

Sept. 10, 1940.

J. H. VOSS

2,214,213

TELEPHONE SYSTEM

Filed June 25, 1938

7 Sheets-Sheet 1

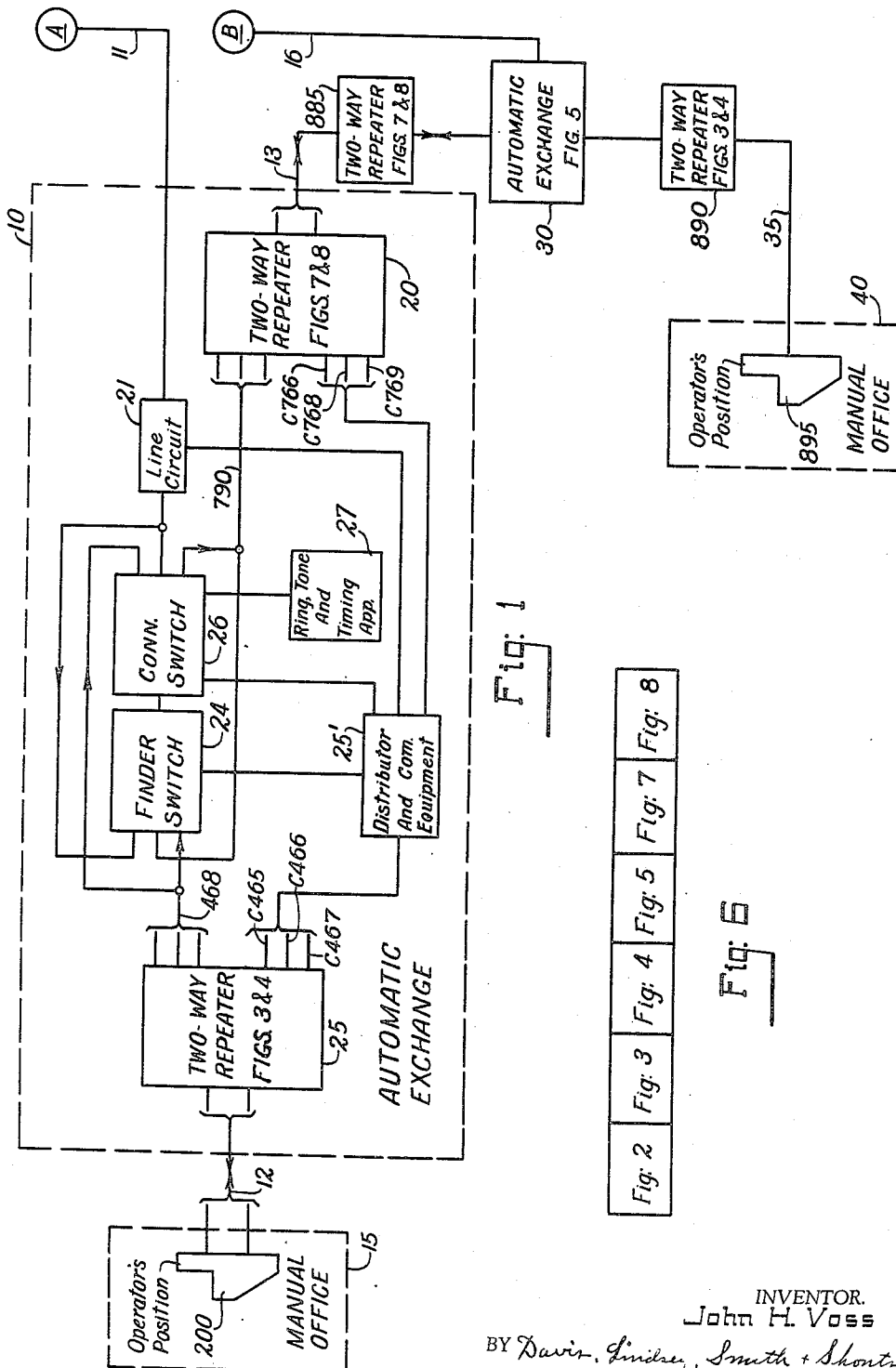


Fig. 1

Fig. 6

Fig. 2 Fig. 3 Fig. 4 Fig. 5 Fig. 7 Fig. 8

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7 Sheets-Sheet 2

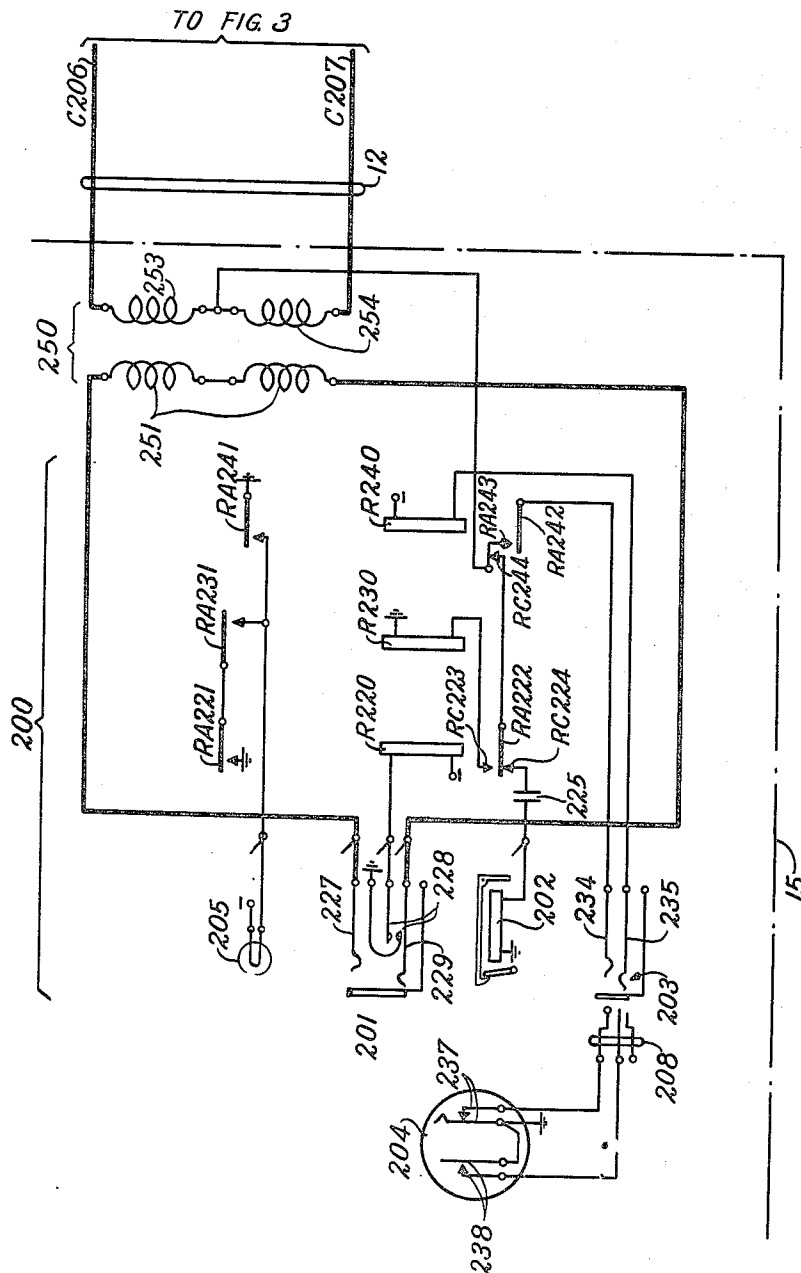


Fig. 2

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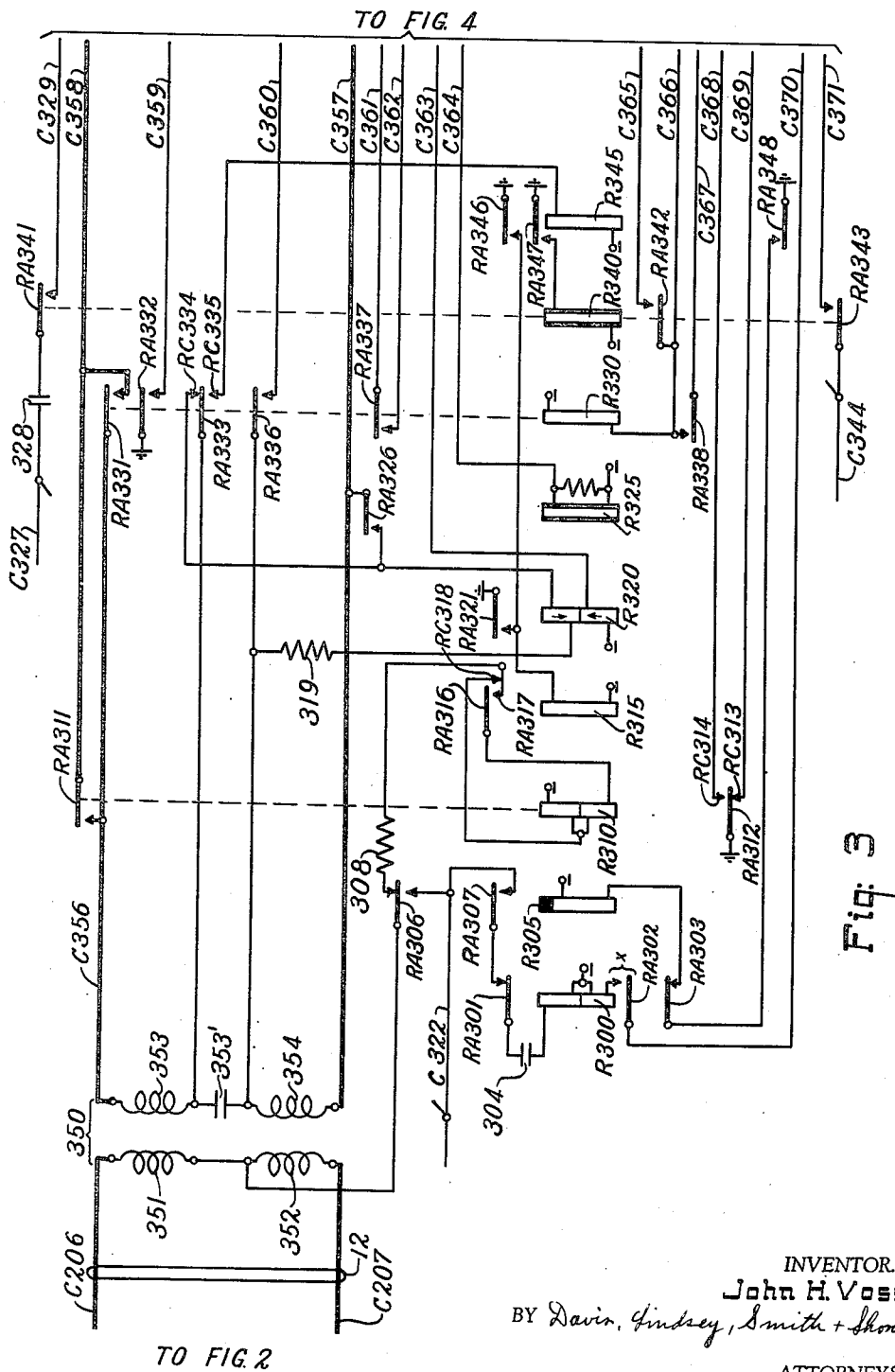
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TELEPHONE SYSTEM

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7 Sheets-Sheet 3



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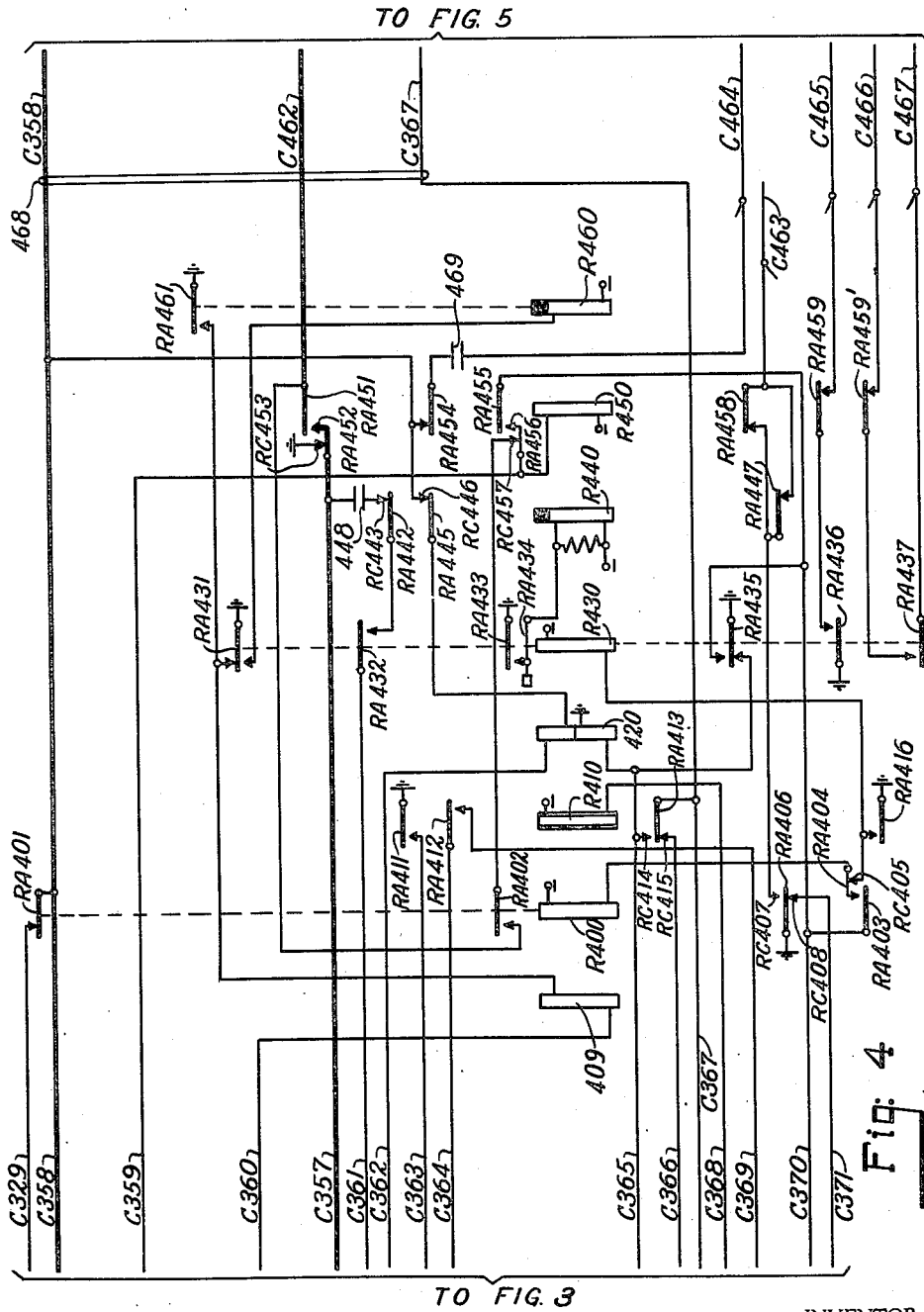
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7 Sheets-Sheet 4



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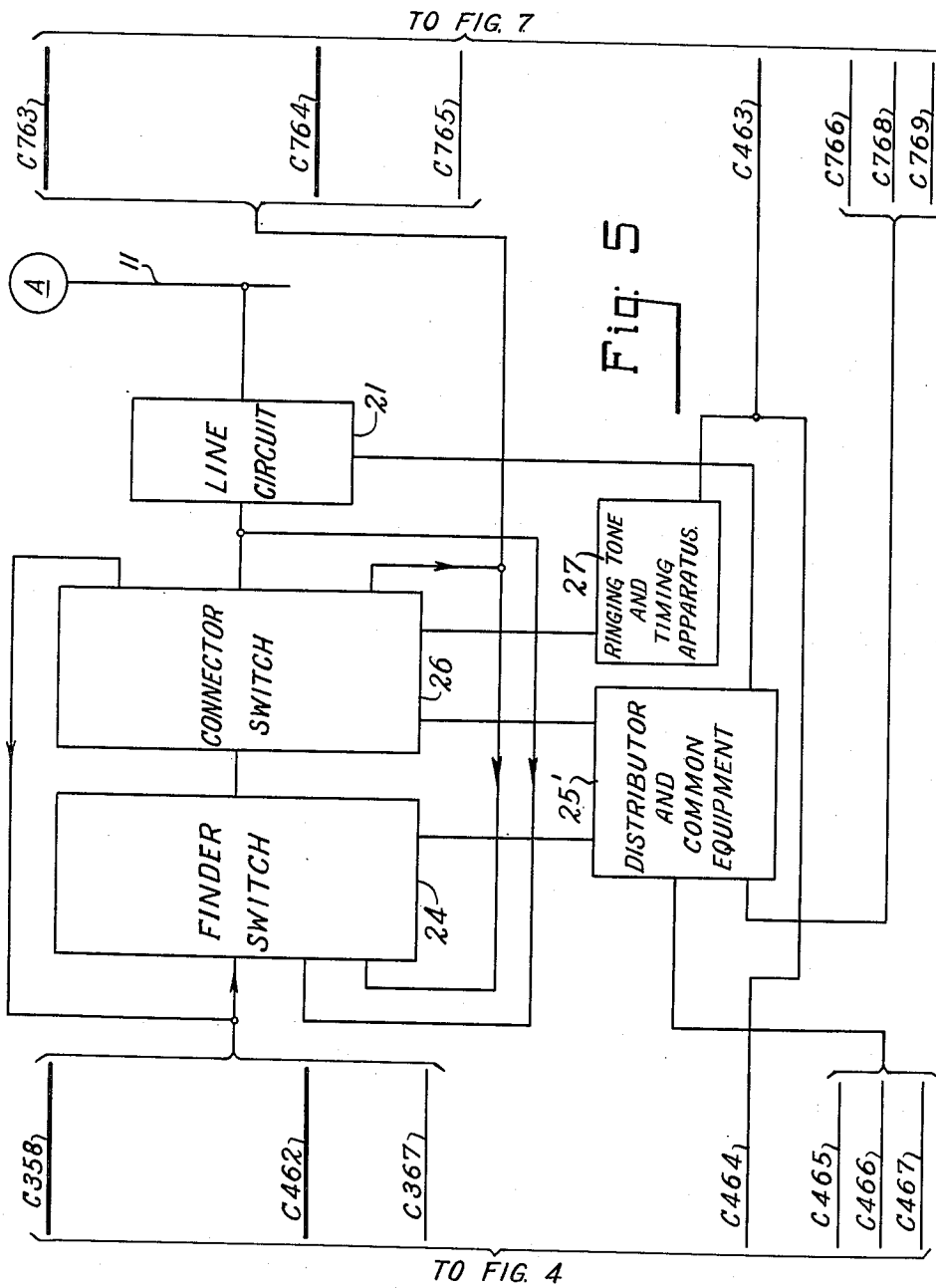
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TELEPHONE SYSTEM

