Aug. 18, 1942. A. J. BUSCH ET AL 2,293,191

TELEPHONE SYSTEM

Filed Sept. 15, 1939 25 Sheets-Sheet 1

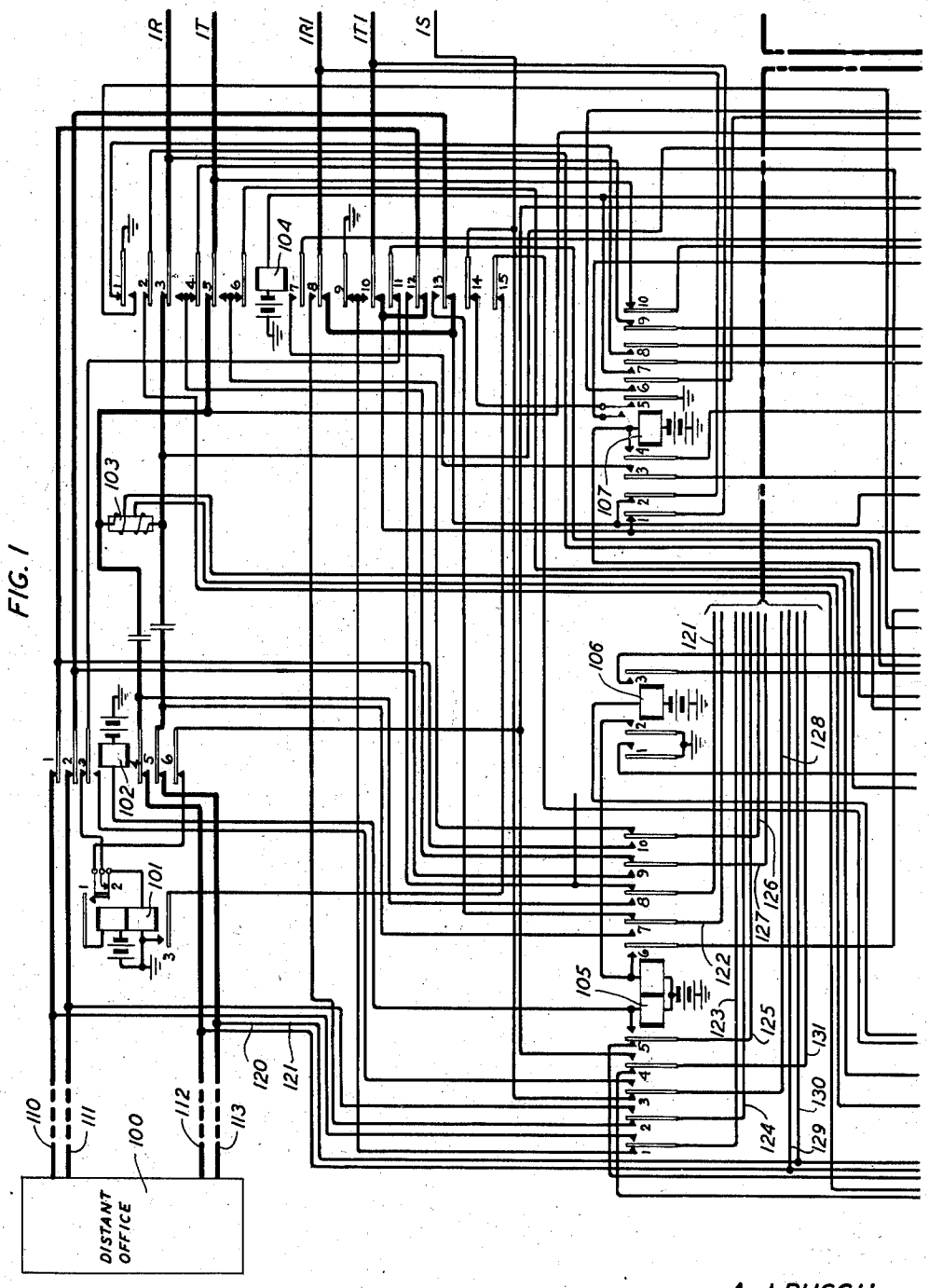


FIG. 1

INVENTORS: A. J. BUSCH
F. J. SCUDDER

BY M. D. McKenney

ATTORNEY

Aug. 18, 1942. A. J. BUSCH ET AL 2,293,191

TELEPHONE SYSTEM

Filed Sept. 15, 1939 25 Sheets-Sheet 2

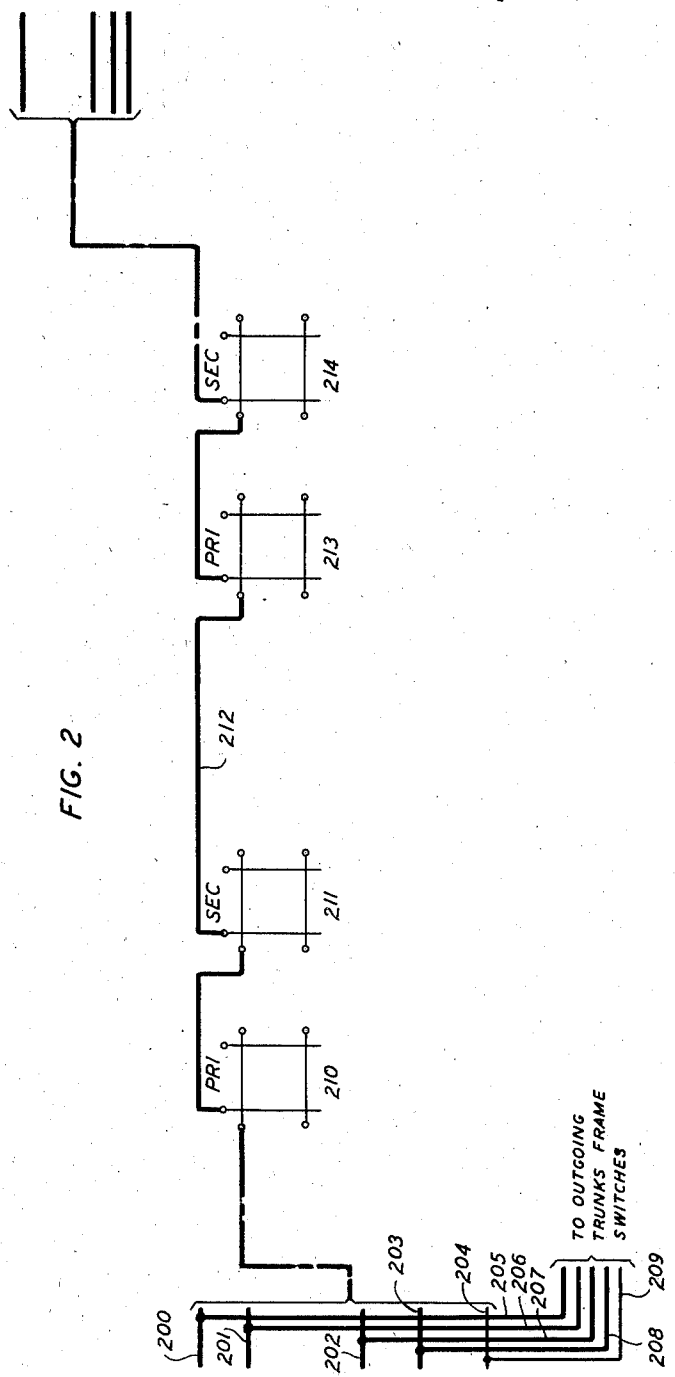


FIG. 2

INVENTORS: A. J. BUSCH
F. J. SCUDDER

BY M. D. McKenney

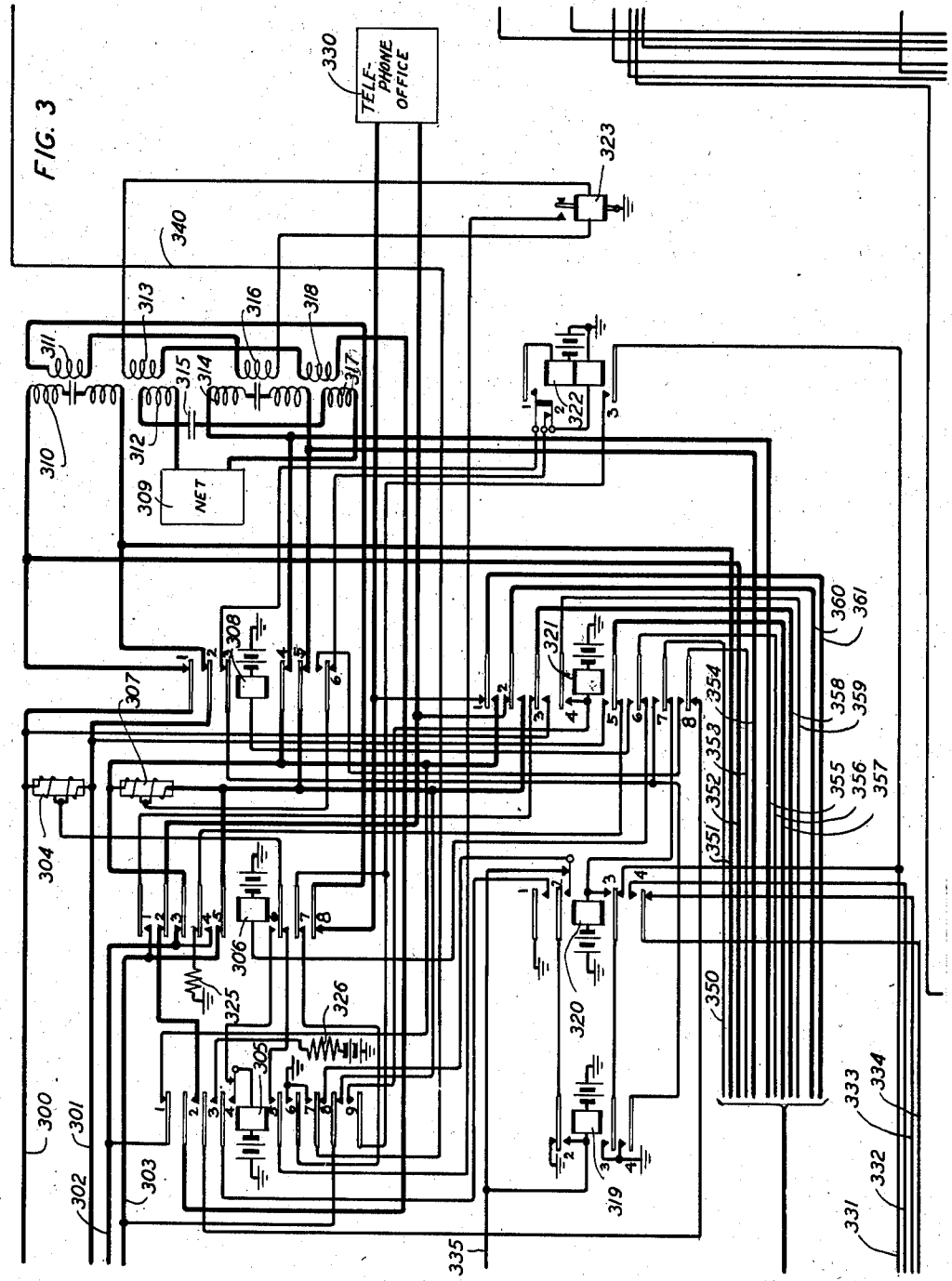
ATTORNEY

Aug. 18, 1942. A. J. BUSCH ET AL 2,293,191

TELEPHONE SYSTEM

Filed Sept. 15, 1939 25 Sheets-Sheet 3

FIG. 3



INVENTORS: A. J. BUSCH
F. J. SCUDDER

BY M. F. McKenney

ATTORNEY

