the operated trunk circuit apparatus 45, the repeater 40 and the toll connector switch 80 until she receives a disconnect signal. The manner in which the trunk circuit apparatus 75 and the repeater 70 are released when the operator in the manual office No. 3 withdraws the plug terminating one end of her cord circuit from the answer jack 1355 is the same as described in section XI. During the release of the repeater 70 and when the relays R1260 and R1330 restore, the loop circuit extending from this repeater to the repeater 40 is interrupted to cause the deenergization and release of the line and hold relays R1610 and R1605, respectively. In response to the release of these two relays, certain of the other control elements of the repeater 40 operate to transmit an alternating current pulse over the trunk line 22 to the trunk circuit apparatus 45. The trunk circuit apparatus 45 responds to this pulse in operating to cause the energization of the supervisory lamp embodied in the operator's cord circuit in use in the manual office No. 1. Thus, the operator supervising the call in the manual office No. 1 is informed that the connection is ready to be released. The manner in which the trunk circuit apparatus 45, the repeater 40 and the connector switch 80 are released when the operator in the manual office No. 1 withdraws the plug terminating the answer end of her cord circuit from the jack 2150 is the same as described previously in sections VII and IX.

XIII. *Forcible release of the repeater 40*

As indicated previously, if the operator in the manual office No. 1 seizes the trunk line 22 by inserting the plug terminating the calling end of her cord circuit in the jack 2150 and fails to dial the digits of the directory number designating the desired substation within a predetermined time interval, the repeater 40 is forcibly released. In this regard it will be recalled from the previous description that when the trunk circuit apparatus 45 is thus seized it functions to transmit a seizing pulse of alternating current over the trunk line 22 to the repeater 40, whereby the relay R1720 is caused to operate to complete a loop circuit extending by way of the line 17 to the toll connector switch 50. The relay R1720, upon fully operating at the end of the alternating current seizing pulse, also completes, at RA1726, one of the previously traced operating circuits for the relay R1830. At RA1728, the relay R1720 completes the previously traced operating circuit for the relay R1870. The relay R1830, upon operating, initiates the cyclic operation of the three relays R1810, R1800 and R1820, and the operation of the timing switch 1680 in the manner previously described. If no further alternating current pulses are transmitted to the repeater 40 after the seizing pulse, the timing switch 1680 continues to operate until the wipers thereof are stepped into engagement with their respective associated ninth contacts. When the wiper 1684 bridges its associated fourth contacts, a circuit is completed for energizing the relay R1755, this circuit extending from ground by way of RA1729, C1656, the wiper 1684, C1667, RA1744, and the winding of R1755 to battery. The relay R1755, upon operating, completes, at RA1656, a path for short-circuiting the winding of the relay R1740. This path is interrupted to permit the energization of the relay R1740 in series with the relay R1755 when the wiper 1684 is operated to disengage its associated fourth contacts. The resulting operation of the relay R1740 is without effect. When the wiper 1684 is operated to bridge its associated ninth contacts, a circuit is completed for energizing the slow-to-release relay