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7 Sheets-Sheet 5



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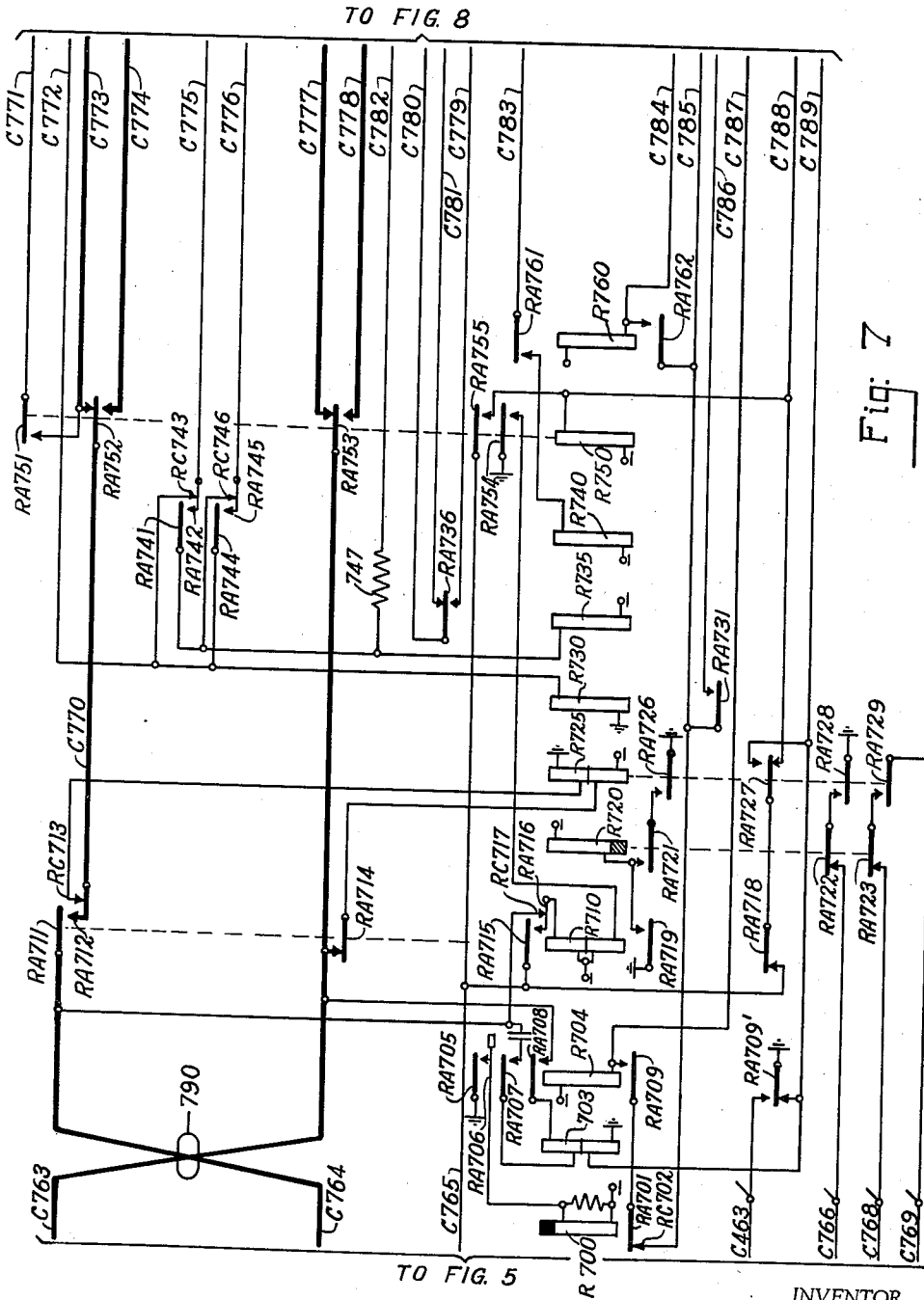
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TELEPHONE SYSTEM

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7 Sheets-Sheet. 6



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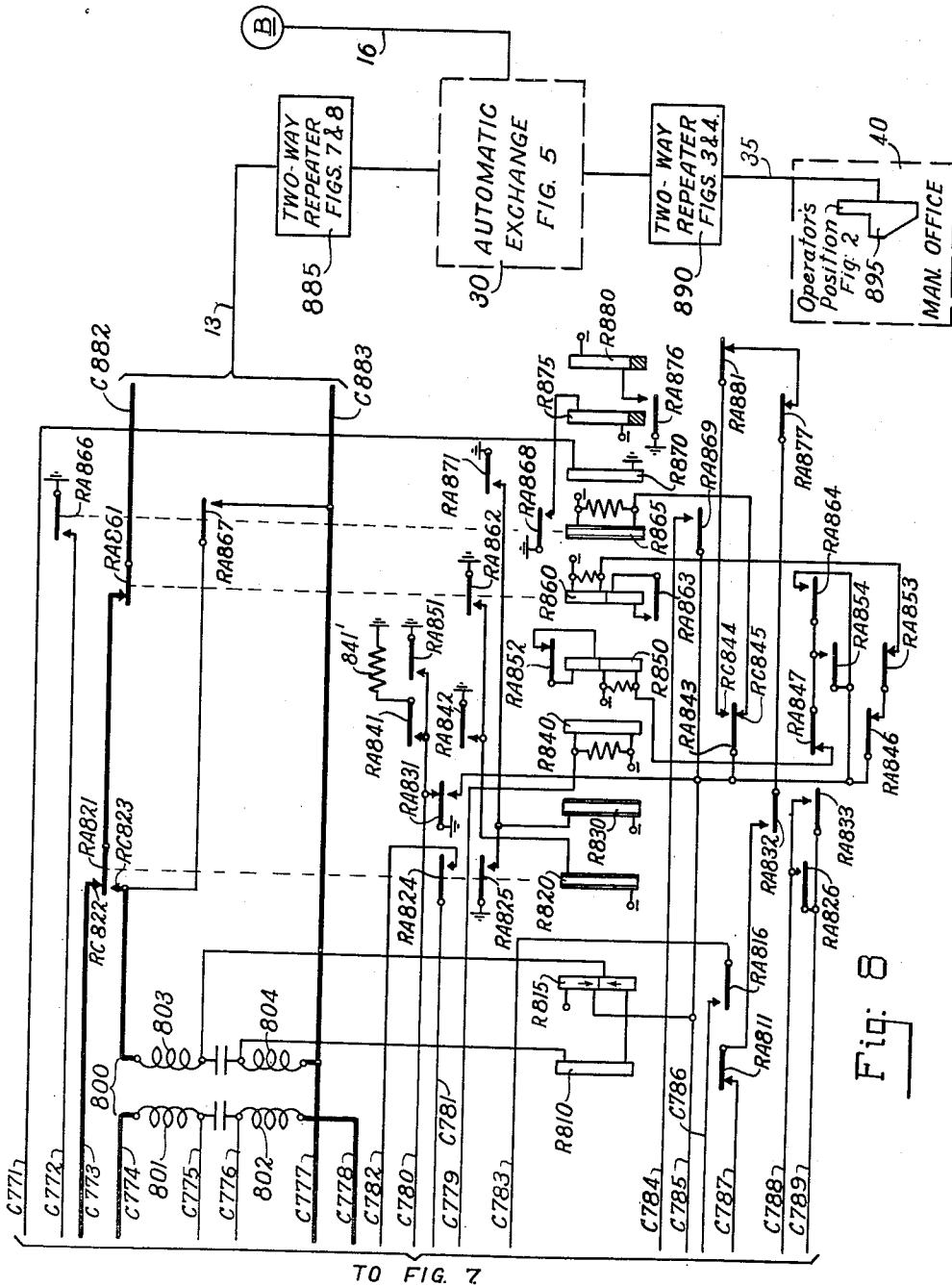
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TELEPHONE SYSTEM

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7 Sheets-Sheet 7



TO FIG. 7

Fig. 8

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UNITED STATES PATENT OFFICE

2,214,213

TELEPHONE SYSTEM

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Application June 25, 1938, Serial No. 215,786

26 Claims. (Cl. 179—27)

The present invention relates to telephone systems and has for one of its objects the provision of improvements in switching and supervisory apparatus for routing connections from an automatic substation through an automatic exchange to an operator's position in a distant manual office.

It is another object of the invention to provide, in a telephone system of the character indicated, an improved and exceedingly simple arrangement for projecting ringing current for a limited time interval over a line extending to an operator's telephone station.

It is a further object of the invention to provide, in a telephone system of the character described, an improved and simple arrangement whereby the calling or called party at an automatic substation may, by performing a connection release operation, control a supervisory signal device provided at the operator's telephone station when a connection between the automatic substation and the operator's telephone station is established.

It is an additional object of the invention to provide, in an automatic telephone system, an improved arrangement, operative when a call is originated at a telephone substation of the paystation type, for transmitting a signal identifying the character of the calling substation to an operator's position or telephone station on a call routed by way of the operator's position.

It is a still further object of the invention to provide, in a repeater associated with a trunk line extending between an automatic exchange and an operator's position in another exchange, an improved circuit arrangement for: transmitting ringing current to the operator's telephone station to energize the signal device thereat, transmitting a paystation signal to the operator in the event a call intended for the operator's position is originated at a telephone station of the paystation type, and controlling a supervisory signal device located at the operator's position.

It is a further and more specific object of the invention to provide in a telephone system, a repeater associated with a trunk line extending between two automatic exchanges, which repeater, in conjunction with a repeater associated with a trunk line extending between one of the automatic exchanges and an operator's position in a distant manual exchange, is operative in an improved manner to transmit paystation tone signals to the operator's position on calls originating at paystations and to control a supervisory signal device located at the operator's position.

The invention is illustrated as being incorporated in a telephone system wherein two manual offices and two automatic exchanges are interconnected by two-way trunk lines and associated repeaters so that connections may be established between any pair of lines of the system irrespective of which of the exchanges terminates the calling and called lines of a desired connection. The automatic switching equipment provided in each of the two automatic exchanges is diagrammatically illustrated as being of the character disclosed and claimed in applicant's co-pending application Serial No. 189,121; filed February 7, 1938. The arrangement is such that, when a call, originated at a telephone station of the paystation type associated with a line terminating in one of the automatic exchanges and intended for a substation associated with a line terminating at one of the manual exchanges, is routed through the automatic switching equipment provided in the automatic exchange and over a trunk line to an operator's position in the manual exchange, the connection thus established comprises a talking circuit between the calling substation and the operator's position which is adapted to be completed in response to the operation of a relay which operates when the call is answered at the operator's telephone station. In accordance with one feature of the present invention, means operative in response to the operation of the above-mentioned relay are provided for transmitting a signal to the operator's position indicating that a call originates at a telephone station of the paystation type. In the event the connection is routed by way of two of the automatic exchanges to the operator's position in the manual office, the established connection comprises a pair of repeaters connected in tandem, the first being associated with the trunk line extending between the two automatic exchanges, and the second being associated with the trunk line extending between the second automatic exchange and the distant manual office. As thus established, the connection comprises a first loop circuit extending between the two operated repeaters and a second loop circuit extending to the operator's telephone station, which second loop circuit is completed through operation of the abovementioned relay when the call is answered by the operator. In accordance with a further feature of the invention, means responsive to the operation of the relay are provided, for interrupting the first loop circuit, and means, included in the first of the tandem connected re-

peaters and operative in response to the interruption of the first loop circuit, are provided for impressing a signal on the second loop circuit indicating that the call originates at a telephone station of the paystation type. A further feature of the invention pertains to the particular arrangement for projecting a splash of ringing current over a trunk line to energize the signal device provided at an operator's position at one of the manual offices. More particularly, this arrangement includes a ringing relay embodied in the repeater associated with the trunk line extending to the operator's position and operative in response to the seizure of the repeater to connect the ringing-current source to the trunk line, thereby to energize the signal device at the operator's position. A ring cutoff relay is also provided, which ring cutoff relay includes a pair of windings, one of which is included in an operating circuit for the ring cutoff relay and is energized over this circuit from the ringing-current source in response to the operation of the ringing relay. The other winding of the ring cutoff relay is included in a holding circuit for the last-mentioned relay, which holding circuit is completed in response to the operation of the ring cutoff relay. The ring cutoff relay also includes contacts for opening the operating circuit of the ringing relay, thereby to arrest the ringing operation in response to the operation of the ring cutoff relay.

In accordance with a further feature of the invention, the supervisory signal device provided at the operator's position in one of the manual offices is arranged to be controlled in an improved manner by apparatus provided in the repeater associated with the trunk line by way of which connections are routed to the operator's position. This feature of the invention is directed to the provision of apparatus operative when a connection between an automatic substation and the operator's position is fully completed, for preventing the release of the operated switch train in response to a release operation performed at the automatic substation together with means responsive to repeated release operations performed at the automatic substation for repeatedly completing the operating circuit for the supervisory signal device. More particularly, the supervisory signal device provided at the operator's position includes an operating circuit which is arranged to be completed in response to the operation of a relay provided at the operator's position. The last-mentioned relay includes a winding which is arranged to be energized by way of a circuit including a winding of a second relay provided in the repeater associated with the trunk line extending to the operator's position. There is also provided an impedance element in the form of a second high resistance winding of the second relay which is adapted to be serially included in the operating circuit for the first relay. The impedance and, more particularly, the resistance, of this second winding is so proportioned relative to the impedances or resistances of the other relay windings that the relay which controls the signal device is operated only when the second winding of the second relay is excluded from its energizing circuit. For the purpose of controlling the operation of the signal device control relay, there is provided in the repeater, means, controllable from a substation included in a connection established to the operator's position, for selectively including the second

winding of the second relay in the operating circuit for the signal device control relay.

Further features of the invention pertain to the particular arrangement of the circuit elements whereby the above 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 the general arrangement of a system having the above-outlined features of the invention incorporated therein, Figs. 2, 3, 4, 5, 7 and 8 illustrate the circuit arrangement of certain of the apparatus embodied in the system of Fig. 1, and Fig. 6 illustrates the mode of combining Figs. 2, 3, 4, 5, 7 and 8 to form a unified system.

Referring now to the drawings, the system there shown comprises two small community automatic exchanges 10 and 30 and two manual offices 15 and 40 arranged to be interconnected by two-way trunk lines, each having associated therewith one or more repeaters constructed and arranged in accordance with the present invention. More particularly, there is provided a group of trunk lines, one of which is indicated at 12, extending between the manual office 15 and the automatic exchange 10; and a second group of trunk lines, one of which is indicated at 13, extending between the automatic exchanges 10 and 30. A third group of trunk lines including the line 35 is provided, the lines of which extend between the automatic exchange 30 and the manual office 40. Each of the enumerated exchanges 10, 15, 30 and 40 also has extending thereto a plurality of subscribers' lines, one of which is indicated at 11 as extending from the substation A to the exchange 10, and a second of which is indicated at 16 as extending from the substation B to the exchange 30. Each of these lines may be of the single or multi-party type, as desired.

The switching apparatus provided in the two automatic exchanges 10 and 30 is preferably identical in character, this apparatus being of the particular arrangement disclosed and claimed in the above-referred-to pending application Serial No. 189,121. In brief this apparatus, which, in its embodiment in the exchange 10, is diagrammatically illustrated in Figs. 1 and 5, comprises a plurality of finder-conductor links, each comprising a finder switch and a connector switch of the all-relay type, at which the lines extending to the exchange 10 terminate. Thus, the line 11 is connected by way of a line circuit 21 to the contact springs of two of the group relays embodied, respectively, in a finder switch 24 and a connector switch 26 forming one finder-conductor link. The line circuit 21 also includes control circuit conductors extending to the distributor and common equipment 25, which equipment is provided for the purpose of assigning links to successive calling lines in a definite order and for causing the finder portion of an assigned link to seize a calling line. Similarly, the trunk line 12, which extends to an operator's position 200 located in the manual office 15, is arranged to be connected by way of a two-way repeater 25 and a link line 468 to certain of the contact springs controlled by group relays respectively provided in each of the two switches

24 and 26. The line circuit for the trunk line 12 is incorporated in and forms a part of the repeater 25, this line circuit being connected and arranged to control start circuits extending to the distributor and common equipment 25' and including the conductors C465 to C467, inclusive. Again, the trunk line 13 extending between the exchange 30 and the exchange 10 is connected by way of a two-way repeater 20 and a link line 790 to the contact springs controlled by other group relays respectively provided in the finder switch 24 and the connector switch 26. The last-mentioned trunk line is also connected by way of a two-way repeater 895, which is in all respects identical with the repeater 20, to the automatic switching equipment embodied in the exchange 30.

The finder switches of the various links embodied in the exchanges 10 and 30 are of the all-relay type and are fully directive in character; that is, all line hunting operations are eliminated through an arrangement wherein only selected ones of the group and unit relays are caused to operate when a link is taken for use. The distributor and common equipment 25' is also of the all-relay type, auxiliary group and unit relays being provided therein which respectively correspond to the group and unit relays embodied in each of the associated finder switches. Each of the connector switches has embodied therein a group of impulse counting relays which function to control the connector group and unit relays during the operation of the connector portion of the link to select a desired line. The arrangement of the connector switches is such that bridged or divided code ringing may be utilized in signaling a desired substation on any selected called line, it being pointed out in this respect that the majority of the lines terminating at the small exchanges 10 and 30 are expected to be of the party line type. In the operation of each connector switch, four digits are necessary in order to select the desired type of ringing and the code of the ringing current and to select the desired line; the first digit being utilized to select a trunk line on a trunk call and to select the type of ringing and partially to select the code of the ringing current on a subscriber line call; the second digit being utilized to select for operation the group relay associated with the group or lines including the called line; the third digit being utilized to select the particular unit relay corresponding to the desired called line; and the fourth digit being utilized finally to select the code of the ringing current and to determine the side of the line over which the ringing current is to be projected, provided divided ringing is to be used in signaling the called substation. The links embodied in the exchange 10 also have associated therewith the usual auxiliary equipment indicated at 27, this equipment comprising apparatus for generating busy and dial-tone voltages, ringing apparatus and a ringing current code interrupter, and timing apparatus arranged to be used in releasing links assigned to faulty lines or lines having a permanent calling condition thereon.