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TELEPHONE SYSTEM

Filed Sept. 15, 1939 25 Sheets-Sheet 4

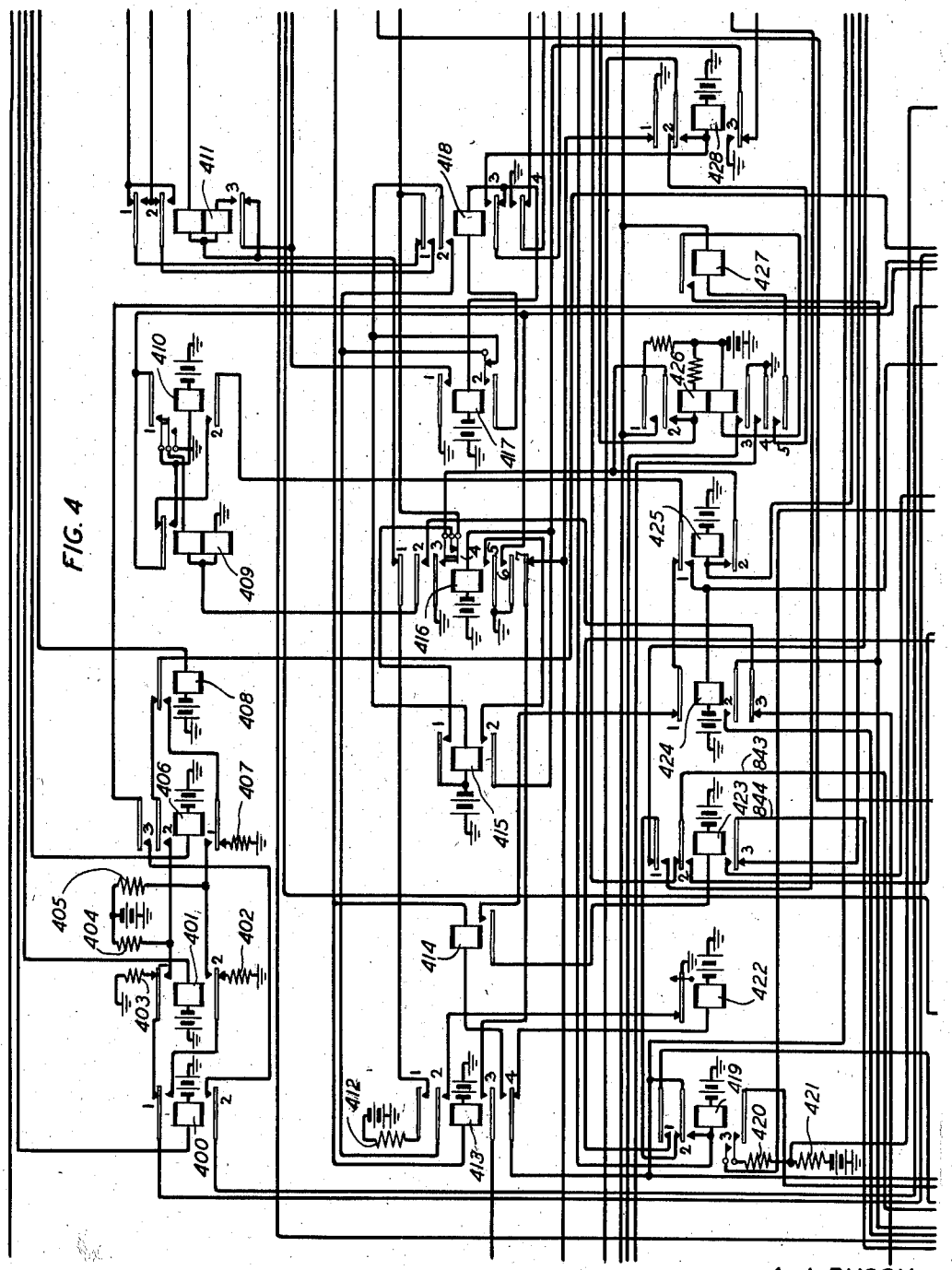

FIG. 4

INVENTORS: A. J. BUSCH
F. J. SCUDDER

BY W. T. McKenney

ATTORNEY

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TELEPHONE SYSTEM

Filed Sept. 15, 1939 25 Sheets-Sheet 5

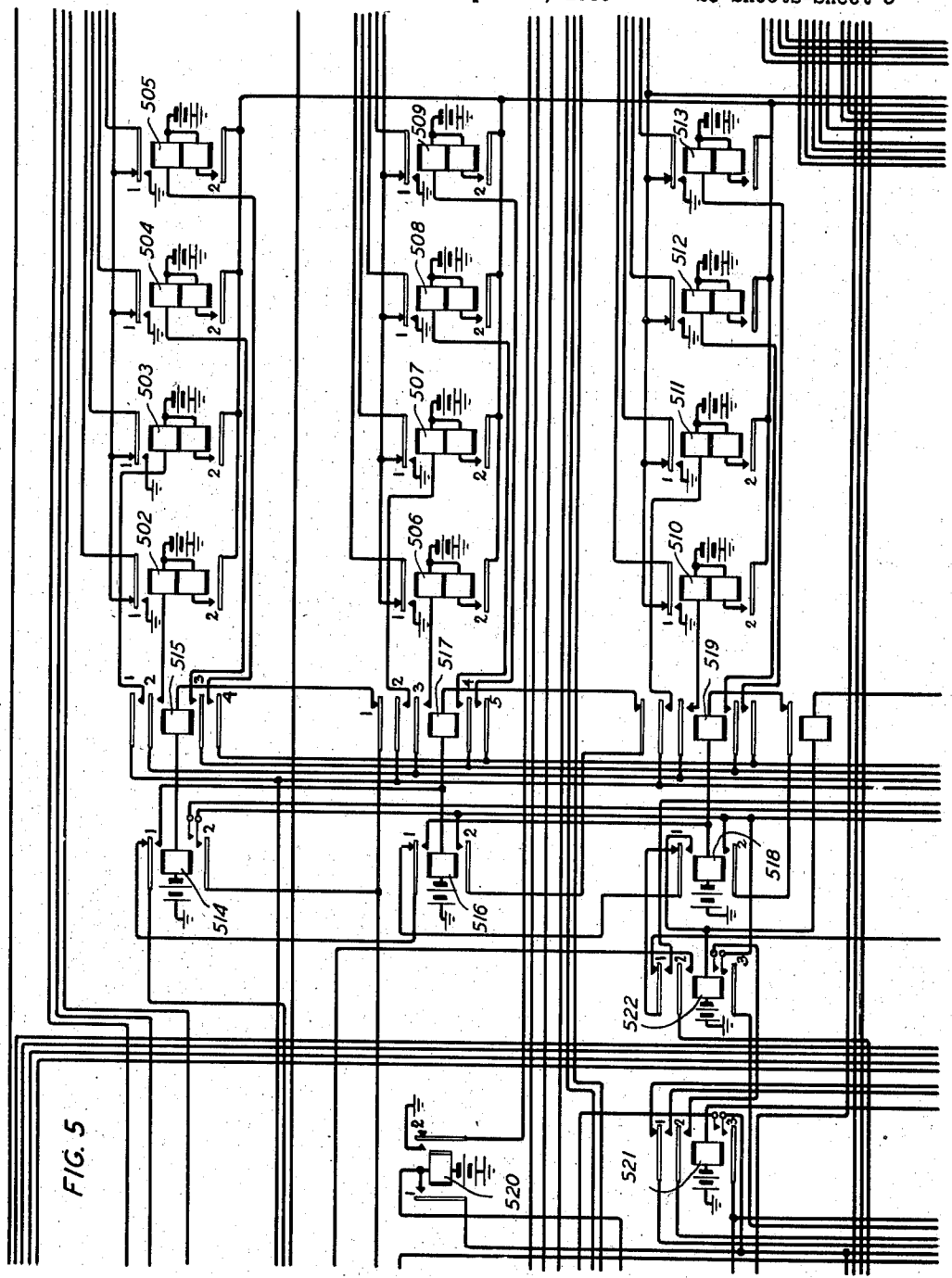

FIG. 5

INVENTORS: A. J. BUSCH
F. J. SCUDDER

BY M. F. McKenney

ATTORNEY

Aug. 18, 1942. A. J. BUSCH ET AL 2,293,191

TELEPHONE SYSTEM

Filed Sept. 15, 1939 25 Sheets-Sheet 6

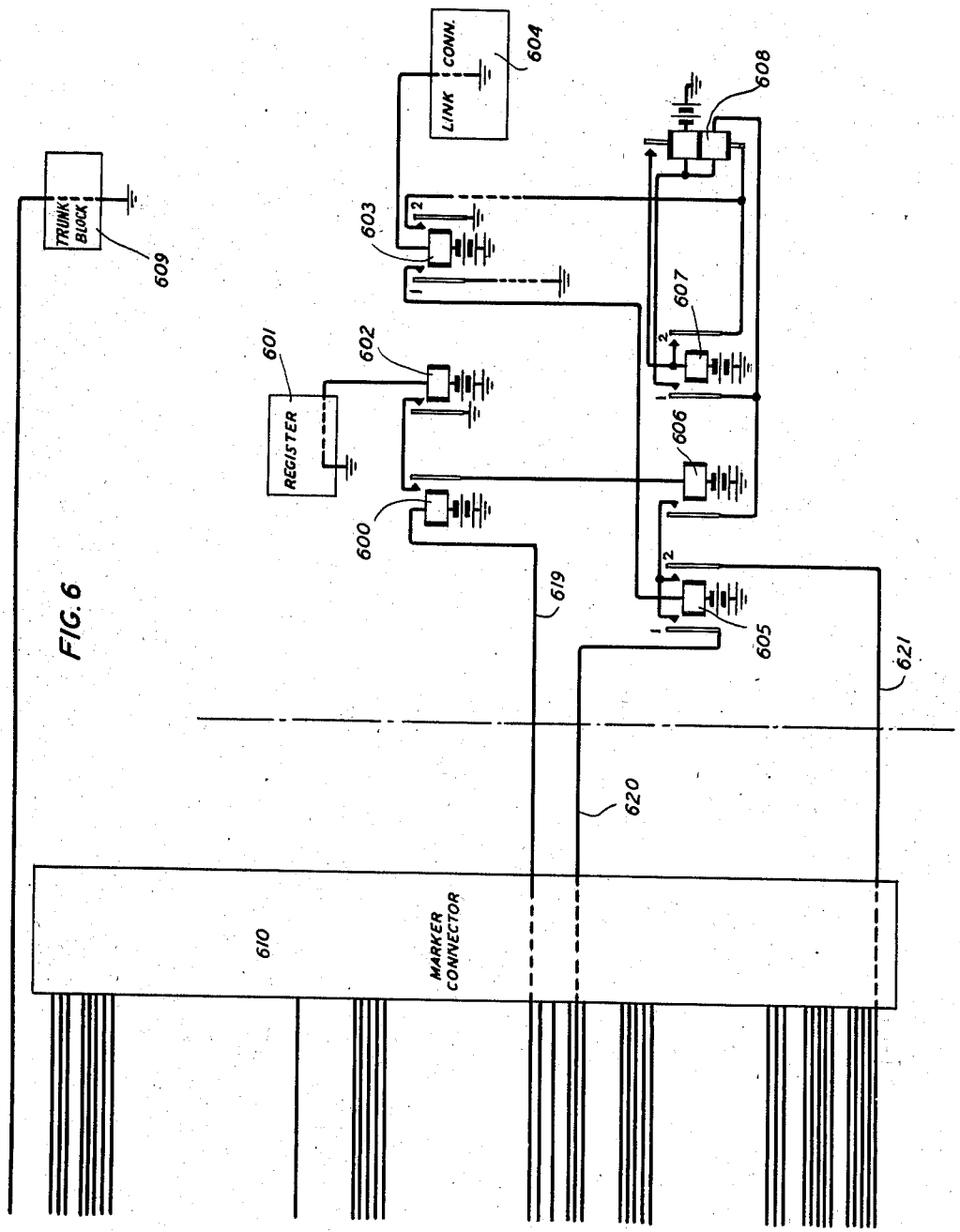

FIG. 6

INVENTORS: A. J. BUSCH
F. J. SCUDDER

BY W. T. McKenney