R1710, this circuit extending from ground by way of the wiper 1684, C1666 and the winding of R1710 to battery. Upon operating, the relay R1710 completes, at RA1712 and RA1711, an alternative holding circuit for the relay R1720, this alternative holding circuit extending by way of the grounded wiper 1684, C1666, RA1712, RA1713 and the two windings of R1720 in series to battery. After this circuit is completed the relay R1710 opens, at RA1713 and its associated resting contact, the initially completed holding circuit for the relay R1720. At RA1711, the relay R1710 prepares an incomplete holding circuit for itself and completes a circuit extending by way of C1772 and RA1864 for energizing the relay R1880 in parallel with the relay R1730. The relay R1880 in operating short-circuits the upper winding of the relay R1860 and completes the previously traced operating circuit for the relay R1850. The relay R1850, upon operating, completes locking circuits for itself and the relay R1870. Following the operation of the relay R1710 and when the wipers 1683 and 1684 are stepped to their respective tenth off-normal positions, the above-traced holding circuit for the relay R1720, the operating circuit for the relay R1730, the operating circuit for the relay R1710 and the path short-circuiting the upper winding of the relay R1860 are interrupted. The relay R1720 immediately restores, to open, at RA1726, the operating circuit for the relay R1830. At RA1728, the relay R1720 opens the locking circuit for the relay R1850 and the operating circuit for the relay R1860. At RA1729, the relay R1720 opens the holding circuit for the series connected relays R1740 and R1755. The relay R1850 in releasing, opens the holding circuit for the relay R1870. Thus the relays R1730, R1850, R1880, R1740, R1755 and R1870 are deenergized and restore. During the portion of the next operating cycle of the three relays R1820, R1810 and R1800 when the last two thereof are restored, the holding circuit for the relay R1830 is interrupted and this relay restores to open the respective operating circuits for the two relays R1800 and R1810. Thus, the cyclic operation of the three enumerated relays is arrested. Upon restoring, the relay R1830, also completes, at RA1834, the previously traced circuit for energizing the release magnet 1686, whereby the wipers of the timing switch 1680 are restored to normal and the off-normal springs 1687 are disengaged to deenergize the release magnet. Shortly following the release of the relay R1720, the relay R1710 restores, to reprepare, at RA1713 and its associated resting contact, the previously traced holding circuit for the relay R1720. Thus, the repeater 40 is fully released. When the relay R1720 is caused to restore in the manner explained above, it functions to interrupt, at its armatures RA1721 to RA1723, inclusive, the completed loop circuit extending to the toll connector switch 50 whereby this connector switch is released in a manner which will be apparent from the preceding description.

If, following the forcible release of the repeater 40, the connection is cleared out at the operator's position in the manual office No. 1, the trunk circuit apparatus 45 operates in the manner previously explained to transmit over the trunk line 22 to the repeater 40 a relatively long release pulse of alternating current. This release pulse is absorbed in the repeater 40 as a seizing pulse so that at the end thereof the relays R1720, R1830 and R1870 are caused to operate. The relay R1720, upon operating, completes the previously traced loop circuit extending to the toll connector switch 50. The relay R1830, upon operating, initiates the cyclic operation of the three relays R1810, R1800 and R1820 and the stepping operation of the timing switch 1680. Since no further alternating current pulses are transmitted to the repeater 40 following receipt of the release pulse, this repeater is forcibly released when the wipers of the switch 1680 have been stepped to their respective ninth off-normal positions in the exact manner described above. During the release of the repeater 40, the loop circuit extending to the toll connector switch 50 is interrupted, thereby to cause the release of this connector switch.

If, following seizure of the trunk circuit apparatus 45, the trunk line 22, the repeater 40 and the toll connector switch 50, the operator withdraws the plug of her cord circuit from the jack 2150 without dialing, and before the repeater 40 has been forcibly released, the indicated repeater is released in a slightly different manner. Thus, following seizure of the enumerated switching units, the relays R1720, R1830 and R1870 of the repeater 40 are in their respective operated positions. In addition, the three relays R1800, R1810 and R1820 are operating in the cyclic manner previously described to cause the step by step operation of the timing switch 1680. With the apparatus in this condition if the operator withdraws the plug terminating one end of her cord circuit from the jack 2150, the trunk circuit apparatus 45 operates to transmit a relatively long release pulse of alternating current over the trunk line 22 to the repeater 40. The relay R1760 responds to this pulse of alternating current by operating, to open, at RA1762 and its associated resting contact, a point in the previously traced holding circuit for the relay R1870. At RA1762 and its associated working contact, the relay R1760 completes the previously traced circuit for energizing the lower winding of R1880 in parallel with the winding of R1730, causing both of these relays to operate. The relay R1880, upon operating, completes, at RA1883, the prepared operating circuit for the relay R1850. The relay R1850, upon operating, completes its holding circuit and opens, at RA1852, the completed operating circuit for the relay R1830. At RA1851, the relay R1850 prepares the circuit for energizing the relay R1640. The relay R1880, upon operating, also interrupts, at RA1883, the previously traced operating circuit for the relay R1870, causing the latter relay to restore after an interval, to complete, at RA1871, the above-mentioned alternative circuit for energizing the relay R1830. Thus, the cyclic operation of the three relays R1810, R1800 and R1820, and the step by step operation of the timing switch 1680 is continued. When the wipers of the switch 1680 have been operated to engage their associated third contacts, the previously traced circuit is completed for energizing the slow-to-release relay R1710. From this point on, the manner in which the operated relays of the repeater are released at the end of the alternating current release pulse is exactly the same as described previously with reference to the normal release of this repeater.