Considering briefly the operation of the switching apparatus embodied in the exchange 10, when a subscriber, such, for example, as the subscriber at the telephone A, initiates a call over the line 11 to a second subscriber's telephone by lifting his receiver from its hook, the line circuit 21 operates to cause the finder-connector link previously assigned by the distributor to the calling line to

be started in operation to seize the calling line. Assuming that the link 24, 26 is delegated by the distributor to set up the connection, the finder portion 24 of the link operates to select the calling line and to connect it through to the conductors of the link line incoming to the connector portion 26 of the link. More particularly, when the line circuit operates, the auxiliary group and subgroup relays corresponding to the calling line and embodied in the distributor and common equipment 25' are caused to operate, together with certain of the relays embodied in the allotter or distributor, and, upon operating, cause the operation of the corresponding group and unit relays embodied in the finder portion 24 of the link. When the calling line 11 is seized by the finder switch 24 and extended by way of this switch through the operation of the group and unit relays to the associated connector switch 26, it is marked as busy in all of the other connector switches, and the control equipment of the seized link is automatically conditioned to respond to the impulses of the first series of impulses dialed at the impulsing device conventionally provided at the substation A. During the impulses of each series, the counting relays embodied therein respond in succession so that, at the end of the series, the particular relay corresponding to the number of impulses making up the series is left operated. At the end of the first series of impulses, the control apparatus of the link operates to determine the type of ringing to be utilized in signaling the desired substation and partially to select the code of the ringing current, providing the number of impulses making up the digit indicates that the call is to be routed to another subscriber's line terminating at the exchange 10. On the other hand, if the number of impulses making up the first digit indicates that the call is to be forwarded by way of one of the trunk lines extending to the manual office 15 or to the automatic exchange 30, the control apparatus embodied in the switch automatically operates, at the end of the digit, to switch the calling loop circuit through to the repeater associated with an idle trunk of the selected group. In this regard, it is mentioned that the trunk selecting apparatus associated with the links is of a character such that an idle trunk of a selected group is made available immediately a previously assigned trunk is taken for use. Obviously, if the call initiated at the substation A is a trunk call, no further operation of the apparatus occurs following the trunk selecting operation of the connector switch 26 until the connection is released. If, on the other hand, the connection is to be routed to another subscriber's line terminating at the exchange 10, three additional digits are dialed, the arrangement being such that, at the end of the second digit, the particular group relay embodied in the connector switch 26 corresponding to the group of lines including the called line, is caused to operate. Similarly, at the end of the third digit, the particular unit relay embodied in the connector switch 26 is caused to operate. Thus, the desired called line is fully selected. The impulses of the fourth digit, as indicated above, cause the control apparatus of the operated link to operate finally to select the code of the ringing current and the side of the selected line over which the ringing current is to be projected provided divided ringing is the type of ringing selected in response to the impulses of the first digit.

When the called line is selected, the control

apparatus of the operated link functions to test the line for the purpose of determining the busy or idle condition thereof. If the called line is busy, busy-tone current, as generated by a portion of the apparatus 27, is not returned over the loop extending to the calling subscriber's substation until after the fourth or code selecting digit is dialed at the calling substation. At the conclusion of his digit and if the called line is busy, busy-tone current is returned over the loop to indicate to the calling party that the desired connection cannot immediately be completed. On the other hand, if the called line is idle at the time it is selected, ringing current of the selected code corresponding to the desired called substation is projected over the called line for the purpose of energizing the signal device provided at the called substation. During the ringing operation, ring-back-tone current is applied to the loop extending to the calling substation to indicate to the calling party that the desired substation is being signaled. Finally, the connection between the calling and called substations is completed when the call is answered at the called substation. The arrangement of the link circuit apparatus is such that release of the link utilized in setting up the desired connection between two lines terminating at the exchange 10 is under the control of the calling party. More particularly, the operated switch train is released in response to a release operation performed at the calling substation.

Referring now in greater detail to the apparatus provided at the operator's position 200 and the apparatus embodied in each of the repeaters 20, 25, 885 and 890, and considering first the line terminating apparatus provided at the operator's position 200, it is pointed out that the trunk line 12 extends to one side of a repeating transformer 250, the other side of which is connected to the springs of an answer jack 201. A dialing or calling jack 203 is also provided which is arranged to receive a plug 208 having its ring and tip contacts connected to the impulsing and shunt springs of a dial controlled impulsing device 204 of conventional construction and arrangement in the manner illustrated. For the purpose of signaling the operator on calls incoming to the operator's position 200, there is provided a signal device in the form of a drop 202 which is arranged to be energized by ringing current projected over the trunk line 12 and traversing a condenser 225 connected in series with the energizing winding of the drop. In order to indicate the condition of connections routed by way of the operator's position 200, there is provided a supervisory signal device in the form of a lamp 205 which is arranged to be controlled by three relays R220, R230 and R240. Of the three enumerated relays, the relay R220 is arranged to be energized when an answer or line connecting plug is inserted in the jack 201 and is operative to prepare the operating circuit for the lamp 205, to open the circuit for energizing the drop 202, and to complete a circuit, described hereinafter, for energizing the control relay R230, which latter relay is of the marginal type. The relay R240 is provided for the purpose of completing an impulsing circuit extending to the repeater 25 and traced hereinafter, this relay being arranged to be energized only during operation of the impulsing device 204 or, more particularly, in response to closure of the shunt springs 238 embodied in the impulsing device 204.

Referring now in greater detail to the repeater 25 illustrated in Figs. 3 and 4, this repeater includes a repeating transformer 350 having one side at which the end of the trunk line 12 extending to the exchange 10 terminates and another side arranged to be connected by way of the link line 468 to the contact springs of certain of the group relays embodied in the finder and connector switches forming the automatic switching equipment of the exchange. This repeater also includes nine relays illustrated in Fig. 3 and six relays illustrated in Fig. 4. Of the relays illustrated in Fig. 3, the two relays R300 and R305 are arranged to control the application of ringing current to the trunk line 12 on a call extended to the operator's position 200 and operate in an improved manner described more particularly hereinafter. The relay R310, which includes two windings, is, in effect, a line relay controllable from the operator's position 200 and arranged to have one or both of its windings energized in series with the winding of the marginal relay R230. The lower winding of R310 is in effect an impedance element which is arranged selectively to be included in the series circuit by way of which the winding of R230 is energized. The impedance of the lower winding of R310 is so proportioned relative to the impedance of the winding of R230 and the impedance of the upper winding of R310 that R230 operates only when the lower winding of R310 is excluded from the series circuit for energizing R310 and R230. For the purpose of selectively including one or both of the two windings of R310 in the series circuit for energizing this relay and R230, there is provided a relay R315 which is controllable by way of a connection extended to the operator's position 200. More particularly, the relay R315 is arranged to be energized in response to the operation of either of two bridging relays R320 and R345, the first of which is of the polarized type and operates only when its two windings are cumulatively energized. The slow-acting relay R325 is provided for the purpose of shunting the series path including the winding 354 of the transformer 350, the upper winding of R320, and the resistor 319 during each series of impulses transmitted from the operator's position 200, thereby to reduce the resistance of an established loop circuit extending to an operated one of the connector switches in the exchange 10 during a dialing operation. The relay R330 is operative in response to the seizure of the link line 468 by one of the connector switches embodied in the exchange 10 and functions as a line switching and control relay in the manner described hereinafter. The slow-acting relay R340, which is under the control of the relay R345, is provided for the purpose of initiating the operation of the ringing apparatus and for the further purpose of completing a circuit, traced hereinafter, for impressing ringing voltage on a calling loop circuit extending to a calling automatic substation. Of the relays illustrated in Fig. 4, the relay R400 is provided for the purpose of controlling the cutoff and line switching relay R450 and for the additional purposes of removing ground from the ringing apparatus start conductor and opening the above-mentioned circuit for impressing ringing voltage on the link line 468. The slow-acting relay R410 is operative in response to the operation of the line relay R310 and, in combination with the relay R430, functions to complete start circuits, described hereinafter, extending to the distrib-

utor and common equipment 25', and to cause a pay station-tone signal to be transmitted to the operator's position 200 on calls incoming to this position and originating at telephone stations of the paystation type. More particularly, the relay R430 is operative, when a call originating at a paystation is answered at the operator's position 200, to cause the signal to be transmitted to the operator's position, and the slow-to-operate relay R440, which operates a predetermined time interval after the operation of R430, is arranged to terminate the signal. The relay R430, in combination with the slow-to-operate relay R460, also functions momentarily to interrupt an established loop circuit extending to the repeating transformer 350 for the purpose of causing a preceding repeater of the character illustrated in Figs. 7 and 8 to transmit a paystation-tone signal to the operator's position 200 on calls originated at paystations and routed by way of the two automatic exchanges 10 and 30 to the operator's position 200. The paystation-tone signal voltage is impressed between the control conductor of the link line 468 and ground on calls originating at telephone stations of the paystation type and associated with lines terminating at the exchange 10. This voltage is, through the operation of the relay R410, impressed upon the input terminals of a coupling device in the form of a transformer 420 having output terminals arranged to be connected across the line conductors of the link line 468 when the relay R430 occupies its operated position. For the purpose of balancing the impedances associated with an established talking circuit when the relay R345 is connected to be energized over a loop extending to the repeating transformer 350, there is provided an impedance element 409 having impedance characteristics substantially identical with those of the winding of R345.

Referring now in greater detail to the repeater 20, illustrated in Figs. 7 and 8, this repeater comprises a repeating transformer 800 having one side terminating the conductors of the trunk line 13 and the other side arranged to be connected by way of the conductors of a link line 790 to certain of the contact springs of certain of the group relays respectively embodied in each of the finder and connector switches located in the exchange 10. The relay and control equipment included in this repeater comprises two relays R704 and R700 which are operative to transmit a paystation signal by way of the trunk line 13 to the operator's position 895 on calls originating at telephone stations of the paystation type associated with lines extending to the exchange 10 and routed to this operator's position. The paystation-tone voltage which appears between the control conductor of the link line 790 and ground is impressed on the line conductors of the trunk line 13 through the provision of a coupling device in the form of a transformer 703, which corresponds to the coupling device 420 shown in Fig. 4. There is also included in the control equipment a line relay R725 which operates when connections are routed by way of the trunk line 13 to the exchange 10 and functions to complete start circuits, described hereinafter, extending to the distributor and common equipment 25'. These start circuits are arranged to be interrupted through the provision of a slow-to-release cutoff relay R720 which is controlled by a line switching relay R710 operative when the repeater 20 is seized by a connector switch located in the exchange 10. The

relay R750 is also operative in response to the seizure of the link line 790 by one of the connector switches provided in the exchange 10 and functions to condition the remaining relay equipment to extend the calling loop circuit to the repeating transformer 800. The bridging relays R730 and R735 are arranged to be energized in series over a loop circuit extending to the repeating transformer 800 and are arranged respectively to control the battery reversing relay R740 and the pulsing relay R840. The battery reversing relay is also controlled by a relay R760 which is a slave to the slow-acting relay R865.

The relay R840 is arranged to control a slow acting relay R820 which, in turn, controls the operating circuit for a second slow-acting hold relay R830. The second slow-acting relay R830 is also arranged to be controlled by a relay R870. The relay R840 is also included in an impulse correcting network comprising two additional relays R850 and R860, the last-mentioned of which functions to repeat impulses by way of the trunk line 13 to the automatic switching equipment provided in the exchange 30. For the purpose of reducing the impedance of an established impulsing circuit extending by way of this trunk line, there is provided a slow-acting relay R865 which is arranged to shunt the line terminals of the windings 803 and 804 included in the repeating transformer 800 during each series of impulses. The relay R865 also operates to shunt the winding of the relay R730, included in the calling loop circuit, during impulsing. The two relays R810 and R815 are bridging relays and include windings arranged to be energized in series over an established loop circuit extending by way of the trunk line 13. More particularly, the relay R815 is of the polarized type, such that it only operates when its two windings are cumulatively energized. It is noted that, after a connection is extended by way of the repeater illustrated in Figs. 7 and 8 to an operator's position in the distant manual office 40, the relay R810 restores each time the established loop circuit to the operator's position is interrupted. Thus, this relay is arranged to respond to the momentary interruption of the loop circuit occurring when the operator at the distant operator's position answers and functions to control the relay R704, which latter relay is operative to cause a paystation-tone signal voltage to be impressed between the conductors of the link line 790. In order to prevent the relay R704 from being energized during the dialing operation, or in other instances when the loop circuit over which the relay R810 is energized, is interrupted, the two slow-to-release relays R875 and R880 are provided, each of which includes contacts for opening the operating circuit for R704.

Referring now more particularly to the operation of the repeater 25 shown in Figs. 3 and 4 to route a connection from the manual office 15 to one of the lines extending to the automatic exchange 10 on a call initiated at or routed by way of the operator's position 200, it is pointed out that the operation of the repeater is started when the operator inserts the plug terminating her telephone set in the jack 201, thereby to connect the line conductors of the cord extending to the operator's telephone set by way of the springs 227 and 229, respectively, to opposite terminals of the winding 251 of the repeating transformer 250. At the springs 228, an obvious circuit is completed

for energizing R220, which relay, upon operating, prepares, at RA221, a circuit for energizing the signal lamp 205 and completes, at RA222 and RC223, a circuit for energizing the winding of R230 in series with the upper winding of R310 embodied in the repeater 25. The last-mentioned circuit extends from ground at the upper terminal of the winding of R230 by way of this winding, RC223, RA222, RC244 and RA243, where it divides into two branches; one extending by way of the winding 254, C207 and the winding 352; and the other extending by way of the winding 253, C206 and the winding 351. From the junction point between the windings 351 and 352, this circuit extends by way of RA306, the resistor 308, RA317, RC318 and the upper winding of R310 to battery. When energized over the above-traced circuit, the two relays R230 and R310 operate, the first thereof completing, at RA231, the above-mentioned circuit for energizing the signal lamp 205, and the second relay, R310 preparing, at RA311, a loop circuit extending to the switching apparatus provided in the exchange 10. At RA312 and RC314, the relay R310 completes a circuit extending by way of C368 for energizing the slow-acting relay R410.

When the relay R410 operates, it completes, at RA411, a circuit extending by way of C363 for energizing the lower winding of the polarized relay R320. The relay R320 does not operate when its lower winding is alone energized, this relay being so constructed and arranged that it operates only when both of its windings are cumulatively energized. At RA412, the relay R410, upon operating, prepares a circuit, traced hereinafter, for energizing the slow-acting relay R325. At RA413 and RC415, the relay R410 opens a point in the circuit, traced hereinafter, for energizing the switching relay R330 and, at RA413 and RC414, the relay R410 completes a path for applying ground to the control conductor C367, thereby to mark the trunk line 12 as busy in the connector switches to which the conductors C358, C462 and C367 of the link line 468 terminate. This marking path extends from ground at the right terminal of the lower winding of the impedance element 420 by way of this lower winding, RC414, and RA413 to the control conductor noted. It is pointed out that, through the operation of R410, the trunk line 12 is marked busy to guard against the seizure thereof by one of the numerical switches provided in the exchange 10, immediately the call is initiated at the operator's position 200. Thus, the trunk line 12 is guarded against seizure during the period when one of the non-numerical switches provided in the exchange 10 is operating to seize the link line 468.

At RA416, the relay R410 completes circuits for respectively energizing the relays R400 and R430. The first of these circuits extends from ground at RA416 by way of RC405, RA404 and the winding of R400 to battery, and the circuit for energizing R430 extends from ground at RA416 and through the winding of R430 to battery. When the two relays R400 and R430 operate, a holding circuit for R400 is completed, which circuit extends from ground at RA435 by way of RA403, RA404 and the winding of R400 to battery. At RA401, the relay R400, upon operating, opens a point in the path, traced hereinafter, for connecting the ringing-tone voltage source to the line conductor C358, and, at RA406, the relay R400 completes a path extending by way of RC407 and RA458 for applying ground to the tone apparatus start conductor C463, thereby to initiate the operation of

this apparatus in a well-known manner. At RA402, the relay R400 prepares a point in the circuit, traced hereinafter, for energizing the relay R450.

The relay R430, upon operating, moves its armature RA433 into engagement with the associated weighted armature RA434. When RA433 strikes the contact carried by RA434, the last-mentioned armature starts to vibrate, alternatively to make and break contact with RA433. As shown, these two armatures are included in the operating circuit for the relay R440, which relay, due to its slow-to-operate characteristic, does not operate for a time interval required for RA434 to settle into resting engagement with RA433. At RA442 and RA445 and their respective associated contacts RC443 and RC446, the relay R440, upon operating, opens two points in the path, traced hereinafter, for impressing a pay-station-tone voltage on the loop, including the trunk line 12 and extending to the operator's position 200. At RA447, the relay R440 opens a point in an alternative path, traced hereinafter, for applying ground to the tone apparatus start conductor C463.

At RA431, the relay R430, upon operating, completes an obvious circuit for energizing the slow-to-operate relay R460, which latter relay, upon operating, prepares, at RA461, a loop circuit which is described hereinafter. At RA436, the relay R430 applies ground to the tens relay control conductor C465, which conductor is included in the operating circuit for the one of the tens or group relays provided in the distributor 25' corresponding to the group of lines including the link line 468. At RA437, the relay R430 connects the start conductor C467 to the unit relay control conductor C466, thereby to prepare the operating circuit for the particular unit relay provided in the distributor 25' which corresponds to the trunk line 12.