ATTORNEY

Aug. 18, 1942. A. J. BUSCH ET AL 2,293,191

TELEPHONE SYSTEM

Filed Sept. 15, 1939 25 Sheets-Sheet 7

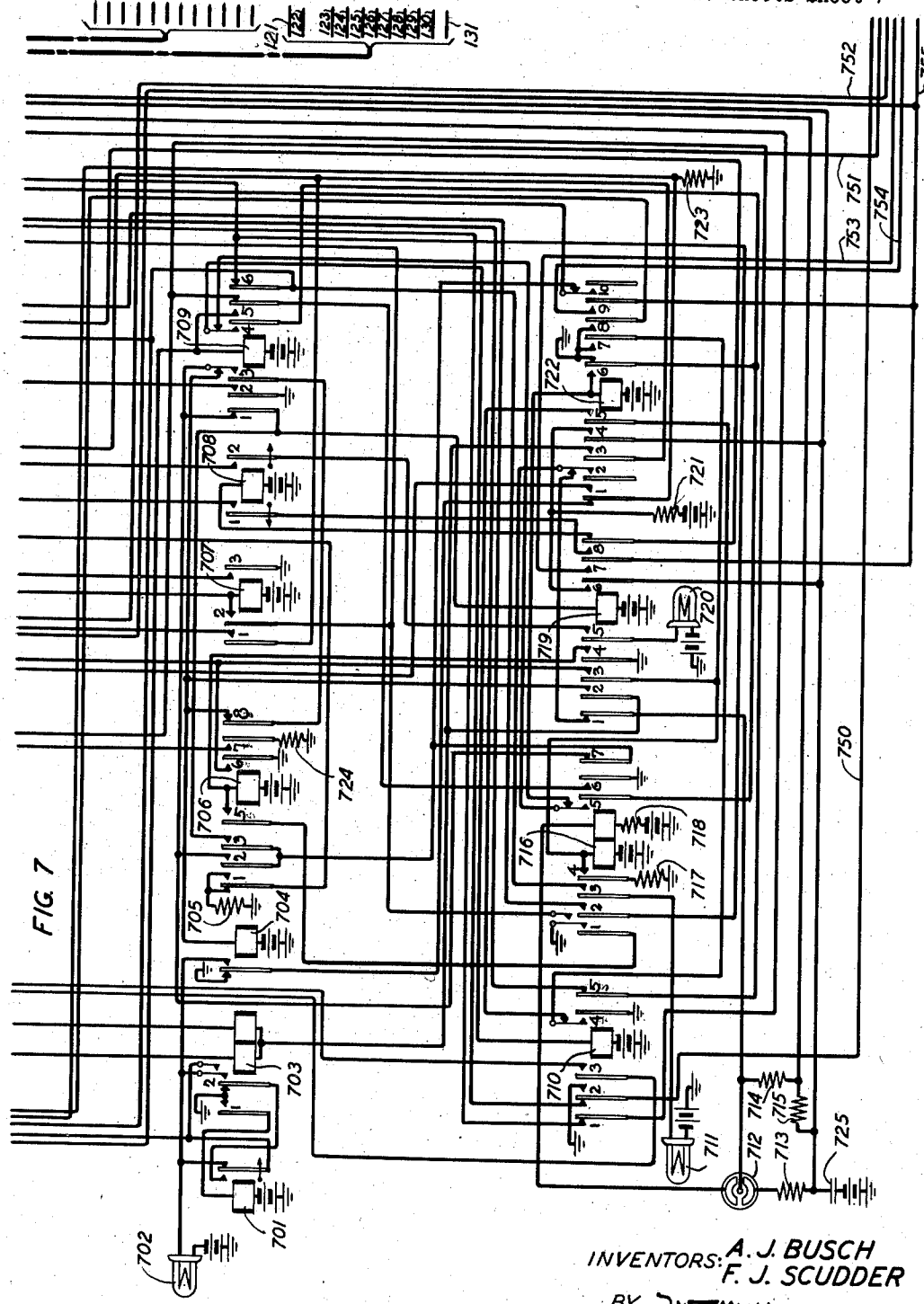

FIG. 7

INVENTORS: A. J. BUSCH
F. J. SCUDDER

BY W. T. McKenney

ATTORNEY

Aug. 18, 1942. A. J. BUSCH ET AL 2,293,191

TELEPHONE SYSTEM

Filed Sept. 15, 1939 25 Sheets-Sheet 8

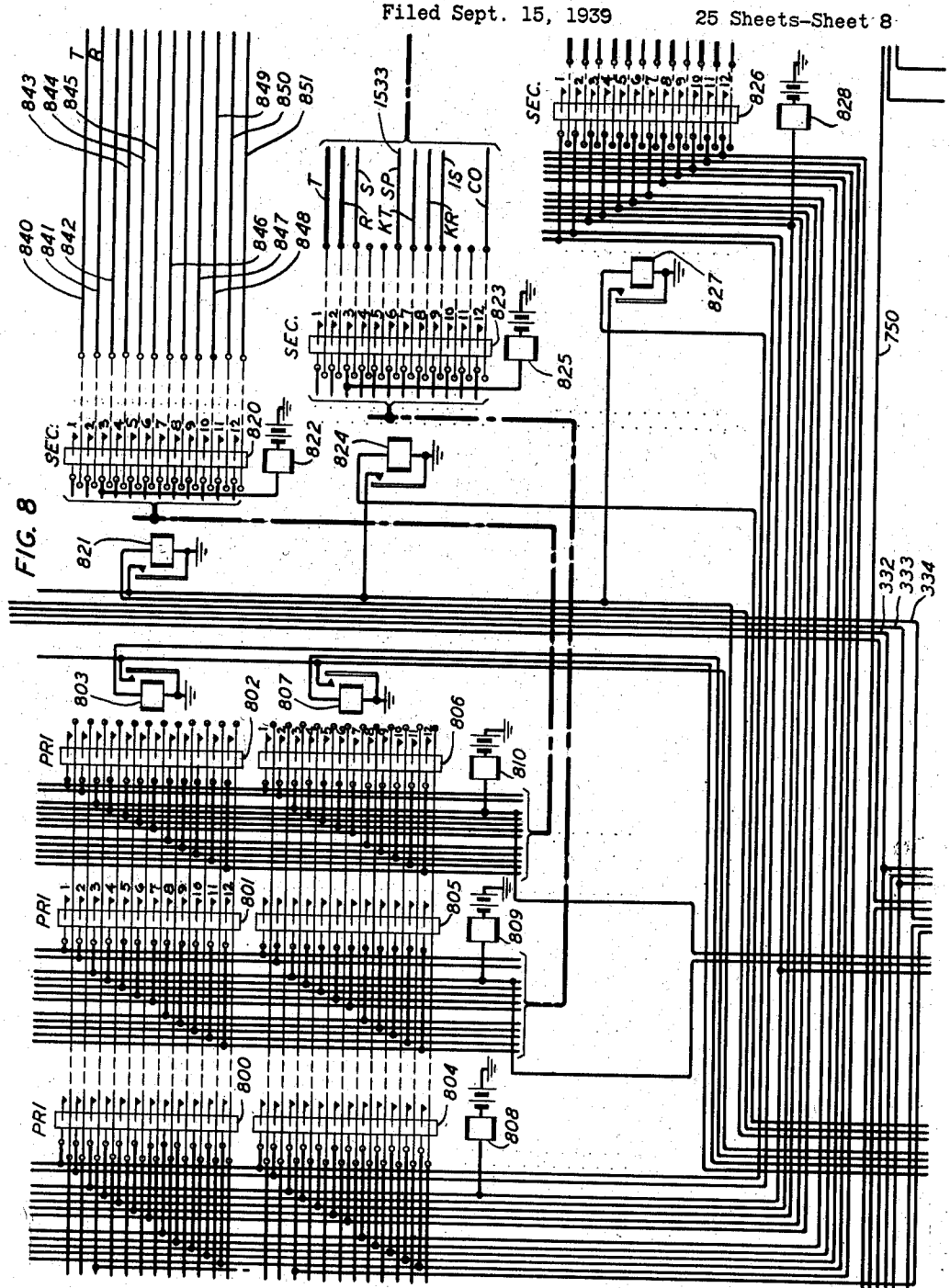

FIG. 8

INVENTORS: A. J. BUSCH
F. J. SCUDDER

BY W. T. McKenney

ATTORNEY

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TELEPHONE SYSTEM

Filed Sept. 15, 1939 25 Sheets-Sheet 9

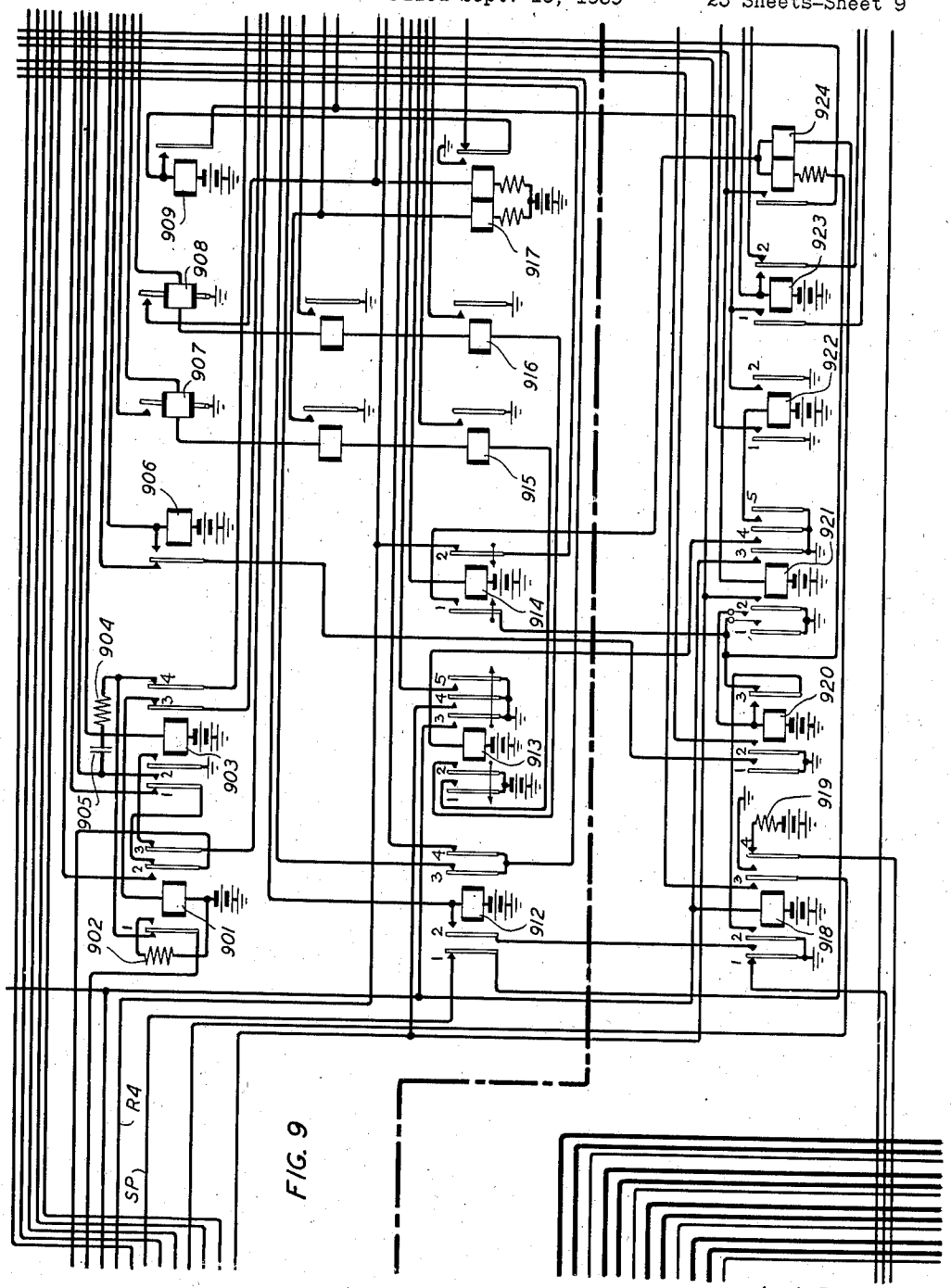

FIG. 9

INVENTORS: A. J. BUSCH
F. J. SCUDDER

BY W. T. McInerney