If an electrical transient, such, for example, as a lightning surge should be impressed across the conductors of the trunk line 22, the trunk circuit apparatus 45 may operate in the manner

previously pointed out to cause the energization of the signal lamp 2155 and thus falsely indicate to the operator in the manual office No. 1 that an incoming call is present on the trunk line 22. The transient voltage may also result in the operation of the alternating current relay R1760, thereby to cause the seizure of the repeater 40 in the exact manner described above with respect to a call routed to this repeater over the trunk line 22. If this false call is not answered within the time interval required for the wipers of the timing switch 1680 to be operated into engagement with their respective associated ninth contacts, the repeater 40 is forcibly released in the manner explained above. Thereafter and when the false call is answered, a short seizing pulse of alternating current is transmitted over the trunk line 22 to the repeater 40 so that this repeater is again seized and conditioned to respond to dial pulses transmitted thereto. The operator, upon ascertaining that the call was falsely routed to her position, may then cause the trunk circuit apparatus 45 and the repeater 40 to be released by withdrawing the plug of her cord circuit from the call and answer jack 2150.

In the event the false call is answered at the operator's position before the repeater 40 has been forcibly released, the alternating current pulse which is transmitted to this repeater when the operator inserts the plug of her cord circuit in the jack 2150, is in the nature of a single digit of one impulse and causes an impulse to be transmitted over the completed loop circuit comprising the link line 17 to the toll connector switch 50. This alternating current pulse also results in the release of the relay R1830, whereby the cyclic operation of the three relays R1800, R1810 and R1820 is arrested and the wipers of the timing switch 1680 are restored to normal. The manner in which the trunk circuit apparatus 45, the repeater 40 and the toll connector switch 50 are released when the operator withdraws the plug terminating one end of her cord circuit from the jack 2150 after ascertaining that the call is false, is exactly the same as described in Section VII with reference to the release of the connection routed to the substation A from the operator's position in the manual office No. 1.

While there has been described what is at present considered to be the preferred embodiment of the invention, it will be understood that various modifications may be made therein, and it is intended to cover in the appended claims all such modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. In a telephone system, a subscriber's line, a metering device associated with said line, a plurality of additional lines respectively located in different rate zones, automatic switching apparatus controllable over said first-named line to route a connection to a called one of said additional lines, and zone metering equipment controlled in accordance with the operation of said switching apparatus, said zone metering equipment including control means operative in response to the completion of said connection for causing said metering device to register an initial charge determined by the rate zone in which said called line is located, a timing device, means controlled by said timing device for causing the reoperation of said control means a predetermined time interval after said connection is established, thereby to cause further operation of said metering device, means controlled by said timing device for initiating the release of said connection a second predetermined time interval after the expiration of said first time interval, and means controlled by said timing device for impressing a warning signal upon said connection shortly before the expiration of each of said two time intervals.