As explained in the above-referred to copending application Serial No. 189,121, when ground is applied to the tens relay start conductor C465 and the start conductor C467 is connected to the unit relay control conductor C466, the group or tens relay provided in the distributor 25', corresponding to the particular group of lines including the link line 468, and the particular unit relay corresponding to this trunk line are caused to operate to initiate the operation of a previously assigned finder switch to seize the link line 468, providing an idle finder-connector link is available.

The apparatus included in the distributor and common equipment 25' is so arranged that, in the event all of the links having access to the link line 468 are busy at the time the calling condition is created on the trunk line 12, busy-tone voltage is impressed between the all-links-busy conductor C464 and ground. Thus, if all of the links provided in the exchange 10 and having access to the link line 468 are busy, a circuit is completed immediately the relay R310 operates for causing a busy-tone signal to be transmitted by way of the trunk line 12 to the operator's position 200. The path of the busy-tone current extends from the ungrounded terminal of the busy-tone source by way of C464, the condenser 469, RA454, C358, RA311, C356, the winding 353, the condenser 353', the winding 354, C357 and RA452 to the grounded terminal of the busy-tone source at RC453. The alternating busy current flowing over the circuit just traced causes a corresponding induced volt-

age to be developed between the terminals of the series connected repeating transformer windings 351 and 352, which voltage is impressed by means comprising the trunk line 12 and the transformer 250 between the terminals of the receiver embodied in the operator's telephone set. The resulting operation of the operator's receiver indicates that the desired connection can not immediately be established.

Assuming that the finder-connector link 24, 26 provided in the exchange 10 is idle at the time the call is initiated at the operator's position 200 and, further, that this link is the link which has been previously assigned by the distributor and common equipment 25' to the use of the call, when the group and units relays provided in the distributor 25' operate, the finder portion 24 of the assigned link is set in operation to seize the link line 468. More particularly, the group and unit relays provided in the switch 24 and corresponding to the operated group and unit relays in the distributor 25' are caused to operate to connect the conductors of the link line 468 through to the trunk extending to the connector switch 26. As explained in the above-referred to copending application, when the line 468 is seized by the finder switch 24 and switched through to the connector switch 26, certain of the relays provided in the connector switch 26 are caused to operate to apply ground potential to one of the line conductors of the trunk line incoming to the switch 26, which one line conductor is, following the complete operation of the finder switch 24, connected to the line conductor C462 of the link line 468. When ground is applied to C462, the relay R450 is energized over a circuit extending by way of this grounded conductor, RA402, RC457, RA456 and the winding of R450 to battery. Upon operating, the relay R450 completes a holding circuit for itself, this circuit extending from ground at RA435 by way of RA455, RA456 and the winding of R450 to battery. At RA456 and RC457, the relay R450 opens a point in its operating circuit, as traced above. At RA454, the relay R450 opens a point in the circuit, traced previously, traversed by the busy-tone current and completed when an all-links-busy condition prevails in the exchange 10.

At RA451 and RA452, the relay R450 completes the above-mentioned loop circuit extending from the repeating transformer 350 by way of the link line 468 and the operated finder switch 24 to the connector switch 26, thereby to provide a holding circuit for the line relays embodied in this connector switch. This loop circuit may be partially traced as extending by way of C358, RA311, C356, the winding 353, RA333, RC334, the upper winding of R320, the resistor 319, the winding 354, C357, RA452 and RA451 to C462. It will be understood that one or more of the respective windings of the two line relays provided in the connector switch 26 are energized in series with the upper winding of R320 when the above-mentioned and partially traced loop circuit is completed. The polarity of the current traversing this circuit is such that the upper and lower windings of R320 are differentially energized. Thus, the relay R320 is not caused to operate at this time.

At RA458, the relay R450, upon operating, interrupts the above-traced path for applying ground to the tone apparatus start conductor C463. At RA459, the relay R450 opens a point in the above-traced path for applying ground to the tens relay control conductor C465 and, at RA459', the relay R450 opens a point in the path

for connecting the start conductor C467 to the units relay control conductor C466. When ground is removed from C465 and the start conductor C467 is disconnected from C466, the distributor and common equipment 25' are released for use in connection with other calls, it being pointed out that this apparatus operates to assign another idle link for use on the next succeeding call immediately the link 24, 26 becomes busy.

Following the operation of the finder switch 24 to seize the link line 468 and the operation of the relay R450 to extend the above-traced loop circuit from the repeating transformer 350 to the operated connector switch 26, ground is returned through the operated finder switch 24 to the control conductor C367 to maintain the line 468 marked as busy, and the connector switch is conditioned to respond to the impulses making up the digits dialed at the operator's position 200. In this regard, it is noted that, when the loop circuit is extended to the connector switch 26, dial tone is returned over the loop and by way of the trunk line 12 to the operator's telephone to indicate that the dialing operation may be started. Upon receiving dial tone, the operator inserts the plug 208 in the jack 203 and operates the dial controlled impulsing device 204 in accordance with the directory number identifying the desired line. If, for example, the line 11 extending to the substation A is being called, a four-digit number identifying the called line and the ringing code of the called substation A is dialed at the operator's position 200. During each series of impulses dialed at the operator's position 200, the shunt springs 238 embodied in the impulsing device 204 are closed to complete a circuit extending by way of the jack spring 235 for energizing the relay R240. This circuit is held completed at the shunt springs 238 throughout each series of impulses. The relay R240, upon operating, interrupts, at RA243 and RC244, the above-traced series circuit including the winding of R230 and the upper winding of R310. At RA242 and RA243, the relay R240 completes an alternative circuit extending by way of the impulsing springs 237 and the jack spring 234 for holding the relay R310 operated. At RA241, the relay R240 completes an obvious alternative circuit for maintaining the signal lamp 295 energized so that, when R230 restores, shortly after the operation of R240, to open the original operating circuit for the lamp 205, the illuminated condition of this lamp is not disturbed. During each impulse of each of the four digits dialed, the springs 237 are opened to interrupt the circuit over which R310 is being held energized, causing this relay to restore to open, at RA311, the loop circuit extending to the connector switch 26. At RA312 and RC314, the relay R310, upon restoring during the open circuit period of each impulse, opens the above-traced operating circuit for R410, but the latter relay, due to its slow-to-release characteristic, remains operated during impulsing. At the beginning of the first impulse of each digit and when R310 restores, the previously mentioned circuit is completed for energizing the slow-acting relay R325, this circuit extending from ground at RA312 by way of RC313, C369, RA412, C364 and the winding of R325 to battery. The relay R325 operates, when first energized over the above traced circuit, and short-circuits, at RA326 the branch of the loop circuit extending to the connector switch 26 which includes the upper winding of R320, the resistor 75

319 and the repeating transformer winding 354, thereby to reduce the resistance of the impulsing circuit by way of which impulses are repeated to the connector switch 26. Due to its slow-to-release characteristic, the relay R325 remains operated during each series of impulses dialed at the operator's position 200. At the end of each digit dialed, the relay R310 remains operated for a sufficient time interval to permit the relay R325 to restore to open the above-mentioned short-circuiting path. Also, at the end of each series of impulses, the shunt springs 238 are opened to interrupt the above-mentioned circuit for energizing R240. When R240 restores, it obviously re completes the above-traced circuit for energizing the winding of R230 and the upper winding of R310 in series, and opens the alternative circuit for energizing the signal lamp 205. This lamp is, however, maintained energized, due to the reoperation of R230. At the end of the dialing operation, the calling plug may, if desired, be withdrawn from the calling jack 203 for use in establishing other connections.

The apparatus embodied in the connector switch 26 responds to the impulses dialed at the operator's position 200 and repeated thereto by the repeater 25 by selecting the called line 11 and by selecting the type of ringing and the code of the ringing current to be used in signaling the called substation, all in the manner explained previously. The arrangement of the control apparatus embodied in the switch 26 is such that the called line is tested to determine the idle or busy condition thereof immediately the line selecting operation of the connector switch is completed. Busy-tone voltage is, however, not applied to the loop extending to the repeating transformer 350 until after the final code selecting digit is dialed. If the called line is busy and busy-tone voltage is ultimately applied to the loop extending to the operated connector switch, the current flowing over the loop causes an induced voltage to be impressed between the line conductors of the trunk line 12 so that a busy-tone signal is generated by operation of the receiver included in the operator's telephone set. On the other hand, if the selected called line is idle, ringing current of the selected code is projected over the line to signal the desired substation A and ring-back tone is impressed on the loop extending to the repeating transformer 350 and is transmitted by way of this transformer, the trunk line 12 and the transformer 250 to the receiver embodied in the operator's telephone set, to indicate that the desired substation is being rung.

The desired conversational connection is completed when the call is answered at the substation A. A direct current bridge is placed across the conductors of the line 11 when the call is answered, which causes the back bridge or battery reversing relay conventionally provided in the connector switch 26 to be energized. When this back bridge relay operates, the exchange battery is reversely connected to the line conductors of the link line 468 in the usual manner, so that the current traversing the upper winding of R320 is reversed and the two windings of the last-mentioned relay are cumulatively energized. The relay R320 now operates to complete, at RA321, an obvious circuit for energizing R315. The relay R315, upon operating, completes, at RA316 and RA317, an alternative circuit for energizing the two windings of R310 in series. This circuit extends from battery at the upper terminal of the upper winding of R310 by way of

the two windings of R310 in series, RA316, RA317, the resistor 308, RA306, the simplex circuit including the two sides of the trunk line 12, RA243, RC244, RA222, RC223 and the winding of R230 to ground. At RA317 and RC318, the relay R315 opens the original operating circuit for R310. The lower winding of R310 is a high resistance winding, such that, when serially included in the circuit by way of which the winding of R230 and the upper winding of R310 are energized, insufficient energization is supplied to the relay R230 to maintain this relay operated. Thus, the relay R230 is caused to restore to open, at RA231, the operating circuit for the signal lamp 205. The deenergized condition of this lamp indicates that a talking connection is fully established.

After the desired connection to the substation A is established, the operator may extend the same to a calling one of the lines terminating at the exchange 15 in the usual manner. Following the completion of the connection between the calling and called parties, the operator at the position 200 need not monitor the connection, but may disconnect her telephone set therefrom and rely upon the signal lamp 205 to indicate when the connection is cleared out at the called substation.

If the party who answers the call at the called substation A desires to resignal the operator without releasing the connection, he may do so by momentarily operating the switchhook provided at the called substation to open the loop circuit extending to the operated connector switch 26 and thus cause the momentary restoration of the back bridge relay embodied in this connector switch. When the back bridge relay of the operated connector switch restores, it reverses battery back over the loop extending to the repeating transformer 350 and in so doing reverses the direction of current flow through the upper winding of R320, causing the last-mentioned relay to restore. Upon restoring, the relay R320 opens, at RA321, the operating circuit for R315 and, when R315 restores, it removes the lower winding of R310 from the series circuit by way of which the relay R230 is energized. When the high resistance lower winding of R310 is removed from the series circuit noted, the relay R230 is sufficiently energized to operate and, upon operating, re completes, at RA231, the operating circuit for the signal lamp 205. Obviously, when the back bridge relay embodied in the connector switch 26 reoperates to again reverse battery over the loop extending to the repeating transformer 350, the two relays R320 and R315 are caused to reoperate in the order named so that the lower winding of R310 is again serially included in the circuit including the upper winding of R310 and the winding of the relay R230. Thus, R230 is caused to restore to interrupt, at RA231, the circuit for energizing the signal lamp 205. The flashing of the lamp 205 indicates to the operator at the position 200 that she is being recalled by the party at the called substation A.

The release of the operated switch train is completely under the control of the operator at the position 200 after the call is answered by the operator. When the party at the called substation A hangs up, the back bridge relay embodied in the connector switch 26 is caused to restore, in the manner pointed out above, to reverse battery back over the loop extending to the repeating transformer 350. Thus, the polarity of the current flowing through the upper winding

of R320 is reversed, and this relay is caused to restore to open the operating circuit for R315. When the relay R315 restores, it removes the lower winding of R310 from the series circuit including the winding of R230, causing the last-mentioned relay to reoperate to again complete the circuit for energizing the signal lamp 205. The continuous illumination of this lamp indicates that the connection has been released at the called substation. The operator may now initiate the release of the established switch train by withdrawing the line connecting plug from the jack 201 to open, at the springs 228, the operating circuit for R220. Upon restoring, the relay R220 opens, at RA222 and RC223, the series circuit over which the two relays R230 and R310 are being held energized in series, causing both of these relays to restore. When the relay R230 restores, it opens, at RA231, the circuit for energizing the signal lamp 205, and, when the relay R310 restores, it opens, at RA311, the loop circuit extending to the operated connector switch 26. Thus, the line and hold relays provided in the connector switch 26 are caused to restore to initiate the release of this switch and the finder switch 24. When the link is entirely released, certain of the relays provided in the connector switch 26 operate to mark the link as idle in the distributor 25', thus rendering the link available for use on other calls.

When the relay R310 restores, it recompletes, at RA312 and RC313, the above-traced operating circuit for R325 and interrupts, at RA312 and RC314, the above-traced circuit over which R410 is being held energized. When R410 restores, it opens, at RA412, the operating circuit for R325 and, at RA416, the operating circuit for R430. The momentary reoperation of R325 is without effect. At RA411, the relay R410 opens the above-traced circuit for energizing the lower winding of R320 and, at RA413 and RC414, it opens a point in the above-traced path for applying ground to the control conductor C367. Thus, the trunk line 12, and more particularly the link line 468, is marked as idle in the connector switches to which the last-mentioned line extends. The relay R430, upon restoring, opens, at RA435 and its associated working contact, the above-traced holding circuits for R400 and R450, causing both of these relays to restore. At this time, ground potential is no longer present on the conductor C462 of the link line 468 so that the relay R450 is not caused to reoperate. At RA431 and RA433, respectively, the relay R430 opens the respective operative operating circuits for R460 and R440, causing both of these relays to restore. The relay R400, upon restoring, opens, at RA403 and RA404, a further point in its holding circuit and, at RA402, a point in the operating circuit for R450. Thus, all of the relays illustrated in Figs. 3 and 4 are returned to their respective restored positions, and the repeater is conditioned for further use.

As pointed out previously, if the connection as routed by way of the trunk line 12, the repeater illustrated in Figs. 3 and 4, and the finder switch 24, to the connector switch 26 is to be extended by way of one of the trunk lines extending between the exchange 10 and the exchange 30 to a line terminating at the last-mentioned exchange, the calling operator at the position 200 is only required to dial a single digit corresponding to the group of trunks noted. When this single digit is dialed, the connector switch 26 operates to seize a repeater associated

with a preselected idle one of the trunk lines in the selected group. For example, if a trunk selecting digit is dialed at the operator's position instead of the digits of the directory number identifying the substation A and the repeater 20 illustrated in Figs. 7 and 8 is seized by the connector switch 26, this connector switch operates to switch the calling loop circuit through to the repeater 20. When the link line 790 extending to the repeater 20 shown in Figs. 7 and 8 is seized by the connector switch 26, ground is supplied to the control conductor C765 to complete a circuit for energizing R750, this circuit extending by way of C765, RA718, RA727 and the winding of R750 to battery. When energized over this circuit, the relay R750 operates to complete, at RA755, an obvious holding circuit for itself. At RA754, the relay R750 completes an obvious circuit for energizing the lower winding of R710, which latter relay, upon operating, completes, at RA715 and RA716, an obvious holding circuit for itself. At RA719, the relay R710 completes an obvious circuit for energizing the slow-to-release hold relay R720 and, at RA718, the relay R710 opens a point in the above-traced operating circuit for R750. At RA712 and RA714, the relay R710 opens a point in the circuit, traced hereinafter, for energizing the line relay R725. At RA716 and RC717, the relay R710 disconnects the line conductor C764 from the upper terminal of the upper winding of R710. With the two relays R710 and R750 operated, the loop circuit is extended to the repeating transformer 800 and the two relays R730 and R735 are energized in series thereover. More particularly, the circuit for energizing R730 in series with R735 may be traced as extending from ground at the lower terminal of the winding of R730 by way of this winding, RC743, RA742, C775, the transformer winding 801, C774, RA752, C770, RA712, RA711, C764, one side of the loop extending to the repeating transformer 350, the bridged upper winding of R320, the other side of the loop extending to the repeating transformer 350, C763, RA753, C778, the winding 802, C776, RA745, RC746 and the winding of R735 to battery. The two relays R730 and R735 operate when energized over this loop circuit, but the polarity of the current traversing the circuit is such that the two windings of R320 are differentially energized and, hence, the relay R320 does not operate. Upon operating, the relay R730 prepares, at RA731, a circuit, traced hereinafter, for energizing R740. The relay R735, upon operating, completes, at RA736 and its associated working contact, a circuit for energizing R840, this circuit extending from ground at RA831 by way of C780, RA736, C779 and the winding of R840 to battery. Upon operating, the relay R840 completes, at RA841, a holding circuit for itself, which holding circuit extends from ground by way of the resistor 841', RA841, C780, RA736, C779 and the winding of R840 to battery. At RA842, the relay R840 completes an obvious circuit for energizing the slow-acting relay R820, which latter relay, upon operating, completes, at RA825, an obvious circuit for energizing R830. The relay R820, upon operating, also completes, at RA826, a path for applying ground to the control conductor C765, this path extending from ground at RA709' by way of C789, RA826, C788 and RA755 to the control conductor noted. The application of ground to the control conductor C765 by the relay R820 serves to prevent the operated

switches in the exchange 10 from releasing and also to prevent the operated relays R710, R720, R730, R735 and R750 from restoring. At RA824, the relay R820 prepares a priming circuit, traced hereinafter, for energizing the pulse responsive relay R735. At RA821 and RC823, the relay R820 completes a loop circuit including the line conductors C882 and C883 of the trunk 13 between the repeating transformer 800 and the two-way repeater 885 associated with the distant end of the trunk line and located in the exchange 30. As indicated above, the repeater 885 is identical in all respects with the repeater shown in Figs. 7 and 8 and the completion of the above-mentioned loop circuit results in the operation of certain of the relays provided therein, which relays, upon operating, cause one of the finder switches in the exchange 30 to seize the repeater 885 and to extend the calling loop circuit to an associated one of the numerical switches embodied in the exchange. More particularly, when the loop circuit is extended to the repeater 885, the windings of the line relay embodied therein and corresponding to R710 shown in Fig. 7 are energized over the loop circuit in series with the winding of R810 and the lower winding of R815. One of the finder switches embodied in the exchange 30 is caused to operate to seize the repeater 885 in response to the operation of the line relay embodied in this repeater. After the loop circuit is switched through to one of the connector switches in the exchange 30, the winding of R810 and the lower winding of R815 are held energized in series with the respective windings of two line relays embodied in the seized connector switch. The relay R810, upon operating, opens, at RA811, a point in the circuit, traced hereinafter, for energizing R704. Shortly after the relay R810 operates, the relay R830, which is energized in response to the operation of R820, operates to complete, at RA831 and its associated working contact an obvious circuit for energizing the upper winding of R815. The two windings of R815 are now differentially energized and, consequently, this relay does not operate. The relay R815 operates only when its two windings are cumulatively energized. The relay R830, upon operating, opens, at RA831 and its associated resting contact, a point in the operating circuit, traced above, for R840. At RA832, the relay R830 prepares a point in the above-mentioned operating circuit for R704 and, at RA833, it completes a multiple path for holding ground on the control conductor C765, this multiple path extending from ground at RA709' or, the lower terminal of the lower winding of the impedance element 703, by way of C789, R833, C788 and RA755 to the control conductor noted.