ATTORNEY

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TELEPHONE SYSTEM

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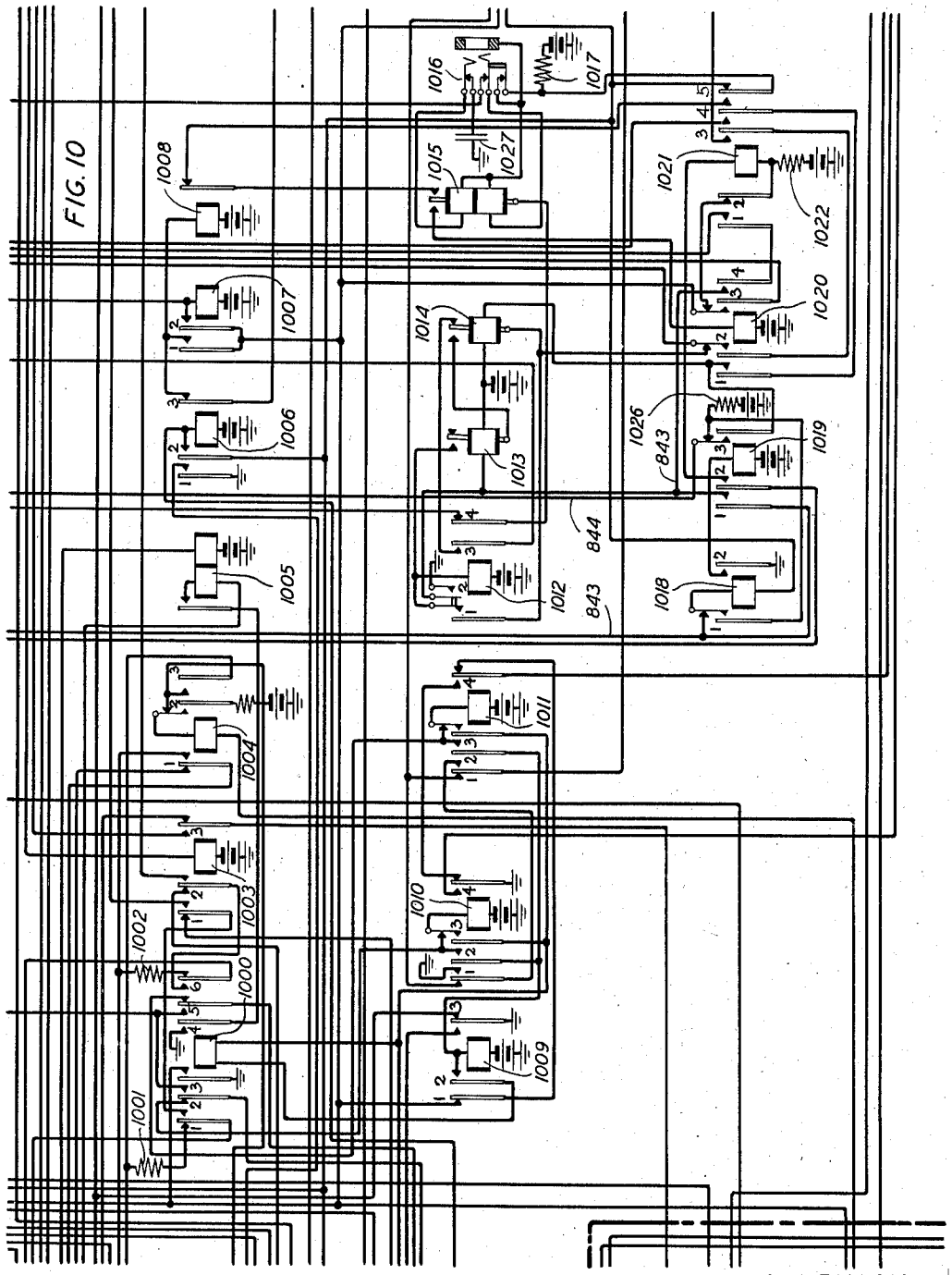
FIG. 10



INVENTORS: A. J. BUSCH
F. J. SCUDDER

BY. W. T. McKenney

ATTORNEY

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TELEPHONE SYSTEM

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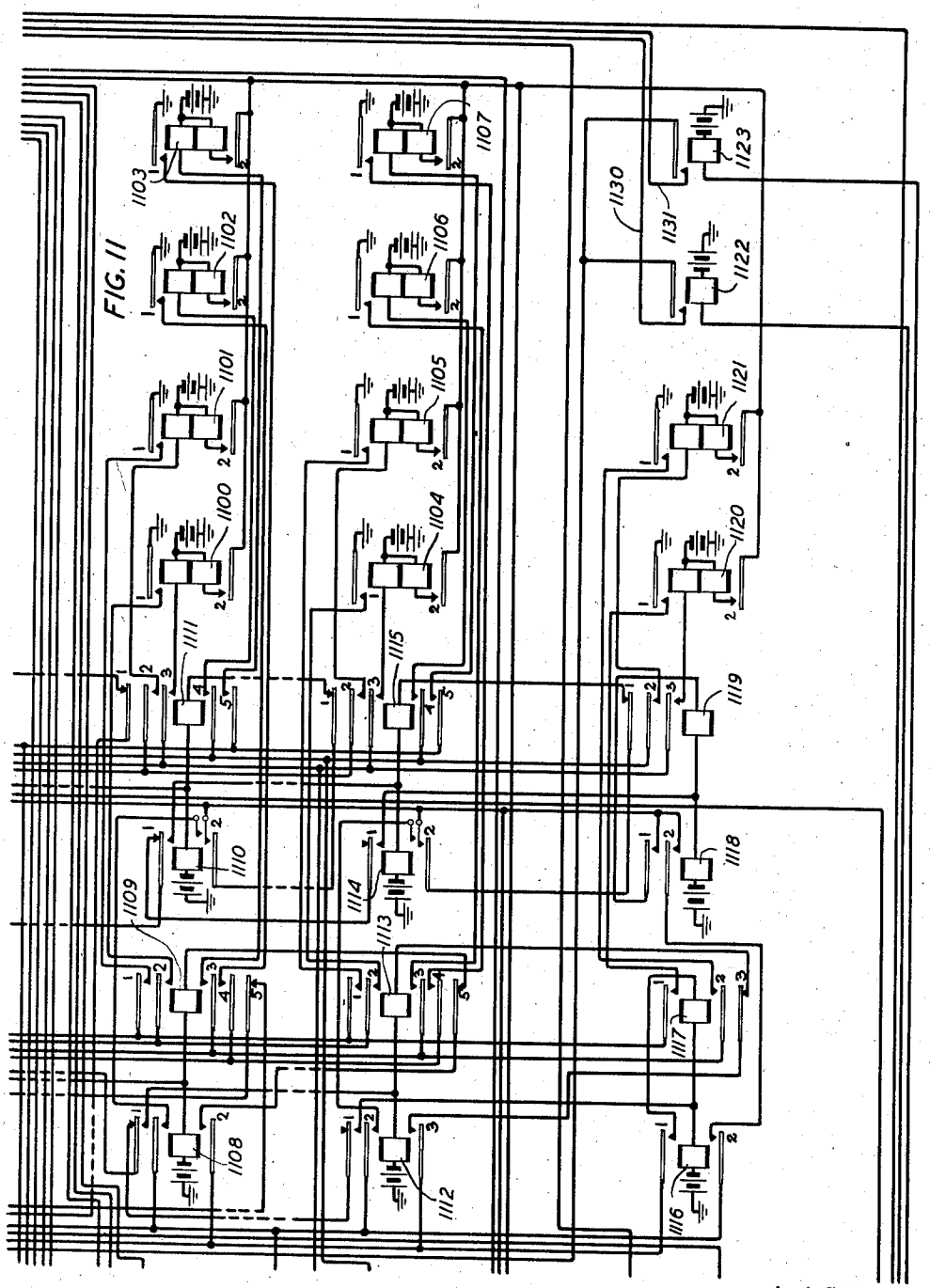
FIG. 11



INVENTORS: A. J. BUSCH
F. J. SCUDDER

BY M. F. McKenney

ATTORNEY

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TELEPHONE SYSTEM

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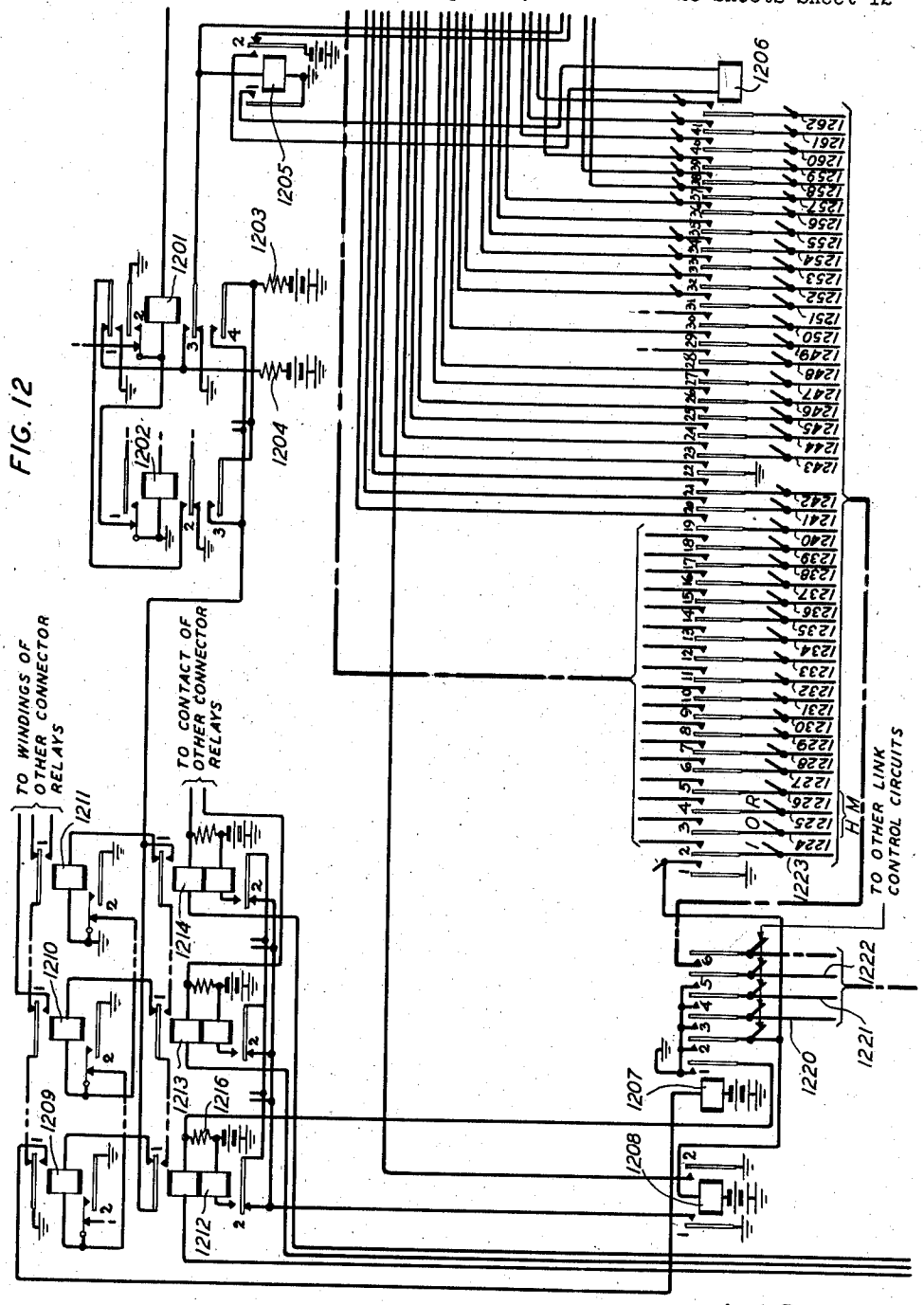