2. In a telephone system, a subscriber's line, a metering device associated with said line, a plurality of additional lines respectively located in different rate zones, automatic switching apparatus controllable over said first-named line to route a connection to a called one of said additional lines, and zone metering equipment controlled in accordance with the operation of said switching apparatus, said zone metering equipment including control means operative in response to the completion of said connection for causing said metering device to register an initial charge determined by the rate zone in which said called line is located, a timing device comprising a switch having a starting position and a number of other operating positions, means responsive to the completion of said connection for initiating the operation of said switch, a plurality of relays, circuits for energizing said relays, said circuits being controlled by said switch and being so connected and arranged that said relays are successively energized in response to successive operations of said switch to one of its operating positions, means for operating said switch to its starting position each time one of said relays operates, a circuit jointly controlled by one of said relays and said switch for transmitting a warning signal over said connection a predetermined time interval after said connection is established, and means controlled by another of said relays for causing the reoperation of said control means shortly after said warning signal is transmitted over said connection, thereby to cause further operation of said metering device.

3. In a telephone system, a subscriber's line, a metering device associated with said line, a plurality of additional lines respectively located in different rate zones, automatic switching apparatus controllable over said first-named line to route a connection to a called one of said additional lines, and zone metering equipment controlled in accordance with the operation of said switching apparatus, said zone metering equipment including control means operative in response to the completion of said connection for causing said metering device to register an initial charge determined by the rate zone in which said called line is located, a timing device comprising a switch having a starting position and a number of other operating positions, means responsive to the completion of said connection for initiating the operation of said switch, a plurality of relays, circuits for energizing said relays, said circuits being controlled by said switch and being so connected and arranged that said relays are successively energized in response to successive operations of said switch to one of its operating positions and certain of said relays are deenergized in response to the succeeding operation of others of said relays, whereby certain of said relays are caused to operate, restore and reoperate in response to repeated operation of said switch to said one operating position, means for operating said switch to its starting position each time one of said relays operates, a signaling circuit jointly controlled by one of said relays and said switch for transmitting a warning signal over said connection a predetermined time inter-

val after said connection is established, means controlled by another of said relays for causing the reoperation of said control means shortly after said signal is transmitted over said connection, thereby to cause further operation of said metering device and means including a circuit jointly controlled by said switch and said two last-mentioned relays for initiating the release of said connection a second predetermined time interval after the expiration of said first-mentioned time interval.

4. In a telephone system, a subscriber's line, a metering device associated with said line, a plurality of additional lines respectively located in different rate zones, automatic switching apparatus controllable over said first-named line to route a connection to a called one of said additional lines, and zone metering equipment controlled in accordance with the operation of said switching apparatus, said zone metering equipment including control means operative in response to the completion of said connection for causing said metering device to register an initial charge determined by the rate zone in which said called line is located, a timing device comprising a switch having a starting position and a number of other operating positions, means responsive to the completion of said connection for initiating the operation of said switch, a plurality of relays, circuits for energizing said relays, said circuits being controlled by said switch and being so connected and arranged that said relays are successively energized in response to successive operations of said switch to one of its operating positions and certain of said relays are deenergized in response to the succeeding operation of others of said relays, whereby certain of said relays are caused to operate, restore and reoperate in response to repeated operation of said switch to said one operating position, means for operating said switch to its starting position each time one of said relays operates, a signaling circuit jointly controlled by one of said relays and said switch for transmitting a warning signal over said connection a predetermined time interval after said connection is established, means controlled by another of said relays for causing the reoperation of said control means shortly after said signal is transmitted over said connection, thereby to cause further operation of said metering device, said signaling circuit being recompleted a second predetermined time interval after the reoperation of said control means and in response to reoperation of said one relay and further operation of said switch, and means including a circuit jointly controlled by said switch and said two last-named relays for initiating the release of said connection shortly after the expiration of said second time interval.