As explained previously, the switching equipment provided in the exchange 30 is substantially a duplication of that shown in Fig. 5 and disclosed in the above-referred to copending application in so far as the automatic switches are concerned. When, therefore, the calling loop circuit is extended by way of the repeater 885 and one of the finder switches in the exchange 30 to the connector switch associated with the operated finder switch, the seized connector switch is conditioned to respond to impulses transmitted thereto in response to further operation of the impulsing device provided at the operator's position 200.

Impulses produced by further operation of the impulsing device 204 provided at the operator's

position 200 are repeated by the repeater 25 shown in Figs. 3 and 4 and through the established switch train comprising the finder 24 and the connector switch 26 to the repeater 20 illustrated in Figs. 7 and 8. At the beginning of the first impulse of the second digit dialed at the operator's position and when R310 restores to open the loop circuit extending through to the repeater 20 shown in Figs. 7 and 8, the relay R735, which is being held energized over this loop circuit, restores to complete, at RA736 and its associated resting contact, a priming circuit for itself, which priming circuit extends from ground by way of the resistor 841', RA841, C780, RA736, C781, RA824, C782, the resistor 747 and the winding of R735 to battery. Due to the resistance of the two resistance elements 841' and 747, the current traversing this priming circuit is insufficient to cause the reoperation of R735. Upon restoring, the relay R735 also interrupts, at RA736 and its associated working contact, the above-traced holding circuit for R840, causing the last-mentioned relay to restore. At RA841, the relay R840, upon restoring, opens the above-traced priming circuit for R735 and, at RA842, it opens a point in the operating circuit for R820. At RA843 and RC845, the relay R840, upon restoring, completes a circuit for energizing the slow-acting relay R865, this circuit extending from ground at RA831 by way of RA843, RC845, and the winding of R865 to battery. At RA846, the relay R840 completes a circuit extending from ground at RA831 and by way of RA853 for energizing the upper winding of R860. At RA847, the relay R840 opens a point in a circuit, traced hereinafter, for energizing the lower winding of R850. The slow-acting relay R865, upon operating, completes, at RA868, an obvious circuit for energizing the slow-to-release relay R875. At RA866, the relay R865 completes a path extending by way of C712 for short-circuiting the winding of R730, thereby to remove the resistance of this winding from the calling loop circuit for the purpose of improving the impulsing characteristics of the calling loop circuit. At RA867, the relay R865 short-circuits the series circuit including the winding of R810, the lower winding of R815 and the windings 803 and 804 of the repeating transformer 800, thereby to reduce the resistance of the loop circuit extending to the operated connector switch located in the distant exchange 30. At RA869, the relay R865 completes a circuit for energizing the relay R760, this circuit extending from ground at RA831 by way of RA869, C784 and the winding of R760 to battery.

The relay R875, upon operating, opens at RA877 a point in the circuit, traced hereinafter, for energizing the lower winding of R704 and completes, at RA876, an obvious circuit for energizing the slow-to-release relay R880 which latter relay operates to open at RA881 a further point in the circuit for energizing R704. The relay R760, upon operating, completes a holding circuit for itself, which circuit extends from ground at RA831 by way of C785, RA762 and the winding of R760 to battery. At RA761, the relay R760 prepares a circuit, traced hereinafter, for energizing R740.

The relay R860 operates, when R840 restores to complete the above-traced circuit for energizing the upper winding of R860, and, upon operating, completes, at RA863, an obvious path for short-circuiting its lower winding, thereby to render itself slow to release. At RA862, the

relay R860 completes an obvious holding circuit for the slow-acting relay R820. At RA864, the relay R860 completes the above-mentioned circuit for energizing the lower winding of R850, this circuit extending from ground at RA831 by way of RA864, RA847 and the lower winding of R850 to battery. Since the upper winding of R850 is normally short-circuited through the armature RA852, this relay is slow to operate. When the relay R850 operates it prepares, at RA851, the above-traced operating circuit for R840 and opens, at RA853, the above-traced operating circuit for R860. At RA854, the relay R850 completes a locking circuit for itself, which circuit extends from ground at RA831 by way of RA854, RA847 and the lower winding of R850 to battery. At RA852, the relay R850 opens the path short-circuiting its upper winding and, at RA853, it opens the above-traced operating circuit for R860. At RA851, the relay R850 completes an alternative priming circuit for R735, this circuit extending by way of C780, RA736, C781, RA824, C782, the resistor 747 and the winding of R735 to battery. Due to the resistance of the resistor 747, the relay R735 does not operate when energized over this alternative priming circuit, but is conditioned to be fast to operate when the calling loop circuit is subsequently recompleted at the end of the open circuit period of the impulse. An interval following the operation of R850, the relay R860 restores to open, at RA864, a point in the above-traced operating circuit for R850. At RA862, the relay R860 opens the above-traced holding circuit for R820 and, at RA863, the relay R860 opens the path short-circuiting its own lower winding.

The relay R850 remains operated until the open circuit period of the first impulse is ended, at which time R735 is again energized over the calling loop circuit. Upon reoperating, the relay R735 opens, at RA736 and its associated resting contact, its alternative priming circuit as traced above and re completes, at RA736 and its associated working contact, the above-traced operating circuit for R840. The last-mentioned relay, upon reoperating, opens, at RA847, a point in the above-traced holding circuit for R850 and opens, at RA846, a point in the above-traced operating circuit for R860. At RA843 and RC845, the relay R840 opens the above-traced operating circuit for R865 and, at RA843 and RC844, prepares the operating circuit, traced hereinafter, for R704, which latter circuit is now held open at RA877 and RA881. Shortly following the reoperation of R840, the relay R850 restores to open, at RA854, a further point in its holding circuit and to close, at RA853, a point in the operating circuit for R860. At RA851, the relay R850, upon restoring, opens a point in the operating circuit for R840, which latter relay is now held energized over its holding circuit as traced above and extending by way of the resistor 841' and RA841.

At the beginning of the open circuit period of the second impulse, the relays R735 and R840 restore, in the order named and in the manner just described, whereby the sequential operation of R860 and R850 followed by the restoration of R860 is repeated. At the end of the open circuit period of the second impulse, when the two relays R735 and R840 reoperate, the relay R850 again restores. During each succeeding impulse of the series, the above-described sequence of operations is repeated, it being pointed out that the relay R865, due to its slow-to-release char-

acteristic, remains operated throughout the series of impulses and only restores at the end of the digit, at which time R840 is held operated for a period of time exceeding the period required for restoration of the relay R865. Each time the relay R865 operates to short-circuit, at RA867, the series circuit including the winding of the relay R810, the latter relay is deenergized and restores to prepare at RA811 a point in the above-mentioned circuit for energizing R704. The circuit for energizing R704 is, however, held open during impulsing by the two operated relays R875 and R880. As indicated above, at the end of each series of impulses the slow-acting relay R865 restores to open, at RA866, the path short-circuiting the winding of R730, permitting the latter relay to reoperate. At RA867, the relay R865, upon restoring, opens the path shunting the series circuit including the two windings 803 and 804, the winding of R810 and the lower winding of R815, causing the relay R810 to reoperate and open, at RA811, the circuit for energizing R704 before the two slow-to-release relays R875 and R880 fall back. At RA869 the relay R865 opens a point in the above-traced operating circuit for R760. At RA868, the relay R865 interrupts the operating circuit for R875, causing R875 and R880 to restore in the order named to reprepare the operating circuit for R704. It will be apparent from the foregoing description that the relation between the period of deenergization of the impulse repeating relay R860 and the period of energization thereof during each impulse is, within limits, independent of the relation between the corresponding periods for the impulse responsive relay R735. More particularly, the restoration of R735 at the beginning of each impulse cycle initiates the operation of the three relays R840, R860 and R850 to repeat the impulse, and the extent of the period during which R860 is energized depends primarily upon the slow-to-release characteristic of this relay and the slow-to-operate characteristic of R850.

During each impulse of each digit, the relay R860 opens, at RA861, a point in the loop circuit extending by way of the trunk line 13, the repeater 885 terminating the distant end of this trunk line, and the operated finder switch in the exchange 30 to the connector switch associated with the operated finder switch. The connector switch into which the impulses are delivered responds in the manner pointed out above with reference to the switching apparatus illustrated in Fig. 5. More particularly if the desired connection is to be routed by way of the operated connector switch in the exchange 30 and one of the trunk lines extending to the manual office 40, a single digit is dialed. The connector switch responds to the digit by seizing a previously assigned idle one of the trunk lines extending to the manual office, or, more particularly, a two-way repeater terminating an idle trunk line, extending to the manual office 40 and switches the calling loop circuit through thereto. On the other hand, if the connection is to be routed to one of the subscribers having a substation associated with one of the lines terminating at the exchange 30, four additional digits are dialed at the operator's position 200, the impulses of which are repeated by the repeater illustrated in Figs. 7 and 8 to the operated connector switch in the exchange 30. This connector switch responds to the impulses to select the desired called line

and the code of the ringing current corresponding to the desired substation on the called line.

If the connection is routed to a subscriber's line terminating at the exchange 30 and the line is found busy at the time it is selected by the operated connector switch having access thereto, busy tone is returned over the trunk line 13 and by way of the repeater illustrated in Figs. 7 and 8, the established switch train in the exchange 10, the repeater illustrated in Figs. 3 and 4, and the trunk line 12 to the operator's position 200. In the event the selected called line is idle and ringing current is projected thereover to signal the desired substation, ring-back tone is delivered over the partially established communication connection to the operator's position to indicate that the desired called substation is being rung.

Assuming the connection is extended to the substation B, the desired conversational circuit is completed when the call is answered at this substation. When the call is answered, the back bridge relay or called party answer relay embodied in the operated connector switch located in the exchange 30 operates to reverse battery back over the trunk line 13, thereby to reverse the direction of current flow through the winding of R810 and the lower winding of R815. The relay R815 is now cumulatively energized and operates to complete, at RA816, the above-mentioned circuit for energizing R740, which circuit extends from ground at RA831 by way of C785, RA731, C786, RA816, C783, RA761 and the winding of R740 to battery. When energized over this circuit, the relay R740 operates its armatures RA741 and RA744 into engagement with their respective associated armature springs RA742 and RA745, thereby to reverse battery back over the loop extending to the repeater illustrated in Figs. 3 and 4. The reversal of battery over the loop extending to the last-mentioned repeater causes the relay R320 to operate in the manner pointed out above, which relay, upon operating, completes the operating circuit for R315. When the relay R315 operates, it includes the high resistance lower winding of R310 in the series circuit by way of which the relay R230 provided at the operator's position 200 is energized, causing the last-mentioned relay to restore. The relay R230, upon restoring, opens the circuit for energizing the signal lamp 205 and this lamp is darkened to indicate that the desired connection is fully completed. During the interval when the called substation B is being rung or after the call is answered, the operator located at the operator's position 200 may extend the connection back to a calling one of the lines terminating at the exchange 15 in the usual manner and rely upon the signal lamp 205 to indicate when the connection is to be released. In this regard it is pointed out that the entire switch train by way of which the connection is routed to the called substation B is held operated until the operator at the operator's position withdraws the line connecting plug from the jack 201. Hence, if the answering party at the called substation B desires to recall the operator at the operator's position 200, he may operate the switch hook at the called substation up and down one or more times to cause the signal lamp 205 to flash, without any danger of releasing the operated switch train.

More particularly, each time the called party momentarily operates the switch hook at the called substation B to its normal position, the loop circuit extending to the called substation is opened for a short interval and the back bridge

relay embodied in the operated connector switch located in the exchange 30 restores for a short period to reverse battery back over the loop extending to the repeater 20 illustrated in Figs. 7 and 8. The momentary reversal of battery over the last-mentioned loop causes the relay R815 to be differentially energized and this relay restores for a short period. Upon restoring, the relay R815 opens, at RA816, the above-traced operating circuit for R740, which latter relay restores to reverse battery back over the loop extending to the repeater 25 illustrated in Figs. 3 and 4. Obviously, when R815 reoperates, the relay R740 reoperates to again reverse battery over the loop extending to the repeater 25. During the interval when R740 is restored, the relay R320 is differentially energized and restores to open the operating circuit for R315, causing the latter relay to restore and remove the high resistance lower winding of R310 from the series circuit over which R230 is energized. Hence, R230 is caused momentarily to reoperate to complete, at RA231, the circuit for energizing the signal lamp 205. The flashing of the signal lamp 205 indicates to the operator that she is being recalled by the called party at the substation B.

When the called party at the substation B hangs up at the end of the conversation, the loop circuit extending to the called substation is interrupted to cause the sequential restoration of R815, R740, R320 and R315 in the manner just described. When R315 restores, the lower winding of R310 is removed from the circuit over which R230 is energized and the last-mentioned relay reoperates to recomplete the circuit for energizing the signal lamp 205. Continuous illumination of the lamp 205 indicates that the connection has been cleared out at the called substation. When the operator at the operator's position 200 withdraws her line connecting plug from the jack 204, the relay R220 restores, in the manner pointed out above, to open the circuit over which R230 and the upper winding of R310 are being held energized in series, causing both of these relays to restore. When the relay R310 restores, the loop circuit extending through the operated switch train in the exchange 10 to the repeater 20, illustrated in Figs. 7 and 8, is opened, causing the two relays R730 and R735 to restore. When R730 falls back it opens, at RA731, the operating circuit for R740, causing the latter relay to restore. The relay R735, upon restoring, opens, at RA736, the holding circuit for R840. When the relay R840 falls back, it opens, at RA842, the operating circuit for R820 and re-completes, at RA843 and RC845, the operating circuit for R865. Upon operating, the relay R865 completes, at RA868, the operating circuit for R875, thereby to cause the sequential operation of R875 and R880. At RA846, the relay R840 completes the above-traced operating circuit for R860, which latter relay, upon operating, opens, at RA861, the loop circuit extending to the operated switch train in the exchange 30. When R860 operates, it completes, at RA864, the operating circuit for R850 and, at RA862, the holding circuit for R820. Shortly thereafter, the relay R850 operates to open, at RA853, the operating circuit for R860 and to complete its holding circuit. When R860 restores, it opens the holding circuit for R820 permitting the last-mentioned relay to fall back, after an interval, to open the operating circuit for R830. When R830 restores, it opens the operating and holding circuits for R850, R860, R865 and R760, causing the operated

ones of these relays to restore. When the relay R865 reoperates, it shunts, at RA867, the series circuit including the two windings 803 and 804, the lower winding of R815 and the winding of R810, causing the last-mentioned relay to restore, and when R865 thereafter restores the loop circuit over which the winding of R810 is energized is open at RA821 and RC823 so that R810 does not reoperate. At RA868, the relay R865 opens the operating circuit for R875, thereby to cause the sequential restoration of this relay and the relay R880. When the relay R860 reoperates, in the manner just described, it opens, at RA861 and RC823, a point in the loop circuit extending between the repeater illustrated in Figs. 7 and 8 and the operated switch train in the automatic exchange 30. Also, when the relay R820 falls back, a further point is opened in this loop circuit so that the operated switch train in the exchange 30 is permitted to release in the manner described above with reference to the apparatus illustrated in Fig. 5. When the two relays R820 and R830 restore, the two paths, traced previously, for applying ground to the control conductor C765 are opened, and the holding circuits for R710 and R750 are interrupted, causing the two last-named relays to restore. When ground is removed from the control conductor C765, the operated switch train in the exchange 10 and including the two switches 24 and 26 is permitted to release in the manner described above. During the release of the operated switch train in the exchange 10, ground is removed from the control conductor C367. Thus, the connection is entirely released and the switching apparatus involved therein is conditioned for further use.

The arrangement of the repeater illustrated in Figs. 7 and 8 is such that this repeater and the preceding switch train in the exchange 10 are held operated until after the operated switch train in the exchange 30 is released. Thus, so long as the loop circuit extending to the called substation is complete, the battery reversing relay provided in the operated link in the exchange 30 is energized and battery potential is extended to C882 through the winding of one of the line relays embodied in the operated link in the exchange 30. Hence, when the relay R820 is caused to restore in response to the release of the connection at the calling end thereof and in the manner just described, it completes a circuit for energizing the relay R870 in series with the line relay embodied in the operated link in the exchange 30 from which battery potential on C882 is derived. This circuit extends from ground by way of the winding of R870, C771, RA751, C773, RC822, RA821, RA861, C882 and the winding of the line relay noted to battery. The energization of this line relay is insufficient to hold the relay operated so that the operated switch train in the exchange 30 is not prevented from releasing. The relay R870 operates when energized over the circuit just traced and completes at RA871 an obvious holding circuit for R830. With R830 operated the repeater illustrated in Figs. 7 and 8 and the switch train in the exchange 10 are held operated until the operated switches in the exchange 30 are released, at which time the circuit over which R870 is being held energized is interrupted. When R870 restores it opens the holding circuit for R830 causing the latter relay to restore to cause the full release of the repeater illustrated in Figs. 7 and 8 and the operated link in the exchange 10 in the manner set forth previously. If the connection is cleared out at the

called substation before the calling party hangs up, the battery reversing relay provided in the operated connector switch in the exchange 30 is restored and, hence, ground potential is present on C882 so that no circuit for energizing R870 is completed in response to the restoration of R820. Thus, the release of the repeater illustrated in Figs. 7 and 8 is not influenced by the relay R870.