FIG. 12

INVENTORS: A. J. BUSCH
F. J. SCUDDER

BY W. T. McKinney

ATTORNEY

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TELEPHONE SYSTEM

Filed Sept. 15, 1939 25 Sheets-Sheet 13

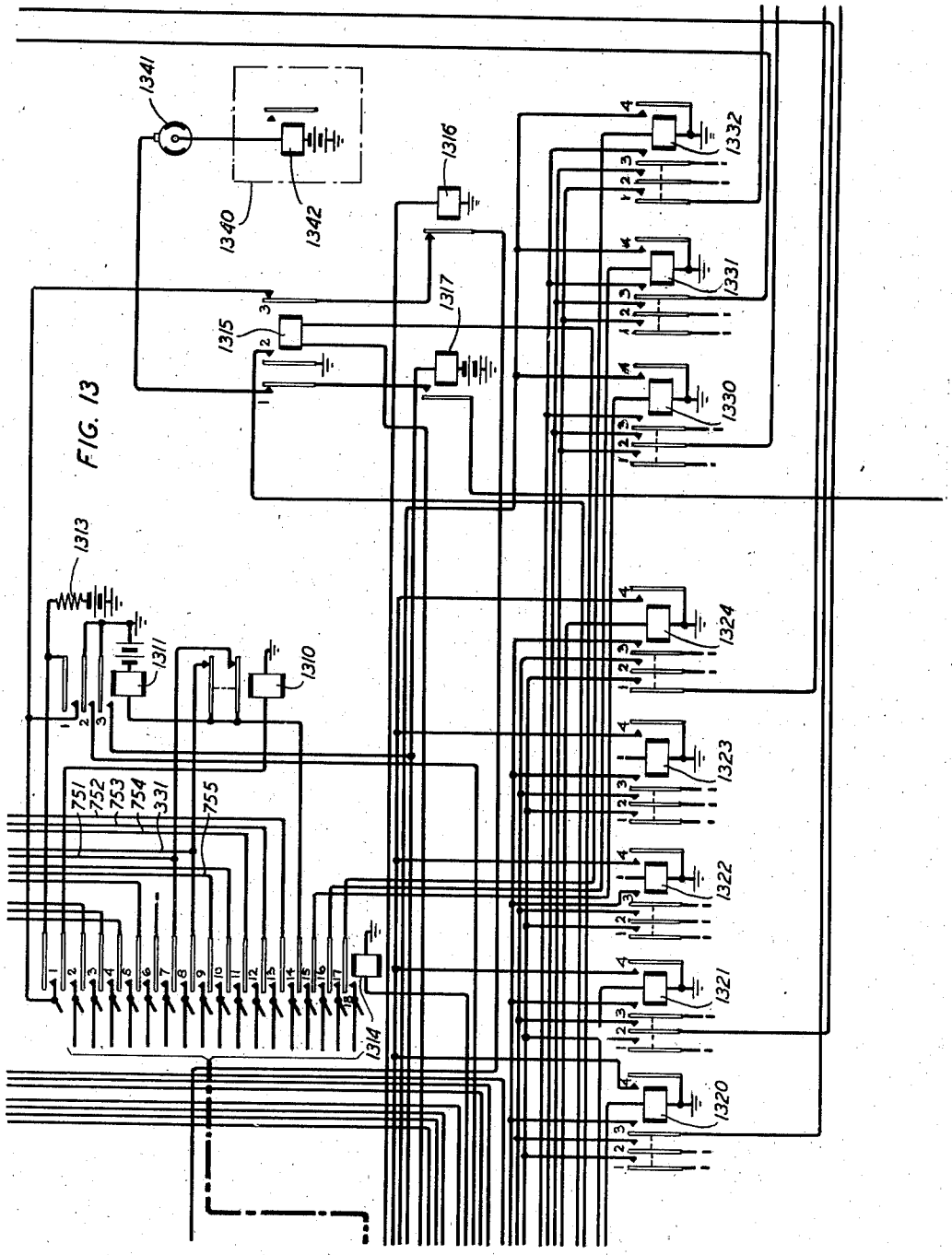

FIG. 13

INVENTORS: A. J. BUSCH
F. J. SCUDDER

BY W. F. McKenney

ATTORNEY

Aug. 18, 1942. A. J. BUSCH ET AL 2,293,191

TELEPHONE SYSTEM

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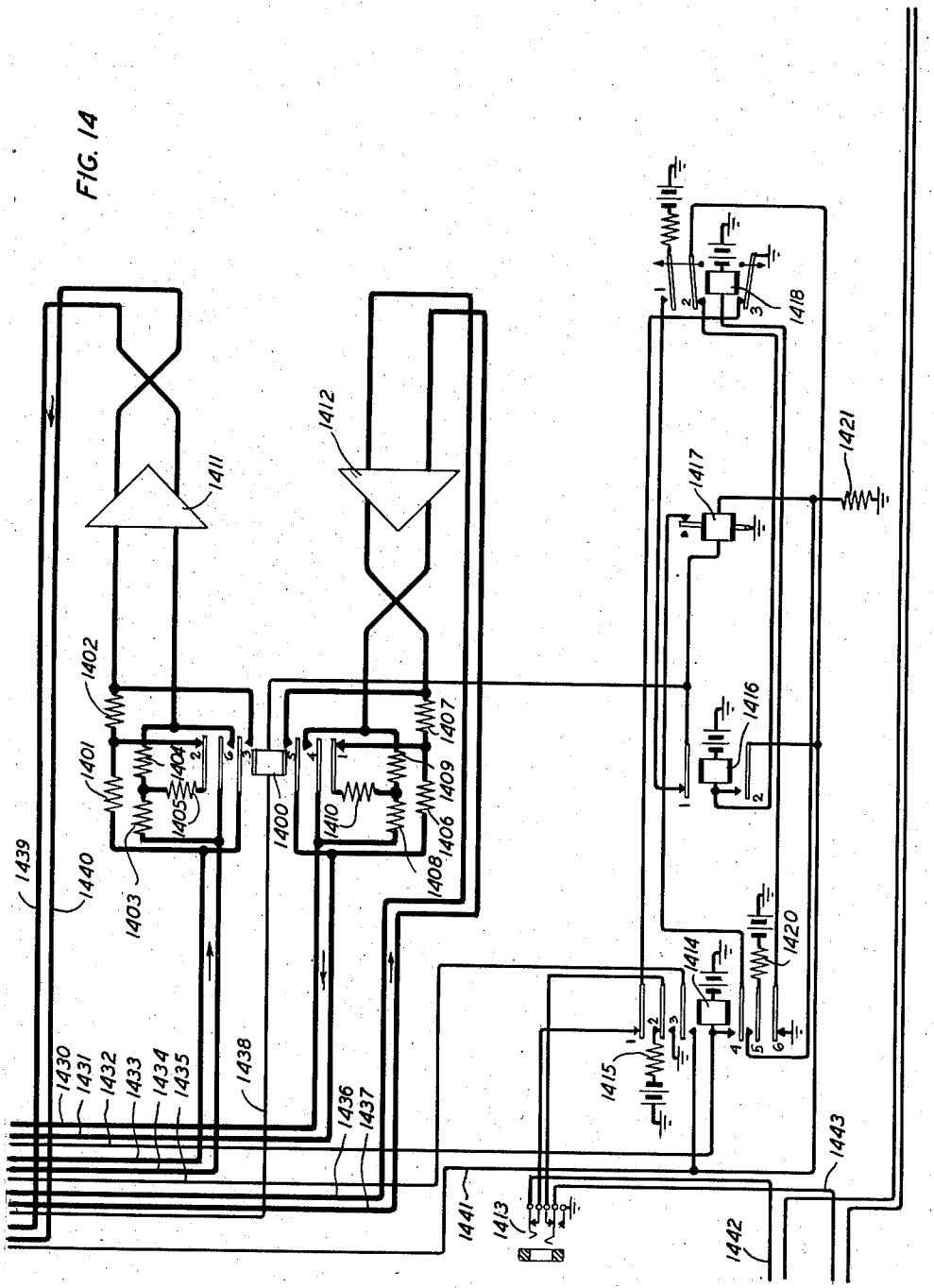
FIG. 14