5. In a telephone system, a subscriber's line, a metering device associated with said line, a plurality of additional lines respectively located in different rate zones, automatic switching apparatus controllable over said first-named line to route a connection to a called one of said additional lines, and zone metering equipment controlled in accordance with the operation of said switching apparatus, said zone metering equipment including control means operative in response to the completion of said connection for causing said metering device to register an initial charge determined by the rate zone in which said called line is located, a timing device comprising a switch having a starting position and a number of other operating positions, means responsive to the completion of said connection for initiating the operation of said switch, a plurality of relays, circuits for energizing said relays, said circuits being controlled by said switch and being so connected and arranged that said relays are successively energized in response to successive operations of said switch to one of its operating positions, means for operating said switch to its starting position each time one of said relays operates, means controlled by one of said relays for causing the reoperation of said control means a predetermined time interval after said connection is established, thereby to cause further operation of said metering device, and means comprising a circuit jointly controlled by certain of said relays and said switch for initiating the release of said connection a second predetermined time interval after the expiration of said first-mentioned time interval.

6. In a telephone system, a subscriber's line, a metering device associated with said line, a plurality of additional lines respectively located in different rate zones, automatic switching apparatus controllable over said first-named line to route a connection to a called one of said lines, and zone metering equipment including a zone register switch controlled in accordance with the operation of said apparatus and operative to select the rate zone in which said called line is located, a control device operative to cause the operation of said metering device, pulsing means operative to generate groups of pulses individually corresponding to said rate zones, and means operative in response to the completion of said connection for connecting said control device through the contacts of said register switch to said pulsing means to receive the pulses of the group determined by the setting of said register switch, whereby said metering device is caused to operate a predetermined number of times determined by the zone in which said called line is located.

7. In a telephone system, a subscriber's line, a metering device associated with said line, a plurality of additional lines respectively located in different rate zones, automatic switching apparatus controllable over said first-named line to route a connection to a called one of said lines, and zone metering equipment including a zone register switch controlled in accordance with the operation of said apparatus and operative to select the rate zone in which said called line is located, a control device operative to cause the operation of said metering device, pulsing means cyclically operative to generate, during each cycle of operation thereof, groups of pulses individually corresponding to said rate zones, a relay operative to connect said control device through the contacts of said register switch to said pulsing means to receive the pulses of the group determined by the setting of said register switch, means operative in response to the completion of said connection for conditioning said relay to operate at the beginning of the next cycle of operation of said pulsing means, whereby said metering device is caused to operate a predetermined number of times determined by the zone in which said called line is located, and means jointly controlled by said relay and said pulsing means for causing the release of said relay at the end of said next cycle of operation of said pulsing means.

8. In a telephone system, a subscriber's line, a metering device associated with said line, a plu-

rality of additional lines respectively located in different rate zones, automatic switching apparatus controllable over said first-named line to route a connection to a called one of said lines, and zone metering equipment including a zone register switch controlled in accordance with the operation of said apparatus and operative to select the rate zone in which said called line is located, a control device operative to cause the operation of said metering device, pulsing means cyclically operative to generate, during each cycle of operation thereof, groups of pulses individually corresponding to said rate zones, a relay operative to connect said control device through the contacts of said register switch to said pulsing means to receive the pulses of the group determined by the setting of said register, means operative in response to the completion of said connection for conditioning said relay to operate at the beginning of the next cycle of operation of said pulsing means, whereby said metering device is caused to operate a predetermined number of times determined by the zone in which said called line is located, a second relay jointly controlled by said pulsing means and said first-mentioned relay and operative to cause the release of said first-mentioned relay at the end of said next cycle of operation of said pulsing means, a locking circuit for said second relay completed, in response to operation of said second relay, timing means operative in response to the completion of said connection, and means controlled by said timing means for interrupting said locking circuit, whereby said second relay is released and said first-named and second relays are caused sequentially to reoperate at the beginning and end of the cycle of operation of said pulsing means next following the release of said second relay.