Referring now more particularly to the operation of the repeater 25, illustrated in Figs. 3 and 4, to route a connection to the operator's position 200 in response to the seizure thereof by one of the connector switches embodied in the exchange 10 and assuming that the call to the manual office 15 is initiated at the substation A, and, further, that the connection is routed by way of the finder switch 24 and the connector switch 26, when the last-mentioned switch operates to seize the link line 468 extending to the repeater, the calling loop circuit is switched through thereto and ground is impressed upon the control conductor C367. The ground potential impressed upon C367 results in the energization of R330 over a circuit extending by way of C367 RA413, RC415, C366 and the winding of R330 to battery. When energized over this circuit, the relay R330 operates to complete, at RA338, a holding circuit for itself, which circuit extends by way of the grounded conductor C367, RA338 and the winding of R330 to battery. At RA332, the relay R330 completes a circuit extending by way of C359 for energizing R450. At RA331, the relay R330 prepares the loop circuit to the repeating transformer 350 and, at RA333 and RA336, connects the winding of R345 to be energized by way of the last-mentioned loop circuit. At RA337, the relay R330 closes a point in the path, traced hereinafter, for impressing paystation-tone voltage across the line conductors C357 and C358. The relay R450, upon operating, opens, at RA454, the previously-traced path for impressing busy tone upon the loop extending to the operator's position 200 when an all-links-busy condition exists. At RA458, the relay R450 opens a point in one path for applying ground to the tone apparatus start conductor. At RA459, the relay R450 opens a point in the path for applying ground to the tens relay control conductor and, at RA459', it opens a point in the path for connecting the start conductor C467 to the unit relay control conductor C466, thereby to prevent a finder-connector link in the exchange 10 from operating when the relay R430 is subsequently caused to operate. At RA451 and RA452, the relay R450 extends the calling loop circuit to the repeating transformer 350, thereby to cause the energization and operation of the relay R345. More particularly, the last-mentioned relay is energized over a circuit extending from ground at RA431 by way of the line balancing impedance element 409, C360, RA336, the winding 354, C357, RA452, RA451, C462 and the corresponding side of the loop extending to the calling substation, the bridge connected between the line conductors of the calling line at the calling substation, the opposite side of the loop extending to the calling substation, C358, RA331, the winding 353, RA333, RC335 and the winding of R345 to battery. Upon operating, the relay R345 completes, at RA346 and RA347, respectively, circuits for energizing the two relays R315 and R340, respectively. At RA348, the relay R345 completes a circuit extending by way of RA303 for energizing the slow-to-operate relay R305. The relay

R315, upon operating, includes the high resistance lower winding of R310 in the previously-traced series circuit for energizing R310 and R230. When the relay R340 operates, it applies
 5 ground to the ringing apparatus start conductor C344 over a path including RA406, RC408, C371 and RA343, thereby to initiate the operation of the ringing apparatus in the usual manner. At
 10 RA342, the relay R340 completes a path for applying ground to the control conductor C367, thereby to maintain the switches 26 and 24, included in the established switch train, operated and to maintain the trunk line 12 marked as
 15 busy in the connector switches located in the exchange 10. The last-mentioned path extends from ground at the right terminal of the lower winding of the impedance element 420, by way of this winding, C365, RA342, C366, RC415 and
 20 RA413 to the control conductor C367. At RA341, the relay R340 completes a circuit for impressing ringing-tone voltage on the loop extending to the calling substation. More particularly, the
 25 path of the current traversing this circuit extends from the ungrounded terminal of the ringing current source, not shown, but embodied in the apparatus 27, by way of C327, the condenser 328, RA341, C329, RA401, C358, one side of the
 30 loop extending to the calling substation, the receiver of the telephone instrument provided at the calling substation, the other side of the loop extending to the calling substation, C462, RA451,
 35 RA452, C357, the winding 354, RA336, C360, the impedance element 409, and RA341 to the grounded terminal of the ringing current source. The operation of the receiver at the calling substation indicates to the calling party that the manual office operator is being signaled.

When the slow-to-operate relay R305 is energized, it operates to complete, at RA306, a circuit
 40 for energizing the signal device or drop 202 provided at the operator's position 200. Specifically, this circuit extends from the ungrounded terminal of the ringing current source by way of C322, RA306, the above-traced simplex circuit including
 45 the two sides of the trunk line 12 and the repeating transformer windings 351, 352, 253 and 254. From the junction point between the two windings 253 and 254, the circuit extends by way of RA243, RC244, RA222, RC224, the condenser 225 and the winding of the magnet embodied in the drop 202 to the grounded terminal of the ringing current source. The resulting
 50 operation of the drop 202 indicates to the operator at the position 200 that an incoming call awaits attention.

When the relay R305 operates, it also completes a circuit for energizing the upper winding of R300, this circuit extending from the ungrounded terminal of the alternating ringing current source by way of C322, RA307, RA301, the
 60 condenser 304, the upper winding of R300 and the exchange battery to the grounded terminal of the ringing current source. When its upper winding is energized over the circuit just traced, the relay R300 closes the "X" contacts associated with RA302 to complete a circuit for energizing
 65 its lower winding, which circuit extends from ground at RA332 by way of C359, RA456, RA455, C370, RA302 and the lower winding of R300 to battery. When its lower winding is energized over the circuit just traced, the relay R300 completes its operation to open, at RA301, the circuit for energizing its upper winding and to open, at RA303, the operating circuit, as traced previously, for R305. Thus, the relay R305 is caused
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to restore to interrupt, at RA306, the above-traced circuit for energizing the drop 202 and to open, at RA307, the above-traced circuit for energizing the upper winding of R300. It will be observed that the two relays R305 and R300 co-
 5 operate to transmit only a splash of ringing current over the trunk line 12 to energize the signal device 202, the period during which ringing current is projected over the line being equal to the time required for R300 fully to operate following the energization of its upper winding.

The operator at the position 200 answers the call in the usual manner by inserting the plug terminating the cord extending to her telephone set in the jack 201, thereby to complete, at the
 15 springs 228, the operating circuit for R220. When the relay R220 operates, it opens, at RA222 and RC224, a further point in the above-traced circuit for energizing the signal device 202. At RA221, the relay R220 prepares the circuit for energizing the signal lamp 205 and, at RA222 and RC223, the relay R220 completes the above-traced circuit for energizing the winding of R230
 20 in series with the upper winding of R310. At this time the high resistance lower winding of R310 is included in the last-mentioned circuit, so that the relay R230 does not operate. The relay R310 operates, however, and completes, at RA312 and RC314, the circuit, traced previously, for energizing the slow-acting relay R410. When
 25 the relay R410 operates, it completes, at RA416, the circuits traced previously for energizing the relays R400 and R430, respectively. At RA406 and RC407 the relay R400 completes a path extending by way of RA447 for applying ground to the tone apparatus start conductor C463, thereby to initiate the operation of this apparatus in the usual manner. At RA413 and RC414, the relay R410 completes the previously-traced path for applying ground to the control
 30 conductor C367, thereby to maintain the switches 24 and 26 operated and to maintain the trunk line 12 marked as busy in the connector switches located in the exchange 10. At RA411 the relay R410 completes the above-traced circuit for energizing the lower winding of R320. At RA412, the relay R410 prepares a point in the operating circuit for R325, and at RA413 and RC415 the relay R410 opens a point in the operating circuit for R330. The relay R400, upon operating, opens, at RA401, the above-traced circuit for impressing ringing-tone voltage on the loop extending to the calling substation and interrupts, at RA406, a point in the above-traced path for applying ground to the ringing apparatus start conductor C344. At RA403 and RA404, the relay R400 completes a locking circuit for itself, which locking circuit extends from ground at RA332 by way of C359, RA456, RA455, RA403, RA404 and the winding of R400 to battery.

The relay R430, upon operating, completes, at RA435, multiple holding circuits for the two relays R400 and R450 and completes, at RA432, the above-mentioned path for impressing paystation-tone voltage on the loop extending to the operator's position 200.

As explained in the above-referred to copending application, when a call is initiated at a substation of the paystation type, an alternating paystation-tone voltage is impressed upon the
 70 control conductor included in the associated line, which voltage is, on trunk calls, impressed between ground and the control conductor of the repeater associated with the selected trunk line. Thus, in the case here being considered, if the
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substation A is of the paystation type, an alternating paystation-tone voltage is impressed between C367 and ground when ground is impressed upon the tone apparatus start conductor C463 to initiate the operation of the tone apparatus. This voltage causes a current to flow by way of RA413 and RC414 through the lower winding of the impedance element 420. The current flowing in the lower winding of the element 420 causes an induced voltage to be developed in the upper winding of the element, which voltage is impressed across the two conductors C356 and C358. More particularly, the induced voltage developed between the terminals of the upper winding of the element 420 causes a current to flow over a circuit which extends from the right terminal of the upper winding of the element 420, by way of RA445, RC446, C358, RA331 or RA311, C356, the winding 353, the condenser 353', the winding 354, C357, the condenser 448, RC443, RA442, RA432, C361, RA337 and C362 to the left terminal of the upper winding of the element 420. It will be noted that this circuit is completed at RA432 in response to the operation of R430. The paystation-tone current traversing the two windings 353 and 354 of the transformer 350 causes an induced paystation-tone voltage to be developed across the two windings 351 and 352, whereby a paystation-tone signal is transmitted by way of the line 12 and the transformer 250 to the operator at the position 200.

When the relay R430 operates, it also opens, at RA431 and its associated resting contact, a point in the loop circuit through the operated switch train to the calling substation. At RA431 and its associated working contact, the relay R430 completes an obvious circuit for energizing the slow-to-operate relay R460, which latter relay, upon operating, re completes, at RA461, the loop circuit extending to the calling substation. During the interval when the loop circuit is open the relay R345 restores, but without effect. It will be apparent that the interruption of the loop circuit extending to the calling substation is only of short duration and, in the case here being considered, is without effect. The purpose of providing the arrangement for momentarily opening the loop circuit when the call is answered at the operator's position is explained more fully hereinafter with reference to a connection routed from a paystation by way of the automatic exchange 10 and the automatic exchange 30 to the operator's position 895 located in the manual office 40. As indicated above, the relay R430, upon operating, rapidly moves its associated armature RA433 into engagement with the contact carried by RA434, causing the last-mentioned armature to start vibrating, intermittently to complete the operating circuit for the slow-to-operate relay R440. When the vibration of RA434 is substantially ended and the contact carried by this armature settles into engagement with RA433, the relay R440 operates to open, at RA442 and RA445 and their respective associated contacts RC443 and RC446, two points in the above-traced circuit traversed by the paystation-tone current. At RA447, the relay R440 opens a point in the path, traced above, for applying ground to the tone apparatus start conductor C463. Following the operation of R440, the desired conversational circuit between the operator's position 200 and the substation A is completed, the operator being informed by the receipt of paystation tone that the call originates from a substation of the pay-

station type. After receiving the information as to the party desired by the calling party, the operator may extend the connection to the desired line in the manner conventionally employed in manual office practice.

If the operator at the position 200 desires to recall the paystation-tone signal, she may do so by momentarily withdrawing her answer plug from the jack 201, thereby to open the operating circuit for R220. When R220 restores it interrupts the circuit for energizing R230 and R310. When R310 restores it opens the operating circuit for R410 and re completes the operating circuit for R325, which latter relay may reoperate but without effect. When R410 restores it opens, at RA416, the operating circuit for R430, causing R430, R440 and R460 to restore. The relay R430, upon restoring, shunts, at RA431, the armature RA461 so that the calling loop circuit is not interrupted when R460 restores. With the calling loop circuit complete, the relay R345 remains operated to hold the relay R340 energized, and with R340 energized the holding circuit for R330 is maintained complete and ground is retained on the control conductor C367 to prevent the operated switch train in the exchange 10 from releasing. More particularly, the holding circuit for R330 extends from ground at the right terminal of the lower winding of the impedance element 420 by way of this winding C365, RA342 and the winding of R330 to battery. The path for holding ground on the control conductor C367 extends by way of the grounded conductor C365, RA342 and RA338 to C367. With R330 operated, the multiple holding circuits for R450 and R400 are held completed at RA332. When the operator's answer plug is reinserted in the jack 201, the relay R220 reoperates to cause the reoperation of R230 and R310. When R310 reoperates it re completes the operating circuit for R410, to cause the operation of R410 and R430. When R430 operates it momentarily opens, at RA431, the calling loop circuit to cause the momentary restoration of R345 and completes the operating circuit for R460, which latter relay upon operating re completes the calling loop circuit to cause the reoperation of R345 before the slow-acting relay R340 can restore. At RA413 and RC414, the relay R410 re completes the multiple path for applying ground to C367 and for conducting paystation-tone current by way of the lower winding of the impedance element 420. When the relay R430 operates it again completes the path, traced previously, for applying paystation-tone voltage across the line conductors C357 and C358, thereby to cause the paystation-tone signal to be transmitted to the operator's position 200. At its armature springs RA433 and RA434, the relay R430 closes the operating circuit for R440, after an interval, and when R440 operates it opens the path for applying paystation-tone voltage between the line conductors C357 and C358, thereby to terminate the signal. From the foregoing it will be apparent that the operator who answers the call at the position 200 may recall the paystation-tone signal as many times as she desires.

After the operator answers the call the operated switch train cannot be released until the operator withdraws her line connecting plug from the jack 201. Thus, so long as the plug is retained in the jack the relay R220 is held energized to maintain the circuit for energizing R310 completed. With R310 operated the operating circuit for R410 is held completed and with the

last-named relay operated ground is retained on the control conductor C367 to prevent the operated switches from being released even though the loop circuit is interrupted at the calling substation. Hence, the arrangement is such that the calling party may repeatedly operate the hook switch provided at the calling substation up and down, for the purpose of flashing the signal lamp 205 to recall the operator, without any danger of releasing the operated switch train. Each time this hook switch provided at the calling substation is momentarily operated to open the loop circuit, the relay R345 restores for a short interval to open, at RA346, the operating circuit for R315. During the interval when R315 is restored, the lower winding of R310 is removed from the series circuit including the winding of R230, causing the latter relay to reoperate and complete the circuit for energizing the lamp 205. Obviously, the relay R230 operates and restores each time the loop circuit extending to the calling substation is interrupted and completed, thereby to cause the signal lamp 205 to be repeatedly energized. The flashing of the lamp indicates to the operator that she is being recalled by the calling subscriber.

When the calling party hangs up at the end of the conversation, the loop circuit extending to the repeating transformer 350 is opened, and the two relays R345 and R315 are caused to restore in the manner just described. At RA347, the relay R345 opens the operating circuit for R340, causing the latter relay to restore. When R315 restores, it removes the high resistance lower winding of R310 from the energizing circuit for R230, causing the last-mentioned relay to reoperate to complete the circuit for energizing the signal lamp 205. The continuous illumination of this lamp indicates to the operator at the position 200 that the connection is ready to be released. When the operator removes her line connecting plug from the jack 201, the line relay R220 restores to open the series circuit over which R310 and R230 are being held energized in series, causing both of these relays to restore. The relay R230, upon restoring, opens the circuit for energizing the signal lamp 205. When R310 falls back, it opens, at RA312 and RC314, the above-traced operating circuit for R410 and completes, at RA312 and RC313 the previously-traced operating circuit for R325. When the relay R410 restores, it opens, at RA411, the above-traced circuit for energizing the lower winding of R320 and, at RA416, a point in the operating circuits for R400 and R430. At RA412, the relay R410 opens the operating circuit for R325, causing this relay to restore. At RA413 and RC415, relay R410, upon restoring, opens a point in the path for applying ground to the control conductor C367, thereby to open the holding circuit for R330 and to initiate the release of the operated switch train in the exchange 10.

When the relay R330 falls back, it opens, at RA338, a point in the holding circuit for itself. At RA331, RA333 and RA336, the relay R330 opens additional points in the loop circuit extending to the calling substation. When the relay R430 falls back, it opens, at RA435 and its associated working contact, a point in the common portion of the multiple holding circuits for R400 and R450, causing both of the two last-mentioned relays to restore. At RA433 and RA434, the relay R430 opens the operating circuit for R440 and, at RA431, it opens the oper-

ating circuit for R460, whereby the two last-named relays are caused to restore. At RA435, the relay R430, upon restoring, also opens a point in the holding circuit for R300, causing this relay to restore. Thus, all of the equipment included in the operated switch train is released and is conditioned for further use.

As indicated above, the arrangement is such that if the connection is cleared out at the operator's position 200 before the calling party hangs up, the switch train including the operated link in the exchange 10 and the repeater illustrated in Figs. 3 and 4 is held operated until the calling party restores his receiver to its hook. Thus, so long as the loop extending to the calling substation is not interrupted, the relays R345, R340, R330, R315, R300, R400 and R450 are held energized, even though the connection is cleared out at the operator's position 200. When, however, the calling party hangs up to interrupt the calling loop circuit, the relay R345 restores to cause the sequential restoration of R315, R340, and R330 in the order named. When R330 restores it opens, at RA332, the respective holding circuits for R450, R400 and R300 causing all of these relays to restore. Also, when R340 restores ground is removed from the control conductor C367, thereby to initiate the release of the operated switches 26 and 24 and to mark the repeater illustrated in Figs. 3 and 4 as idle.