INVENTORS: A. J. BUSCH
F. J. SCUDDER

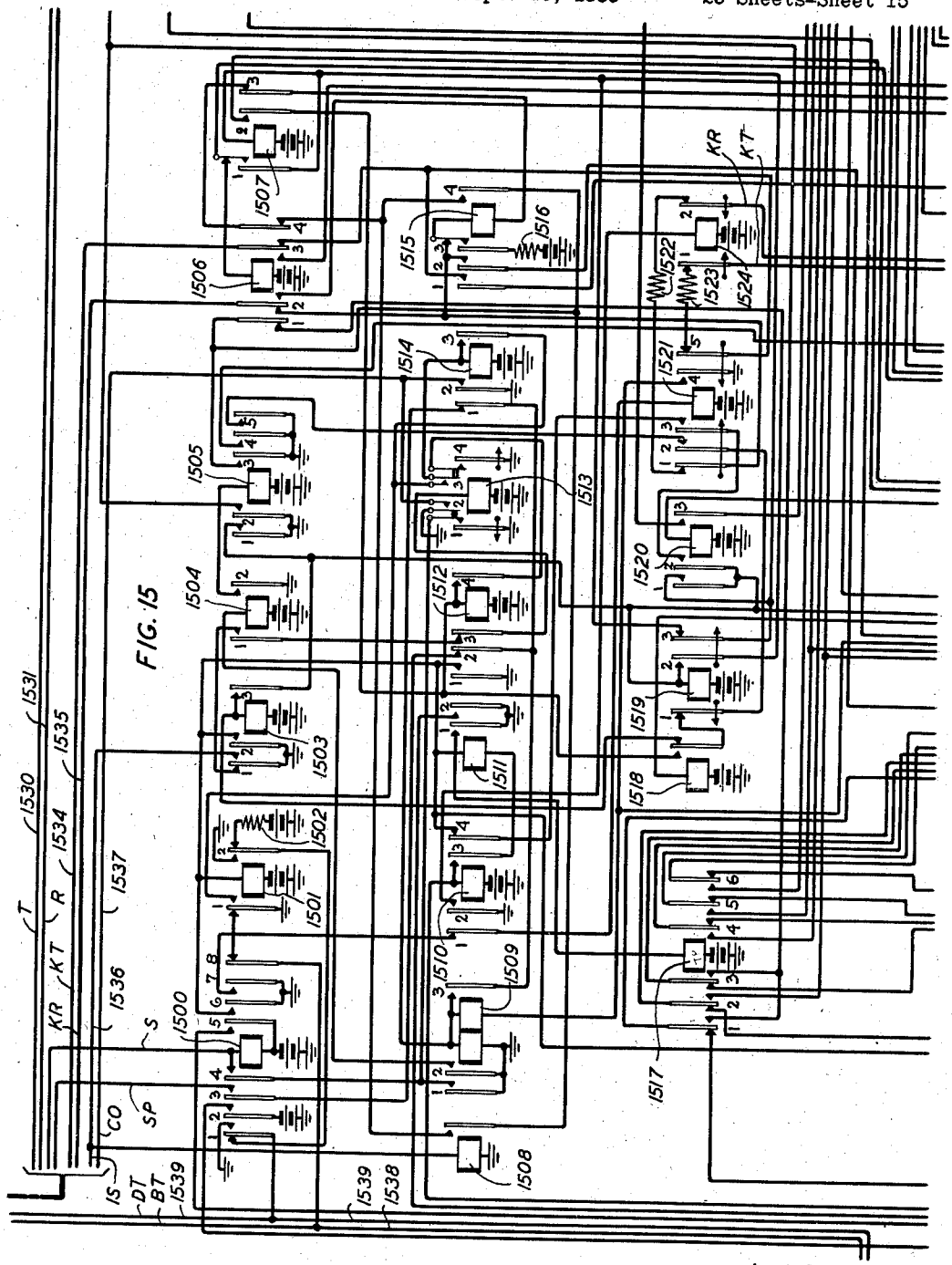
BY W. T. McKenney

ATTORNEY

Aug. 18, 1942. A. J. BUSCH ET AL 2,293,191

TELEPHONE SYSTEM

Filed Sept. 15, 1939 25 Sheets-Sheet 15



INVENTORS: A. J. BUSCH
F. J. SCUDDER

BY W. T. McKenney

ATTORNEY

Aug. 18, 1942. A. J. BUSCH ET AL 2,293,191

TELEPHONE SYSTEM

Filed Sept. 15, 1939 25 Sheets-Sheet 16

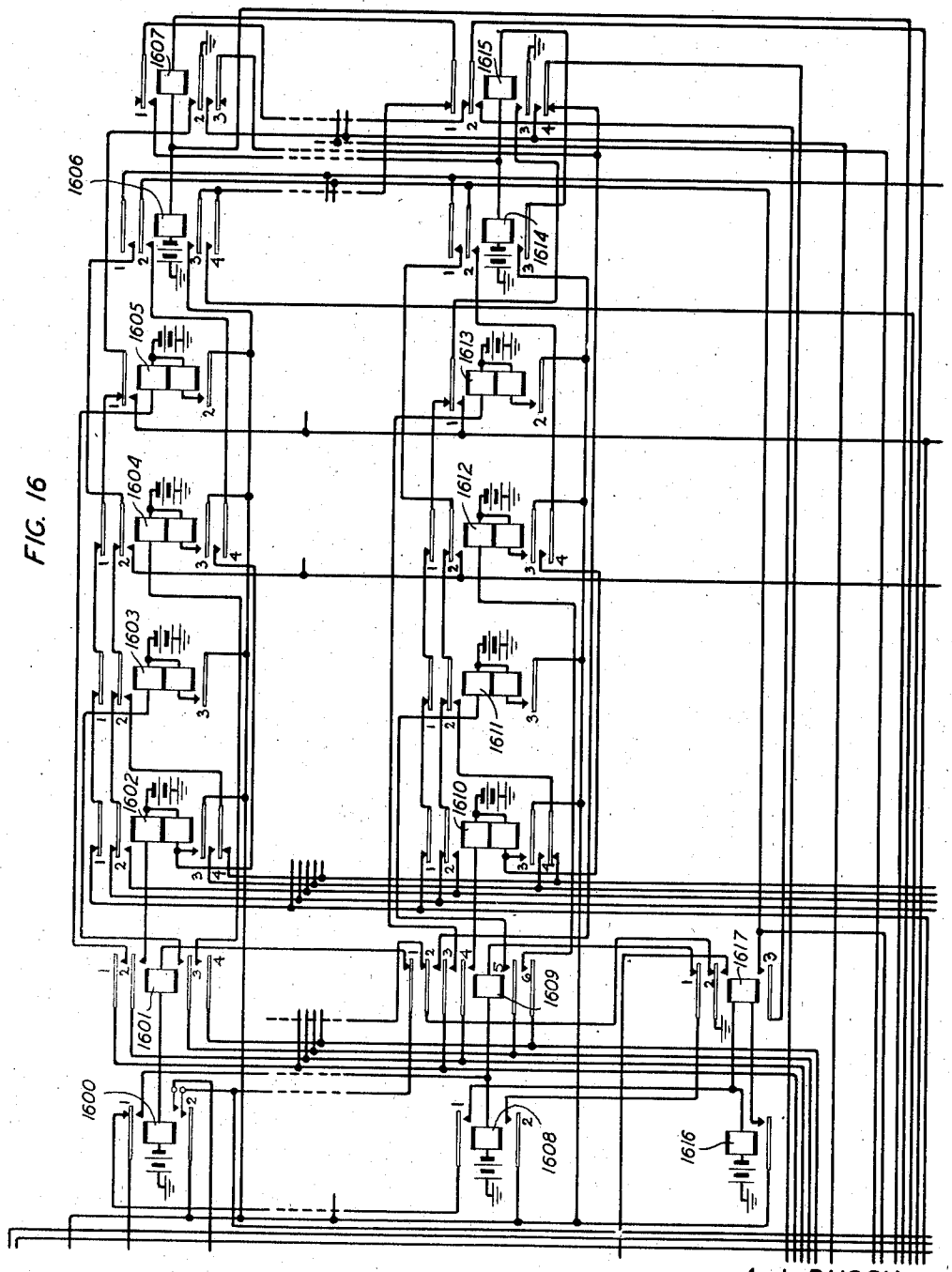


FIG. 16

INVENTORS: A. J. BUSCH
F. J. SCUDDER

BY W. T. McTierney

ATTORNEY

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TELEPHONE SYSTEM

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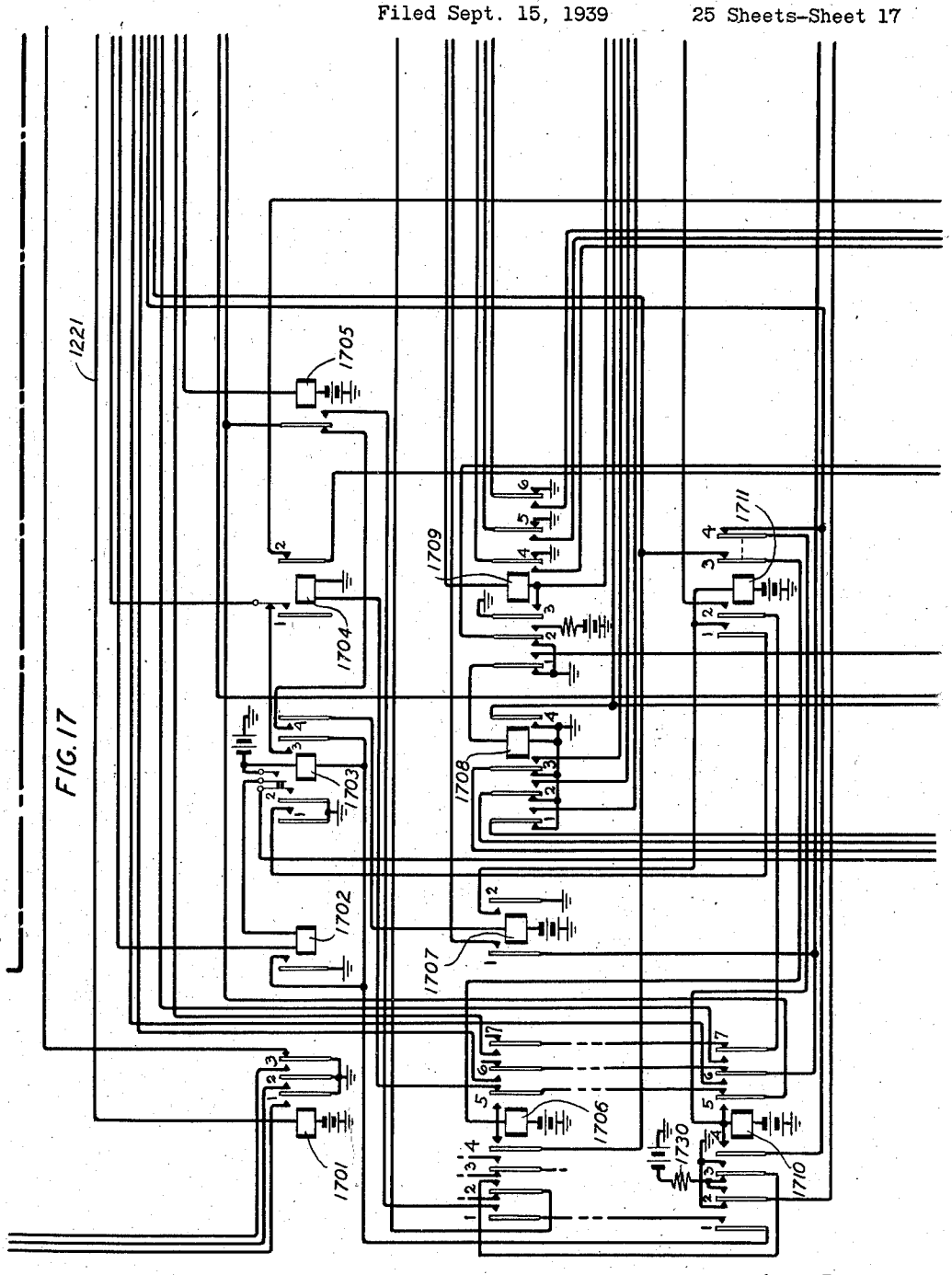

FIG. 17

INVENTORS: A. J. BUSCH
F. J. SCUDDER

BY W. R. McInerney

ATTORNEY

Aug. 18, 1942. A. J. BUSCH ET AL 2,293,191

TELEPHONE SYSTEM

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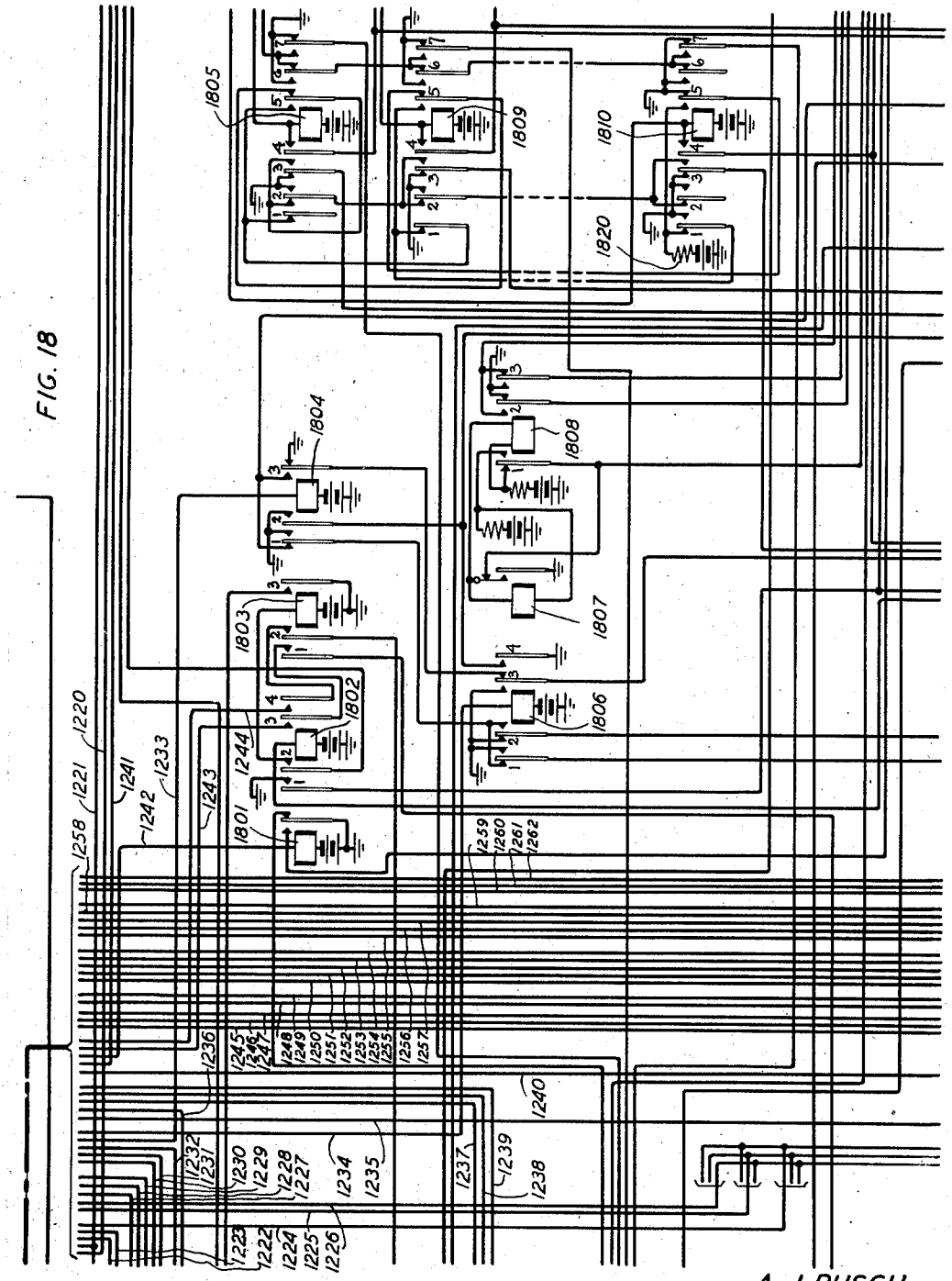
FIG. 18



INVENTORS: A. J. BUSCH
F. J. SCUDDER

BY M. T. McEnerney

ATTORNEY

Aug. 18, 1942. A. J. BUSCH ET AL 2,293,191

TELEPHONE SYSTEM

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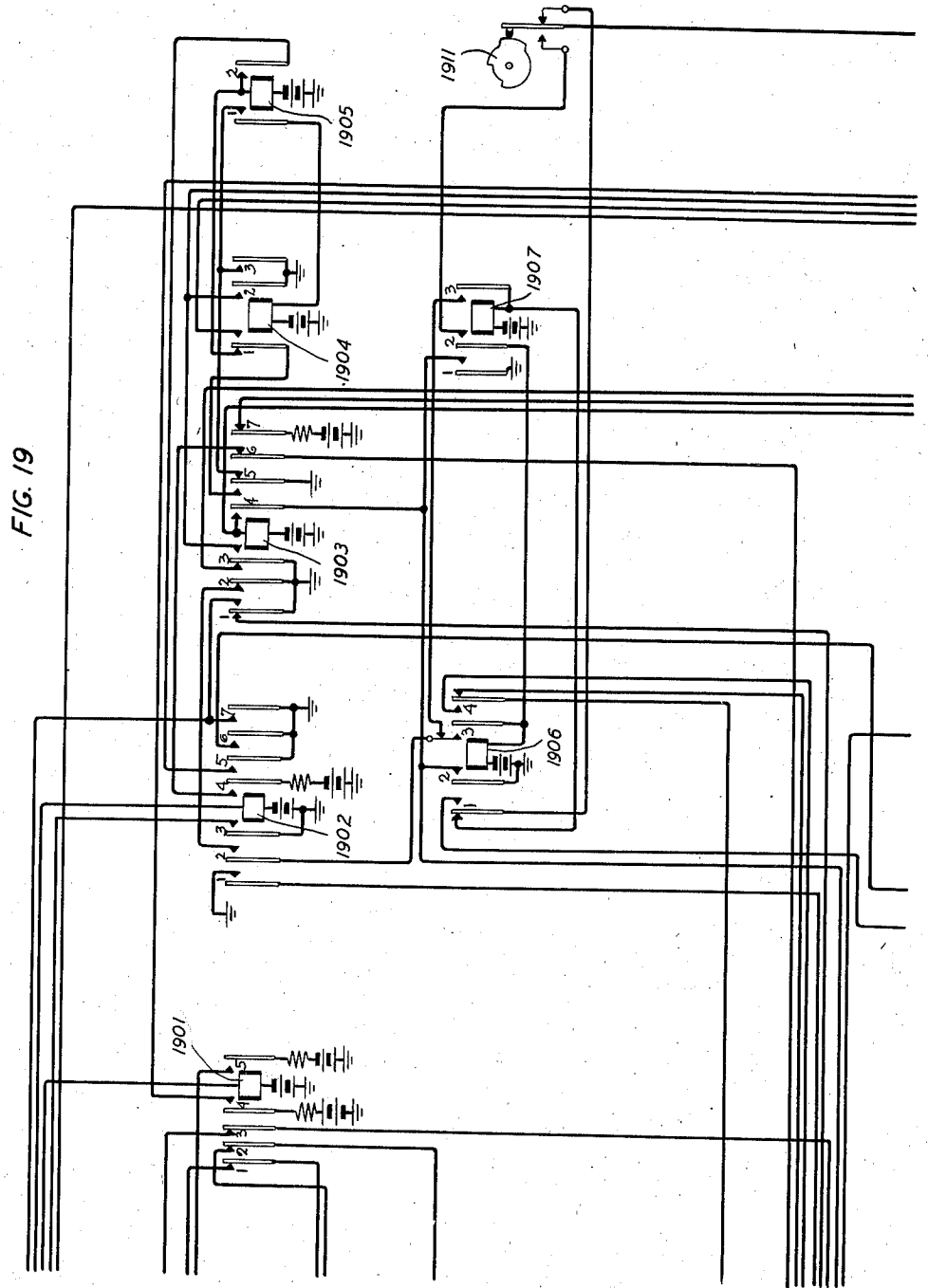