9. In a telephone system, a subscriber's line, a metering device associated with said line, a plurality of additional lines respectively located in different rate zones, automatic switching apparatus including an impulse responsive switch controllable over said first-named line for routing a connection to a called one of said additional lines, and zone metering equipment associated with said switch and including a zone register switch operative in accordance with the impulses transmitted to said first-mentioned switch to select the zone in which said called line is located, means operative to release said zone register switch and to condition said zone register switch to operate in accordance with the impulses of a second series of impulses transmitted to said first-mentioned switch in the event said called line is located in a two digit rate zone, and means operative in response to the completion of said connection and controlled in accordance with the setting of said zone register switch for causing said metering device to register a charge determined by the rate zone in which said called line is located.

10. In a telephone system, a subscriber's line, a metering device associated with said line, a plurality of additional lines respectively located in different rate zones, automatic switching apparatus including an impulse responsive switch controllable over said first-named line to route a connection to a called one of said additional lines, and zone metering equipment associated with said switch and including a zone register switch having a normal position and operative to off-normal positions individually corresponding to said rate zones, means controlled by impulses transmitted to said first-mentioned switch for repeating said impulses to said register switch, whereby said register switch is operated to one of its off-normal positions during the first series of impulses transmitted to said first-mentioned switch, means operative to return said register switch to its normal position and to condition said last-mentioned means to respond to a second series of impulses transmitted to said first-mentioned switch in the event said called line is located in a two digit rate zone, and means operative in response to the completion of said connection and controlled in accordance with the off-normal position occupied by said register switch for causing said metering device to register a charge determined by the rate zone in which said called line is located.

11. In an automatic telephone system, a plurality of subscribers' lines, call metering devices individual to said lines, an operator's position, automatic switching apparatus for setting up connections between said lines on local calls originating on said lines and for extending connections from said lines to said operator's position, means whereby said metering devices are automatically operated under the control of said automatic switching apparatus to register predetermined charges for said local call connections, and means controllable from said operator's position for repeatedly operating any one of said devices to register a toll charge for a connection routed by way of said operator's position.

12. In an automatic telephone system, a plurality of subscribers' lines, a metering device associated with one of said lines, automatic switching apparatus for setting up a connection between said one line and another of said lines, means automatically operative to cause the operation of said metering device before the automatic switching apparatus through which said connection is routed is fully released, an operator's position, said automatic switching apparatus also being operative to establish a connection between said one line and said operator's position, a manually operable control device at said operator's position, and means controlled in accordance with the operation of said control device for causing the repeated operation of said metering device.

13. In an automatic telephone system, a plurality of subscribers' lines, a meterin gdevice associated with one of said lines, automatic switching apparatus directively controllable over said one line to route a connection to a called one of said lines, means operative in response to the release of said connection for causing the operation of said metering device, an operator's position, said automatic switching apparatus also being directively controllable over said one line to route a connection to said operator's position, a manually operable control device at said operator's position, and means controllable over at least a portion of said last-mentioned connection and in accordance with the operation of said control device for causing the repeated operation of said metering device.

14. In an automatic telephone system, a plurality of subscribers' lines, a metering device associated with one of said lines, automatic switching apparatus directively controllable over said one line to route a connection to a called one of said lines, means operative in response to the release of said connection for causing the operation of said metering device, an operator's position, said automatic switching apparatus also be-

ing directively controllable over said one line to route a connection to said operator's position, a dial operated calling device at said operator's position, and means controllable over at least a portion of said last-mentioned connection and operative in response to operation of said calling device for causing said metering device to operate the number of times designated by the operation of said calling device.

15. In an automatic telephone system, a first exchange, subscribers' lines extending to said exchange, a metering device associated with one of said lines, automatic switching apparatus in said exchange, said automatic switching apparatus being directively controllable over said one line to route a connection to another called line, means automatically operative to cause the operation of said metering device before the automatic switching apparatus through which said connection is routed is fully released, a second exchange, an operator's position in said second exchange, a trunk line extending to said operator's position, a repeater accessible to said automatic switching apparatus and terminating said trunk line in said first exchange, said automatic switching apparatus also being directively controllable over said one line to route a connection through said repeater and over said trunk line to said operator's position, and means included in said repeater and controllable over said trunk line from said operator's position for causing the operation of said metering device.