Referring now more particularly to the operation of the repeater illustrated in Figs. 7 and 8, during operation of the apparatus to set up a connection between the substations B and A on a call initiated at the first-mentioned substation, it is pointed out that, when the automatic switching equipment provided in the exchange 30 operates to switch the calling loop through to the repeater 885 located in this exchange and associated with the trunk line 13, this last-mentioned repeater operates in the exact manner set forth previously with reference to the repeater 20, illustrated in Figs. 7 and 8, to extend an intermediate loop circuit by way of the trunk line conductors C882 and C883 of the trunk line 13 to the repeater shown in Figs. 7 and 8. This loop circuit includes the winding of the relay, included in the repeater 885 and corresponding to R810 shown in Fig. 8, and also the lower winding of the relay, included in the repeater 885 and corresponding to R815 shown in Fig. 8, so that a bridge is effectively placed across the conductors C882 and C883 of the trunk line 13. When this bridging path is completed, the line relay R725 is energized over a circuit extending from ground at the right terminal of the upper winding of this relay by way of this winding, RC713, RA712, C770, RA752, C773, RC822, RA821, RA861, C882, the bridge between C882 and C883 in the repeater 885, C883, R777, RA753, RA714 and the lower winding of R725 to battery. When energized over this circuit, the relay R725 operates to complete a path for applying ground to the control conductor C765, this path extending from ground at RA709 by way of RA727 and RA718, to the control conductor noted. This ground serves to mark the trunk line 13 as busy in the connector switches having access thereto. At RA728, the relay R725, upon operating, applies ground to the group or tens relay control conductor C766 and, at RA729, it connects the units relay control conductor C768 to the start conductor C769. Thus, the distributor 25' operates to cause a pre-assigned idle one of the finder switches to seize

the link line 790. When the line 790 is seized by the finder switch, the line conductors C763 and C764 are connected through to the operated connector switch and certain of the relays embodied therein are caused to operate to apply ground potential to the line conductor C764 in the manner explained previously. When this line conductor is grounded, the relay R710 is energized over a circuit extending by way of RC717, RA716 and the upper winding of R710 to battery. Also, when the link line 790 is seized by the finder switch and switched through to a connector switch, ground potential is returned to the control conductor C765 from the operated connector switch.

The relay R710 operates when its upper winding is energized in the manner just described and, upon operating, completes, at RA715, an obvious holding circuit for itself. At RA719, the relay R710 completes an obvious circuit for energizing the slow-to-release relay R720, which latter relay, upon operating, opens, at RA722, a point in the above-traced path for applying ground to the tens relay control conductor C766 and interrupts, at RA723, the connection between the start conductor C769 and the units relay control conductor C768.

At RA718, the relay R710, upon operating, opens a point in the path by way of which ground was initially applied to the control conductor C765. At RA711 and RA712, the relay R710 extends the calling loop circuit through to the operated connector switch, thereby to hold the line and hold relays embodied in this connector switch operated. At RA712 and RA714, the relay R710 opens two points in the above-traced operating circuit for R725, causing the last-mentioned relay to restore. When the relay R725 restores, it opens a further point in the above-traced path for applying ground to C766 and, at RA729, a further point in the path for connecting the start conductor C769 to the units relay control conductor C768. In this connection, it will be understood that, when R720 operates to interrupt the paths noted, the distributor and common equipment 25' is released to be used in connection with other calls.

After the loop circuit is extended through to the operated connector switch in the exchange 10, further impulses dialed at the calling substation B are repeated by the repeater 885 through the repeater 20 to this connector switch for the purpose of causing the switch to select the desired called line 11. The mode of operation of the connector switch to select this line, to test the selected line for the purpose of determining the idle or busy condition thereof, and to project ringing current thereover is set forth previously. The desired conversational circuit is completed when the call is answered at the called substation, it being pointed out that this operation in no way affects any of the apparatus embodied in the repeater 20, shown in Figs. 7 and 8.

The release of the connection is primarily under the control of the last party to hang up. More particularly, when the calling party hangs up to interrupt the loop circuit extending to the repeater 885, this repeater starts to release and during its release interrupts the loop circuit extending through the repeater 20 to the operated connector switch in the exchange 10, thereby to initiate the release of the switch train in the exchange 10 providing the called party has restored his receiver to its hook. As indicated pre-

viously, so long as the called loop circuit is not interrupted the battery reversing relay provided in the operated connector switch in the exchange 10 is held operated to prevent the switch train from fully releasing. When, however, the call is cleared out at the called substation, the operated switches in the exchange 10 are caused to release and the repeater 885 is caused to complete its release. When the operated switches in the exchange 10 are being restored to normal, ground is removed from the control conductor C765 to open the holding circuit for the relay R710. When R710 restores, it opens, at RA719, the operating circuit for R720, causing the last-mentioned relay to restore. Also, when R710 restores, it completes a path for applying battery to the control conductor C765, this path extending by way of RA718, RA727 and the winding of R750 to battery. The application of battery potential to C765 serves to mark the trunk line 13 as idle. Following the restoration of the two relays R710 and R720, the repeater 25, illustrated in Figs. 7 and 8, is fully released.

If a call initiated at a substation of the paystation type and associated with a line terminating at the exchange 10, is routed by way of the automatic switching equipment in this exchange, the repeater 20, illustrated in Figs. 7 and 8, the trunk line 13, the repeater 885 the automatic switching equipment embodied in the exchange 30 and the repeater 890 to the operator's position 895 in the exchange 40 the last-mentioned repeater cooperates with the repeater 20, illustrated in Figs. 7 and 8, to signal the operator at the position 895 that the call originates from a telephone substation of the paystation type. Also, when the call is answered at the operator's position, the release of the operated switch train is only effected when the connection is cleared out by the operator. In this regard, it is pointed out that the repeater 890 is in all respects identical with the repeater illustrated in Figs. 3 and 4. Hence, the manner in which the two repeaters 20 and 890 cooperate to transmit a paystation-tone signal to the operator's position 895 may best be explained by referring to the repeater illustrated in Figs. 3 and 4 in describing the operation of the repeater 890. Also, the apparatus provided at the operator's position 895 is identical with that shown in Fig. 2, and reference will be made to the apparatus of Fig. 2 in describing the operation of the apparatus provided at the operator's position 895. Considering the repeater illustrated in Figs. 3 and 4, it will be recalled from the preceding description that, when the operator in the manual office answers an incoming call, the relay R310 operates to cause the operation of R410, followed by the operation of the two relays R400 and R430. It will also be recalled that, when R430 operates, it interrupts, at RA431, the established loop circuit extending back over the link line 468. Also, upon operating, the relay R430 completes, at RA431, the operating circuit for the slow-to-operate relay R460, which latter relay operates a short time interval after the operation of R430 to recomplete at RA461, the above-mentioned loop circuit extending back over the link line 468. Considering the repeater of Figs. 3 and 4 as the repeater 890, the loop circuit which is momentarily interrupted by the operation of R430 extends back to the repeater shown in Figs. 7 and 8. From the foregoing description, it will be apparent that the relays R810, R820, R830 and R840 of Fig. 8, and the

relays R710, R720, R730 R735, R750 and R760 of Fig. 7 are operated at the time the loop circuit, which extends to the repeating transformer 800, is momentarily interrupted by operation of the relay R430 embodied in the repeater 890. During the interval when the loop circuit is interrupted, the relay R810 restores to complete, at RA811, the previously-mentioned circuit for energizing the lower winding of R704. Specifically, this circuit extends from ground at RA831 by way of RA843, RC844, RA881, RA877, RA832, RA811, C787 and the lower winding of R704 to battery. When energized over this circuit, the relay R704 operates to complete, at RA709, a holding circuit for itself, which holding circuit extends from ground at RA831 by way of C785, RC702, RA701, RA709 and the winding of R704 to battery. Shortly after the operation of R704, the relay R460 embodied in the repeater 890 operates to recomplete the loop extending back to the repeater 20, causing the relay R810 to reoperate and open, at RA811, the operating circuit for R704. At RA709' and its associated working contact, the relay R704 completes an obvious path for applying ground to the tone apparatus start conductor C463, thereby to initiate the operation of this apparatus embodied in the auxiliary apparatus 27, providing it is not already operating. At RA709' and its associated resting contact, the relay R704 opens a point in the path traced previously for directly applying ground to the control conductor C765, but ground is retained on C765 over a path extending from C765 by way of RA755, C788, RA826 or RA833, C789, and the lower winding of the impedance element 703 to ground. The ground extended to C765 over this path serves to prevent the operated switch train in the exchange 10 from releasing and to hold the two relays R710 and R750 operated. As a result of the operation of the tone apparatus, paystation tone is impressed on the control conductor associated with the calling line and is forwarded by way of the operated switch train in the exchange 10, so that it appears between the control conductor C765 and ground. This voltage causes paystation-tone current to traverse the lower winding of the impedance element 703, the path of this current extending from the ungrounded terminal of the tone current source by way of C765, the operated armature RA755, C788, RA826 or RA833, C789 and the lower winding of the element 703 to the grounded terminal of the tone current source. This current causes a corresponding voltage to be induced in the upper winding of the impedance element 703, which voltage is impressed by way of the operated armatures RA707 and RA708 of the relay R704 across the line conductors C770 and C763 so that a paystation-tone signal is transmitted by way of the trunk line 13, the repeater 885, the operated switch train in the exchange 30 and the repeater 890 to the telephone set being used by the operator located at the operator's position 895. The operator who answers the call hears the signal in her receiver and is informed that the call originates at a substation of the paystation type.

When the relay R704 operates, it also attracts the armature RA705 into engagement with the contact carried by the weighted or pendulum type armature RA706, whereby vibration of the last-mentioned armature is initiated. The operating circuit for the relay R700 is intermittently completed during the vibration of RA706 but due to the slow-to-operate characteristic of this

relay, it does not operate until the vibration or the armature RA706 is substantially ended and this armature settles into constant engagement with RA705. At the end of the interval required for the vibration of RA706 to cease, the relay R700 operates to open, at RA701 and RC702, the above-traced holding circuit for R704, causing the last-mentioned relay to restore. Upon restoring, the relay R704 opens, at RA709, a further point in its holding circuit and interrupts, at RA707 and RA708, two points in the above-mentioned path for impressing paystation-tone voltage between the conductors C763 and C770 extending to the repeating transformer 800. Thus, the paystation-tone signal is terminated. At RA705, the relay R704 interrupts the operating circuit for R700, causing the last-mentioned relay to restore to reprepare, at RA701 and RC702, a point in the holding circuit for R704. Since the loop circuit extending between the repeater 890 and the repeater 20, illustrated in Figs. 7 and 8, is only momentarily interrupted, the relay R810 is caused to reoperate in the manner described above, to open, at RA811, the operating circuit for R704 before the relay R700 restores to reprepare the holding circuit for the relay R704. Thus, the two relays R704 and R700 remain deenergized following the restoration thereof. At RA709', the relay R704 interrupts the path for applying ground to the tone apparatus start conductor C463 and re-completes the path for applying ground directly to the control conductor C765.

To recall the paystation tone, the operator may momentarily withdraw her line connecting plug from the jack located at the operator's position 895 and corresponding to the jack 201 illustrated in Fig. 2. When this operation is performed and considering the apparatus of Fig. 2 as being located at the operator's position 895, the relay restores to open the circuit over which R310 is being held operated. Thus, the relay R310 is caused to restore to open, at RA312 and RC314, the operating circuit for R410. When R410 restores, it opens, at RA416, the operating circuit for R430, which latter relay, upon restoring, completes, at RA431, a shunt around the operated armature RA461 and opens the operating circuit for R460, causing the last-named relay to restore. When the operator reinserts the answer plug in the answer jack 201, the relay R310 reoperates to cause the sequential reoperation of the two relays R410 and R430. When the last-mentioned relay reoperates, it opens, at RA431, the loop circuit extending back to the repeater 20 and reCompletes the operating circuit for R460. When R460 reoperates, it reCompletes the loop circuit extending to the repeater 20.

During the interval when the loop circuit extending between the repeater 890 and the repeater 20 is interrupted, the relay R810 restores, in the manner pointed out above, to recomplete, at RA811, the above-traced operating circuit for R704. Thus, the relays R704 and R700 are caused sequentially to operate and restore in the order named and in the manner just described so that paystation-tone signal is again transmitted to the operator's position 895. It will be observed that with the above-described arrangement, the operator at the operator's position 895 may recall paystation tone as many times as she desires.

After the connection to the operator's position 895 is established, the operator may extend the connection to the desired called line in the manner conventionally used in manual office practice. After the connection is fully completed the op-

erater may disconnect from the connection, and rely upon the signal lamp 205 to indicate when the connection is to be released. If the calling party desires to resignal the operator at the position 895 after the connection is completed, he may do so by operating the switch hook provided at the calling substation up and down one or more times momentarily to interrupt the loop circuit extending through the operated switch train in the exchange 10 to the repeater 20, illustrated in Figs. 7 and 8. Each time this loop circuit is opened the two relays R730 and R735 restore. The relay R735, upon restoring, opens, at RA736, the holding circuit for R840, which latter relay, upon restoring, opens, at RA842, the operating circuit for R820. At RA846, the relay R840 completes the above-traced operating circuit for R860. At RA843 and RC845, the relay R840 completes the operating circuit for R865, thereby to cause the sequential operation of R865, R875 and R880. When R860 operates, it opens, at RA861, a point in the established loop circuit extending through to the operated repeater 890, illustrated in detail in Figs. 3 and 4. At RA862 the relay R860 completes the multiple holding circuit for R820, and, at RA864, it completes the above-traced operating circuit for R850. The relay R850, upon operating, completes the priming circuit for R735, and the holding circuit for itself, and opens the operating circuit for R860, causing the last-mentioned relay to restore to recomplete the loop circuit extending to the repeater 890, all in the manner described previously. When the loop circuit extending to the repeater 890 is interrupted, the relay R810 restores to prepare the operating circuit for R704, but the operated relays R875 and R880 prevent the relay R704 from being energized to impress paystation tone on the loop extending to the repeater 890. Each time the calling loop circuit is recompleted at the calling substation the relays R730 and R735 reoperate, the latter relay functioning to recomplete the operating circuit for R840. When R840 reoperates it re completes the holding circuit for R820, opens the holding circuit for R850 and initiates the sequential restoration of R865, R875 and R880.

Each time the loop circuit extending to the repeater 890 is interrupted, the relay R345 restores to interrupt, at RA347, the operating circuit for R340 and, at RA346, the operating circuit for R315. Obviously, when the loop circuit is recompleted, the relay R345 reoperates to recomplete the two operating circuits noted. During the interval when R315 is restored, it removes the high resistance lower winding of R310 from the series circuit including the winding of the relay R230 located at the operator's position 895, causing R230 to operate. When the last-mentioned relay operates, the operating circuit for the signal lamp 205 provided at the operator's position 895 is completed. Obviously, when the relay R315 reoperates, the high resistance lower winding of R310 is reinserted in the series circuit by way of which the relay is energized, so that the last-named relay restores to open the energizing circuit for the signal lamp 205 provided at the operator's position 895. The flashing of the lamp 205 indicates to the operator that she is being recalled by the calling party.

During a flashing recall operation of the character just described, the relay R870 functions to prevent the release of the switch train in the exchange 10 if the calling or signalling party holds the calling loop circuit open for too long a time interval. Thus, if the calling loop circuit is held

open for a prolonged time interval the relay R820 is caused to restore in the manner described previously to open, at RA825, the operating circuit for R830. Upon restoring, the relay R820 also completes, at RA821 and RC822, a circuit for energizing R870, this circuit extending from ground by way of the winding of R870, C771, RA751, C773, RC822, RA821, R861, C882, one side of the line circuit as extended through the repeater 885 and the operated link in the exchange 30, C358, RA331, the winding 353, RA333, RC335 and the winding of R345 to battery. When energized over this circuit, the relay R870 operates to complete, at RA871, the holding circuit for R830, thereby to prevent the latter relay from restoring. With R830 operated ground is retained on the control conductor C765 to hold the switch train in the exchange 10 operated. Also, with R830 operated the repeater illustrated in Figs. 7 and 8 is prevented from releasing. Obviously, when the calling loop circuit is recompleted at the end of a prolonged signalling operation performed at the calling substation, the relays R730, R840 and R820 are caused to reoperate in the order named. When R820 reoperates the above-traced operating circuit for R870 is broken, causing the last-mentioned relay to restore to open the holding circuit for R830. It is noted that, due to the high resistance of R870, the relay R345 is insufficiently energized to operate or to remain operated when energized in series with R870. Hence, the completion of the above-traced circuit for energizing R870 does not interfere with the release of the established connection when it is cleared out at the operator's position 895. The energization and operation of R870 during the release of the connection does, however, prevent the operated repeater shown in Figs. 7 and 8 and the operated switches in the exchange 10 from releasing in response to a release operation performed at the calling substation or before the operated switches in the exchange 30 are released. Thus, there is obviated the possibility of the repeater illustrated in Figs. 7 and 8 being taken for use before it is actually idle.

The release of the connection as established between the substation A and the operator's position 895 is only initiated when the operator withdraws the connecting plug from the answer jack located at this position and corresponding to the jack 201 illustrated in Fig. 2. The manner in which the operated switch train comprising the repeater 890, the operated switches in the exchange 30, the repeater 885, the repeater 20 and the operated switches in the exchange 10 is released, is in all respects similar to the release operations described previously and will be readily apparent from the foregoing description.

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 first telephone station of the pay station type, a second telephone station, means including a repeater for establishing a connection between said stations on a call initiated at said first station, said connection comprising a talking circuit, a device operative to complete said talking circuit when said call is answered at said second station, a relay

included in said repeater and operative in response to the operation of said device, means responsive to the operation of said relay for impressing a signal on said circuit indicating that said call originates at a telephone station of the pay station type, a slow-to-operate relay, an operating circuit for said slow-to-operate relay, vibratory contacts controlled by said first-mentioned relay for completing said operating circuit, and means responsive to the operation of said slow-to-operate relay for terminating said signal.

2. In a telephone system, a first telephone station of the pay station type, a second telephone station, means including a repeater for establishing a connection between said stations on a call initiated at said first station, said connection comprising a talking circuit, a device operative to complete said talking circuit when said call is answered at said second station, a relay included in said repeater and operative in response to the operation of said device, means responsive to the operation of said relay for impressing a signal on said circuit indicating that said call originates at a telephone station of the pay station type, a slow-to-operate relay, an operating circuit for said slow-to-operate relay, vibratory contacts controlled by said first-mentioned relay for completing said operating circuit, and means responsive to the operation of said slow-to-operate relay for terminating said signal, said relays being connected and arranged to restore and reoperate in response to the interruption and recompletion of said talking circuit, thereby to again impress said signal on said talking circuit for a time interval.