FIG. 19

INVENTORS: A. J. BUSCH
F. J. SCUDDER

BY W. T. McKenney

ATTORNEY

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TELEPHONE SYSTEM

Filed Sept. 15, 1939 25 Sheets-Sheet 20

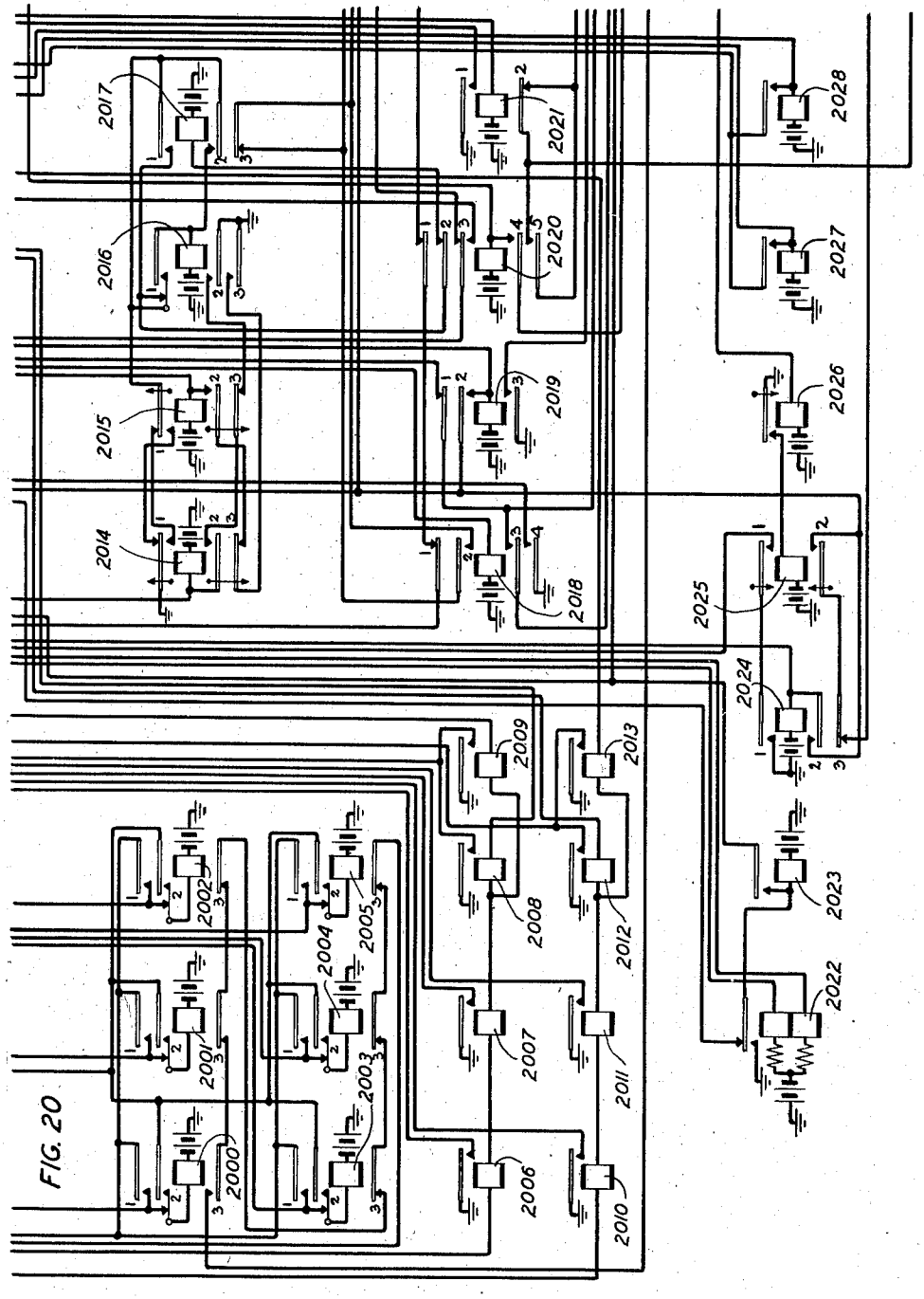

FIG. 20

INVENTORS: A. J. BUSCH
F. J. SCUDDER

BY W. P. McKenney

ATTORNEY

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TELEPHONE SYSTEM

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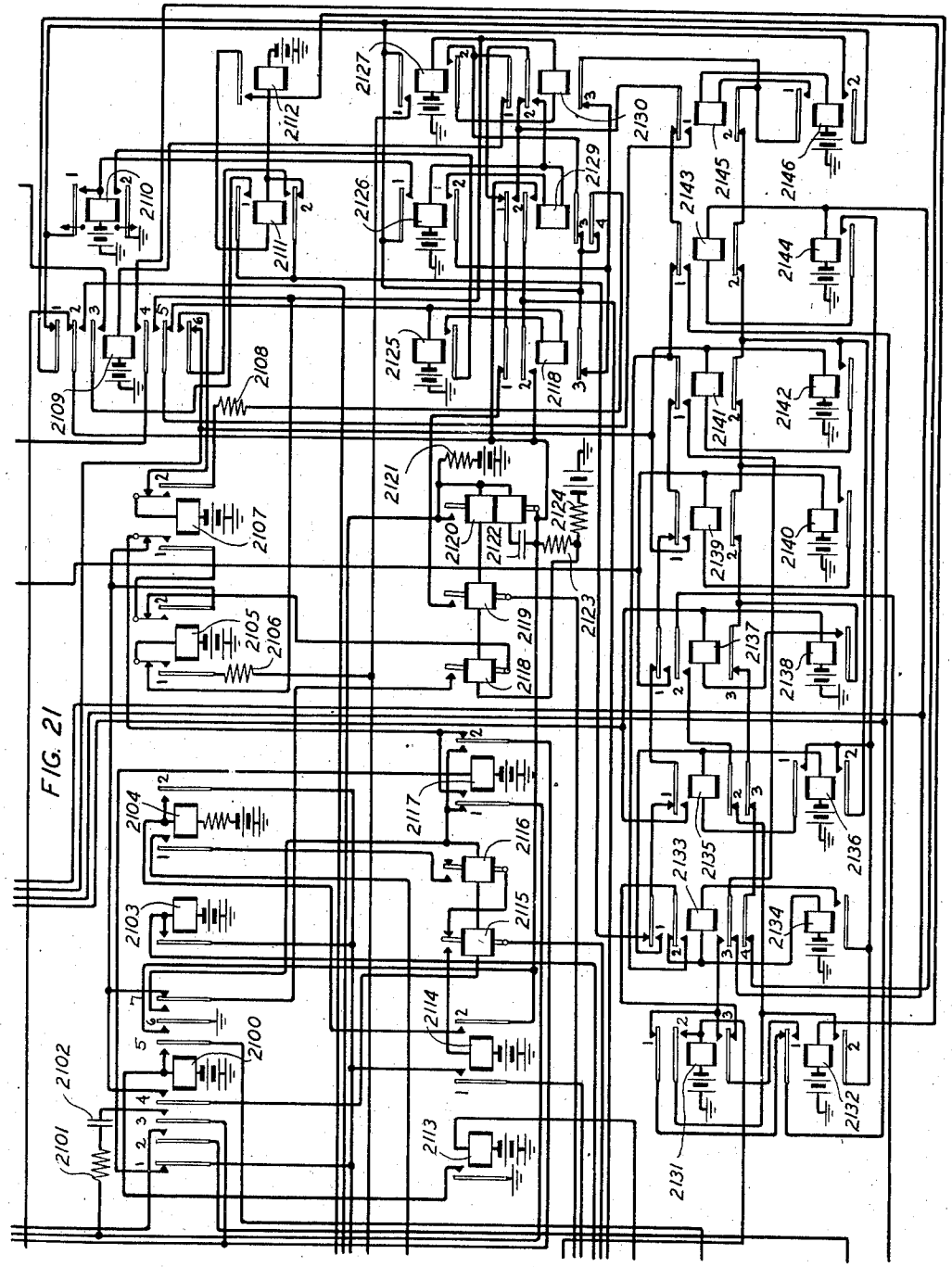

FIG. 21

INVENTORS: A. J. BUSCH
F. J. SCUDDER

BY W. P. McGuinness

ATTORNEY

Aug. 18, 1942. A. J. BUSCH ET AL 2,293,191

TELEPHONE SYSTEM

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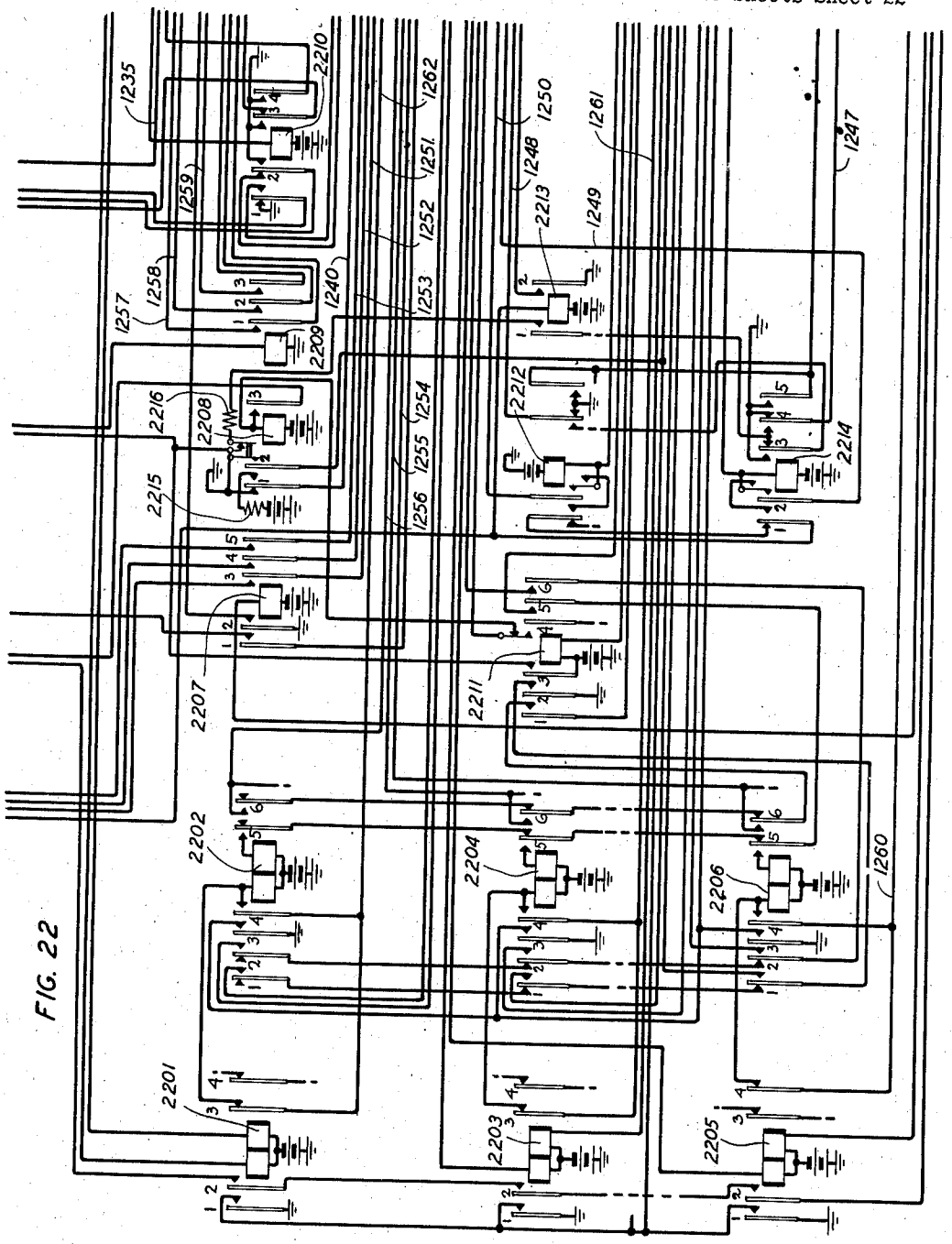