16. In an automatic telephone system, a first exchange, subscribers' lines extending to said exchange, a metering device associated with one of said lines, automatic switching apparatus in said exchange, said automatic switching apparatus being directively controllable over said one line to route a connection to another called line, means automatically operative to cause the operation of said metering device before the automatic switching apparatus through which said connection is routed is fully released, a second exchange, an operator's position in said second exchange, a trunk line extending to said operator's position, a repeater accessible to said automatic switching apparatus and terminating said trunk line in said first exchange, said automatic switching apparatus also being directively controllable over said one line to route a connection through said repeater and over said trunk line to said operator's position, a manually operable control device at said operator's position, and means included in said repeater and controllable over said trunk line in accordance with the operation of said control device for causing the repeated operation of said metering device.

17. In an automatic telephone system, a first exchange, subscribers' lines extending to said exchange, a metering device associated with one of said lines, automatic switching apparatus in said exchange, said automatic switching apparatus being directively controllable over said one line to route a connection to another called line, means automatically operative to cause the operation of said metering device before the automatic switching apparatus through which said connection is routed is fully released, a second exchange, an operator's position in said second exchange, a trunk line extending to said operator's position, a repeater accessible to said automatic switching apparatus and terminating said trunk line in said first exchange, said automatic switching apparatus also being directively controllable over said one line to route a connection through said repeater and over said trunk line to said operator's position, a dial operated calling device at said operator's position, and means included in said repeater and controllable over said trunk line in accordance with the operation of said calling device for causing said metering device to operate the number of times designated by the operation of said calling device.

18. In an automatic telephone system, a first subscriber's line, an electromagnetically controlled metering device associated with said line, a circuit including a metering conductor for energizing said device, a second subscriber's line, automatic switching apparatus including a connector switch directively controllable over said first subscriber's line for routing a connection to said second subscriber's line, said connector switch including back bridge and hold relays both of which are operated while said connection is established, a metering control relay operative to impress a predetermined potential upon said metering lead thereby to energize said circuit, and an operating circuit for said metering control relay, said operating circuit being jointly controlled by said hold and back bridge relays and being completed for a short time interval during the release of said connection.

19. In an automatic telephone system, a first subscriber's line, an electromagnetically controlled metering device associated with said line, a circuit including a metering conductor for energizing said device, a second subscriber's line, automatic switching apparatus including a connector switch directively controllable over said first subscriber's line for routing a connection to said second subscriber's line, said connector switch including back bridge and hold relays both of which are operated while said connection is established, a metering control relay operative to impress a predetermined potential upon said metering lead thereby to energize said circuit, an operating circuit for said metering control relay, said operating circuit being jointly controlled by said hold and back bridge relays and being completed for a short time interval during the release of said connection, and operator's position, a trunk line extending to said operator's position, a repeater terminating one end of said trunk line and accessible to said connector switch, said repeater including a metering conductor, said connector switch being directively controllable over said first subscriber's line to select said repeater and including means responsive to the selection of said repeater for interrupting said first-named circuit, for energizing said metering control relay and for connecting said metering conductors together, thereby to render said metering device controllable from said operator's position, and means responsive to the energization of said metering control relay for establishing a connection between said first subscriber's line and said repeater.

20. In an automatic telephone system, a subscriber's line, a metering device associated with said line, an operator's position, a dial controlled calling device at said operator's position, automatic switching apparatus for establishing a connection between said line and said operator's position, and means operative in response to operation of said calling device for causing the repeated operation of said metering device.

21. In an automatic telephone system which includes lines each equipped with a metering device and automatic switching equipment con-

trollable over calling ones of said lines to set up connections between said lines; zone metering equipment including means for automatically operating the metering device associated with a calling one of said lines at the beginning of each of a plurality of measured time intervals, means for automatically releasing the connection involving said calling line after a predetermined number of said time intervals have been measured, and means for transmitting a signal over the connection involving said calling line shortly before the end of each measured time interval.

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