3. In a telephone system, a first telephone station of the pay station type, a second telephone station, means including a repeater for establishing a connection between said stations on a call initiated at said first station, said connection comprising a talking circuit, a device operative to complete said talking circuit when said call is answered at said second station, a relay included in said repeater and operative in response to the operation of said device, means responsive to the operation of said relay for impressing a signal on said circuit indicating that said call originates at a telephone station of the pay station type, said relay having a holding circuit arranged to be completed in response to the operation of said relay, a slow-to-operate relay, an operating circuit for said slow-to-operate relay, vibratory contacts controlled by said first-mentioned relay for completing said operating circuit, and means responsive to the operation of said slow-to-operate relay for opening said holding circuit, whereby said first-mentioned relay is caused to restore and said signal is terminated.

4. In a telephone system, a first telephone station of the pay station type, a second telephone station, means for establishing a connection between said stations on a call initiated at said first station, said connection comprising a talking circuit, a device operative to complete said talking circuit when said call is answered at said second station, said talking circuit comprising a direct current loop circuit, means operative in response to the operation of said device for momentarily interrupting said loop circuit, and means responsive to the interruption of said loop circuit for impressing a signal on said talking circuit indicating that said call originates at a telephone station of the pay station type.

5. In a telephone system, a first telephone sta-

tion of the pay station type, a second telephone station, means for establishing a connection between said stations on a call initiated at said first station, said connection comprising a talking circuit, a device operative to complete said talking circuit when said call is answered at said second station, said talking circuit comprising a direct current loop circuit, means operative in response to the operation of said device for momentarily interrupting said loop circuit, means responsive to the interruption of said loop circuit for impressing a signal on said talking circuit indicating that said call originates at a telephone station of the pay station type, and means controlled by said last-named means for terminating said signal.

6. In a telephone system, a first telephone station of the pay station type, a second telephone station, means for establishing a connection between said stations on a call initiated at said first station, said connection comprising a talking circuit, a device operative to complete said talking circuit when said call is answered at said second station, said talking circuit comprising a direct current loop circuit, means responsive to the operation of said device for momentarily interrupting said loop circuit, means operative in response to the interruption of said loop circuit for impressing a signal on said talking circuit indicating that said call originates at a telephone station of the pay station type, means controlled by said last-named means for terminating said signal, means responsive to the interruption and recompletion of said talking circuit at said second station for again interrupting said loop circuit, and means responsive to the last-mentioned interruption of said loop circuit for again impressing said signal on said talking circuit.

7. In a telephone system, a first telephone station of the pay station type, a second telephone station, means including a pair of repeaters adapted to be connected in tandem for establishing a connection between said stations on a call initiated at said first station, said connection comprising one loop circuit extending between said repeaters and a second loop circuit extending to said second telephone station, a device operative to complete said second loop circuit when said call is answered at said second telephone station, means operative in response to the operation of said device for interrupting said one loop circuit, and means responsive to the interruption of said one loop circuit for impressing a signal on said second loop circuit indicating that said call originates at a telephone station of the pay station type.

8. In a telephone system, a first telephone station of the pay station type, a second telephone station, means including a pair of repeaters adapted to be connected in tandem for establishing a connection between said stations on a call initiated at said first station, said connection comprising one loop circuit extending between said repeaters and a second loop circuit extending to said second telephone station, a device operative to complete said second loop circuit when said call is answered at said second telephone station, means responsive to the operation of said device for interrupting said one loop circuit, means operative in response to the interruption of said one loop circuit for impressing a signal on said second loop circuit indicating that said call originates at a telephone station of the pay station type, and means controlled by said last-named means for terminating said signal.

9. In a telephone system, a first telephone station of the paystation type, a second telephone station, means including a pair of repeaters adapted to be connected in tandem for establishing a connection between said stations on a call initiated at said first station, said connection comprising one loop circuit extending between said repeaters and a second loop circuit extending to said second telephone station, a device operative to complete said second loop circuit when said call is answered at said second telephone station, means responsive to the operation of said device for interrupting said one loop circuit, means responsive to the interruption of said one loop circuit for impressing a signal on said second loop circuit indicating that said call originates at a telephone station of the paystation type, means controlled by said last-named means for terminating said signal, means responsive to the interruption and recompletion of said second loop circuit for again interrupting said one loop circuit, and means responsive to said last-mentioned interruption of said loop circuit for again impressing said signal on said second loop circuit.

10. In a telephone system, a first telephone station of the pay station type, a second telephone station, means including a pair of repeaters adapted to be connected in tandem for establishing a connection between said stations on a call initiated at said first station, said connection comprising one loop circuit extending between said repeaters and a second loop circuit extending to said second telephone station, a device operative to complete said second loop circuit when said call is answered at said second telephone station, a first relay included in one of said repeaters and operative in response to the operation of said device, a slow-to-operate relay energized in response to the operation of said first relay, means responsive to the operation of said first relay for interrupting said one loop circuit, means responsive to the operation of said slow-to-operate relay for recompleting said one loop circuit, a third relay included in the other of said repeaters and having a winding included in said one loop circuit, whereby said third relay restores when said one loop circuit is interrupted, a fourth relay included in said other repeater and operative in response to the operation of said third relay, means responsive to the operation of said fourth relay for impressing a signal on said second loop circuit indicating that said call originates at a telephone station of the paystation type, and means controlled by said fourth relay for terminating said signal.

11. In a telephone system, a telephone station, a line extending to said station, a signal device at said station, a source of ringing current, said signal device being connected and arranged to be energized over a circuit including said line, a relay operative to connect said source to said line, thereby to energize said signal device, a second relay including a pair of windings, an operating circuit for said second relay, said operating circuit including one of said windings and said source and being completed in response to the operation of said first-mentioned relay, a holding circuit for said second relay, said holding circuit including the other of said windings and being completed in response to the operation of said second relay, and means responsive to the operation of said second relay for causing the restoration of said first-mentioned relay, thereby to

disconnect said source from said line and to open the operating circuit for said second relay.

12. In a telephone system, a telephone station, a repeater, a line extending between said station and said repeater, an automatic switch operative to seize said repeater on a call to said station, a signal device at said station, a source of ringing current, said signal device being connected and arranged to be energized over a circuit including said line and said source, a relay operative to complete said circuit, an operating circuit for said relay, means responsive to the seizure of said repeater by said switch for completing said operating circuit, a second relay including a pair of windings, an operating circuit for said second relay, said last-named operating circuit including one of said windings and said ringing current source and being completed in response to the operation of said first-mentioned relay, a holding circuit for said second relay, said holding circuit including the other of said windings and being completed in response to the operation of said second relay, and means responsive to the operation of said second relay for interrupting the operating circuit for said first-mentioned relay, whereby said first-mentioned relay restores to open the circuit for energizing said signal device.

13. In a telephone system, an exchange, a plurality of lines extending to said exchange, telephone stations individually associated with certain of said lines, one of said stations being of the paystation type, automatic switching apparatus in said exchange, means including said apparatus for setting up a connection between a calling one of said stations and a called one of said stations, said connection being releasable in response to a release operation performed at the calling station, an operator's telephone station, a signal device at said operator's telephone station, means including said automatic switching apparatus for setting up a connection between said paystation and said operator's station on a call initiated at said paystation, said last-mentioned connection comprising a talking circuit, a device operative to complete said talking circuit when the call is answered at said operator's station, means responsive to the operation of said last-mentioned device for impressing a signal on said circuit indicating that said call originates at a station of the paystation type, means for preventing the release of said last-mentioned connection in response to a release operation performed at said paystation, and means responsive to a release operation performed at said paystation for causing said signal device to indicate that said connection has been released.

14. In a telephone system, an exchange, a plurality of lines extending to said exchange, telephone stations individually associated with certain of said lines, one of said stations being of the paystation type, automatic switching apparatus in said exchange, means including said apparatus for setting up a connection between a calling one of said stations and a called one of said stations, said connections being releasable in response to a release operation performed at the calling station, an operator's telephone station, a signal device at said operator's telephone station, means including said automatic switching apparatus and a pair of tandem connected repeaters for setting up a connection between said paystation and said operator's station on a call initiated at said paystation, said last-mentioned connection comprising a talking circuit, a device operative to complete said talking circuit when the call

is answered at said operator's station, means responsive to the operation of said last-mentioned device for impressing a signal on said circuit indicating that said call originates at a station of the paystation type, means for preventing the release of said connection in response to a release operation performed at said paystation, and means comprising relays respectively included in said repeaters and sequentially operative in response to a release operation performed at said paystation for causing said signal device to indicate that said connection is released, said relays being repeatedly operative in response to repeated release operations performed at said paystation, thereby to cause said signal device repeatedly to operate.

15. In a telephone system, an exchange, a plurality of lines extending to said exchange, telephone stations individually associated with certain of said lines, one of said stations being of the pay station type, automatic switching apparatus in said exchange, means including said apparatus for setting up a connection between a calling one of said stations and a called one of said stations, said connection being releasable in response to a release operation performed at the calling station, an operator's telephone station, a signal device at said operator's telephone station, means including said automatic switching apparatus and a pair of repeaters connected in tandem for setting up a connection between said paystation and said operator's station on a call initiated at said paystation, said connection comprising one loop circuit extending between said repeaters and a second loop circuit extending to said operator's station, a device operative to complete said second loop circuit when said call is answered at said operator's station, means operative in response to the operation of said device for interrupting said one loop circuit, means responsive to the interruption of said one loop circuit for impressing a signal on said second loop circuit indicating that said call originates at a telephone station of the paystation type, means for preventing the release of the last-mentioned connection in response to a release operation performed at said paystation, and means responsive to a release operation performed at said paystation for changing the condition of said signal device.

16. In a telephone system, an operator's telephone station, a supervisory signal device at said station, a circuit for energizing said device, a second telephone station, switching means for establishing a connection between said stations, a first relay at said operator's station, said first relay including a winding and being operative to complete said circuit, a second relay included in said switching means, said second relay including a winding and being operative to complete a point in said connection, a second circuit for energizing the winding of said first relay in series with the winding of said second relay, an impedance element adapted to be serially included in said second circuit, the impedance of said element being so proportional relative to the impedance of the windings of said relays that said first relay is operated only when said impedance element is excluded from said second circuit and said second relay is operated both when said impedance element is excluded from and included in said second circuit, and means controllable from said second station for selectively including said impedance element in said second circuit.

17. In a telephone system, an operator's tele-

phone station, a supervising signal device at said station, a circuit for energizing said signal device, a second telephone station, switching means for establishing a connection between said stations on a call initiated at said operator's telephone station, a first relay at said operator's station, said first relay including a winding and being operative to complete said circuit, a second relay included in said switching means, said second relay including a winding and being operative to complete a point in said connection, a second circuit for energizing the winding of said first relay in series with the winding of said second relay, an impedance element adapted to be serially included in said second circuit, the impedance of said element being so proportioned relative to the impedances of the windings of said relays that said first relay is operated only when said impedance element is excluded from said second circuit and said second relay is operated both when said impedance element is excluded from and included in said second circuit, means operative in response to the initiation of said call for completing said second circuit, and means operative when said call is answered for including said impedance element in said second circuit.

18. In a telephone system, an operator's telephone station, a supervising signal device at said station, a circuit for energizing said signal device, a second telephone station, switching means for establishing a connection between said stations on a call initiated at said operator's telephone station, a first relay at said operator's station, said first relay including a winding and being operative to complete said circuit, a second relay included in said switching means, said second relay including a winding and being operative to complete a point in said connection, a second circuit for energizing the winding of said first relay in series with the winding of said second relay, an impedance element adapted to be serially included in said second circuit, the impedance of said element being so proportioned relative to the impedances of the windings of said relays that said first relay is operated only when said impedance element is excluded from said second circuit and said second relay is operated both when said impedance element is excluded from and included in said second circuit, means operative in response to the initiation of said call for completing said second circuit, and means operative when said call is answered for including said impedance element in said second circuit, said last-named means being operative to exclude said impedance element from said second circuit in response to an operation performed at said second telephone station.

19. In a telephone system, an operator's telephone station, a supervisory signal device at said station, a circuit for energizing said signal device, a second telephone station, switching means for establishing a connection between said stations on a call initiated at said second telephone station, a first relay at said operator's station, said first relay including a winding and being operative to complete said circuit, a second relay included in said switching means, said second relay including a winding and being operative to complete a point in said connection, a second circuit for energizing the winding of said first relay in series with the winding of said second relay, an impedance element adapted to be serially included in said second circuit, the impedance of said element being so proportioned relative to the impedances of

the windings of said relays that said first relay is operated only when said impedance element is excluded from said second circuit and said second relay is operated both when said impedance element is excluded from and included in said second circuit, means operative during the establishing of said connection for including said impedance element in said second circuit, and means operative when said call is answered at said operator's station for completing said second circuit with said impedance element included therein.

20. In a telephone system, an operator's telephone station, a supervisory signal device at said station, a circuit for energizing said signal device, a second telephone station, switching means for establishing a connection between said stations on a call initiated at said second telephone station, a first relay at said operator's station, said first relay including a winding and being operative to complete said circuit, a second relay included in said switching means, said second relay including a winding and being operative to complete a point in said connection, a second circuit for energizing the winding of said first relay in series with the winding of said second relay, an impedance element adapted to be serially included in said second circuit, the impedance of said element being so proportioned relative to the impedances of the windings of said relay that said first relay is operated only when said impedance element is excluded from said second circuit and said second relay is operated both when said impedance element is excluded from and included in said second circuit, means operative during the establishing of said connection for including said impedance element in said second circuit, means operative when said call is answered at said operator's station for completing said second circuit with said impedance element included therein, and means responsive to an operation performed at said second station for excluding said impedance element from said second circuit.

21. In a telephone system, an operator's telephone station, a supervisory signal device at said station, a circuit for energizing said device, a second telephone station, switching means for establishing a connection between said stations, a first relay at said operator's station, said first relay including a winding and being operative to complete said circuit, a second relay included in said switching means, said second relay including a first winding and being operative to complete a point in said connection, a second circuit for energizing the winding of said first relay in series with said first winding of said second relay, said second relay including a second winding adapted to be serially included in said second circuit, the impedance of said second winding being so proportioned relative to the impedance of the winding of said first relay and the impedance of said first winding that said first relay is operated only when said second winding is excluded from said second circuit and said second relay is operated both when said second winding is included in and excluded from said second circuit, and means controllable from said second station for selectively including said second winding in said second circuit.

22. In a telephone system, an operator's telephone station, a supervisory signal device at said station, a circuit for energizing said device, a second telephone station, switching means for establishing a connection between said stations on a

call initiated at said operator's telephone station, a first relay at said operator's station, said first relay including a winding and being operative to complete said circuit, a second relay included in said switching means, said second relay including a first winding and being operative to complete a point in said connection, a second circuit for energizing the winding of said first relay in series with said first winding of said second relay, said second relay including a second winding adapted to be serially included in said second circuit, the impedance of said second winding being so proportioned relative to the impedance of the winding of said first relay and the impedance of said first winding that said first relay is operated only when said second winding is excluded from said second circuit and said second relay is operated both when said second winding is included in and excluded from said second circuit, means operative in response to the initiation of said call for completing said second circuit, and means operative when said call is answered for including said second winding in said second circuit.

23. In a telephone system, an operator's telephone station, a supervisory signal device at said station, a circuit for energizing said device, a second telephone station, switching means for establishing a connection between said stations on a call initiated at said second telephone station, a first relay at said operator's station, said first relay including a winding and being operative to complete said circuit, a second relay included in said switching means, said second relay including a first winding and being operative to complete a point in said connection, a second circuit for energizing the winding of said first relay in series with said first winding of said second relay, said second relay including a second winding adapted to be serially included in said second circuit, the impedance of said second winding being so proportioned relative to the impedance of the winding of said first relay and the impedance of said first winding that said first relay is operated only when said second winding is excluded from said second circuit and said second relay is operated both when said second winding is included in and excluded from said second circuit, means operative during the establishing of said connection for including said second winding in said second circuit, and means operative when said call is answered for completing said second circuit with said second winding included therein.

24. In a telephone system, an operator's telephone station, a signal device at said station, a circuit for energizing said device, a second telephone station of the paystation type, means for establishing a connection between said stations on a call initiated at said second telephone station, said connection comprising a talking circuit adapted to be completed when the call is answered at said operator's station, a relay, an operating circuit for said relay, means responsive to the operation of said relay for transmitting a signal to said operator's telephone station indicating that said call originates at a telephone station of the paystation type, a second relay operative from one of its two positions to the other when said talking circuit is completed, means responsive to the completion of said talking circuit for momentarily interrupting said talking circuit thereby to cause said second relay to operate from its said other position to its said one position to complete said operating circuit,

means responsive to a subsequent interruption of said talking circuit at said second station for completing the circuit for energizing said signal device and for causing said second relay to operate to its said other position, and means responsive to the subsequent interruption of said talking circuit at said second station for preventing a second signal from being transmitted to said operator's station.

10 25. In a telephone system, an operator's telephone station, a signal device at said station, a circuit for energizing said device, a second telephone station of the pay station type, means for establishing a connection between said stations on a call initiated at said second telephone station, said connection comprising a talking circuit adapted to be completed when the call is answered at said operator's station, a relay, an operating circuit for said relay, means responsive to the operation of said relay for transmitting a signal to said operator's telephone station indicating that said call originates at a telephone station of the pay station type, a second relay operative from one of its two positions to the other when said talking circuit is completed, means responsive to the completion of said talking circuit for momentarily interrupting said talking circuit thereby to cause said second relay to operate from its said other position to its said one position to complete said operating circuit,

means responsive to a subsequent interruption of said talking circuit at said second station for completing the circuit for energizing said signal device and for causing said second relay to operate to its said other position, and means responsive to the operation of said last-named means for opening a point in said operating circuit before said second relay is operated to its said one position, thereby to prevent a second signal from being transmitted to said operator's station.

26. In a telephone system, a first telephone station of a particular character, a second telephone station, means including a pair of repeaters adapted to be connected in tandem for establishing a connection between said stations on a call initiated at said first station, said connection comprising one loop circuit extending between said repeaters and a second loop circuit extending to said second telephone station, a device operative to complete said second loop circuit when said call is answered at said second telephone station, means operative in response to the operation of said device for interrupting said one loop circuit, and means responsive to the interruption of said one loop circuit for impressing a signal on said second loop circuit indicative of the character of said first telephone station.

JOHN HENRY VOSS. 30