FIG. 22

INVENTORS: A. J. BUSCH
F. J. SCUDDER

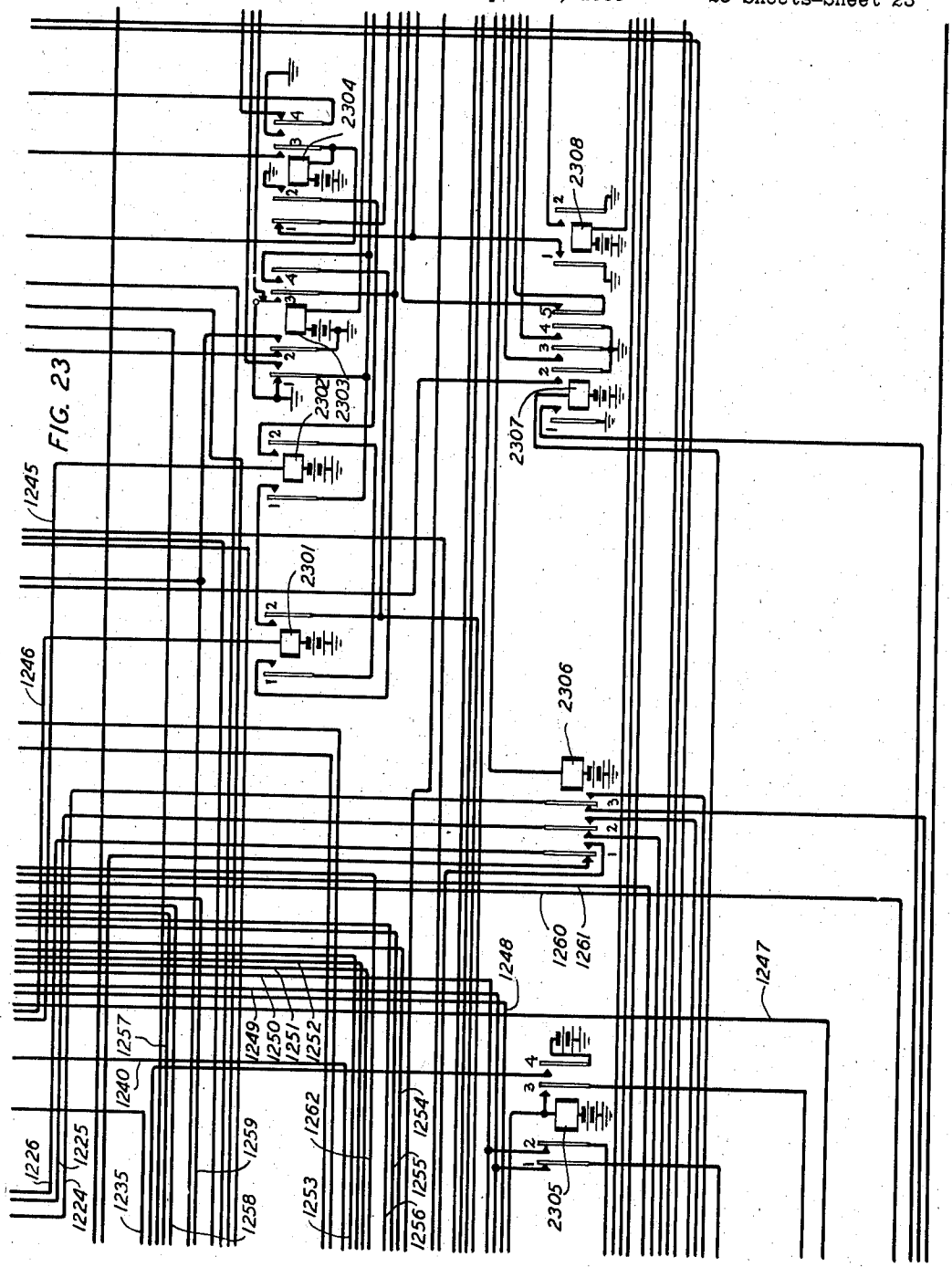
BY W. T. McKenney

ATTORNEY

Aug. 18, 1942. A. J. BUSCH ET AL 2,293,191

TELEPHONE SYSTEM

Filed Sept. 15, 1939 25 Sheets-Sheet 23



INVENTORS: A. J. BUSCH
F. J. SCUDDER

BY M. F. McKenney

ATTORNEY

Aug. 18, 1942. A. J. BUSCH ET AL 2,293,191

TELEPHONE SYSTEM

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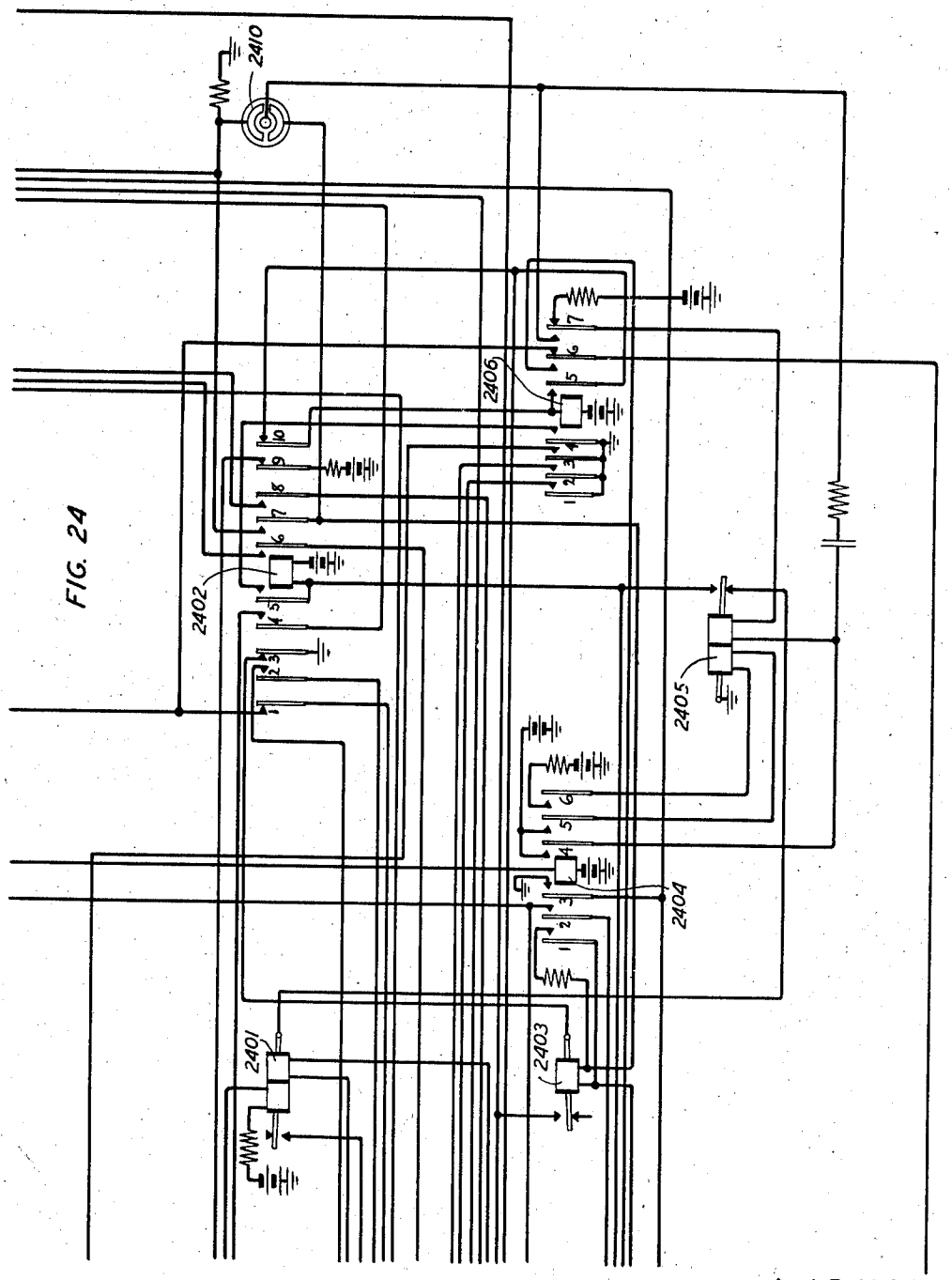

FIG. 24

INVENTORS: A. J. BUSCH
F. J. SCUDDER

BY W. T. McKenney

ATTORNEY

Aug. 18, 1942. A. J. BUSCH ET AL 2,293,191

TELEPHONE SYSTEM

Filed Sept. 15, 1939 25 Sheets-Sheet 25

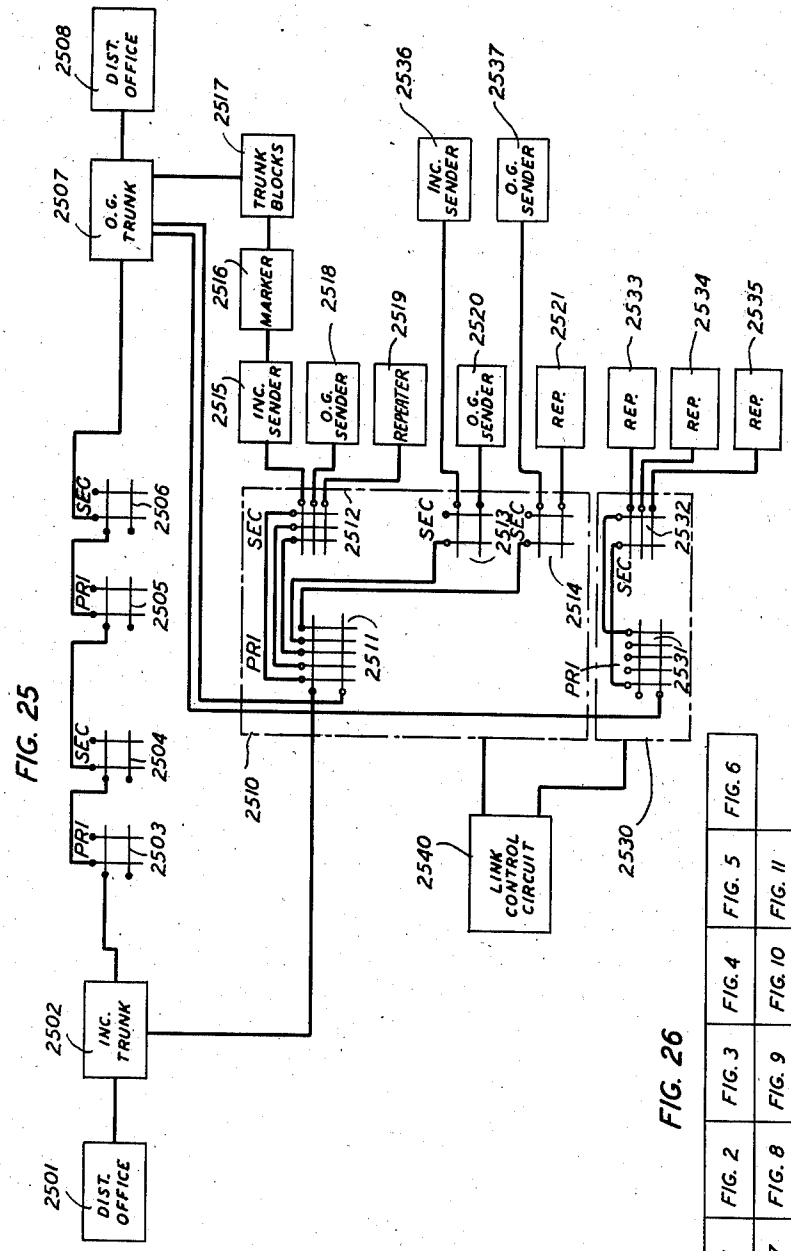

FIG. 25

FIG. 26

FIG. 1	FIG. 2	FIG. 3	FIG. 4	FIG. 5	FIG. 6
FIG. 7	FIG. 8	FIG. 9	FIG. 10	FIG. 11	
FIG. 12	FIG. 13	FIG. 14	FIG. 15	FIG. 16	
FIG. 17	FIG. 18	FIG. 19	FIG. 20	FIG. 21	
FIG. 22	FIG. 23	FIG. 24			

INVENTORS: A. J. BUSCH
F. J. SCUDDER

BY W. P. McKenney

ATTORNEY

Patented Aug. 18, 1942 2,293,191

UNITED STATES PATENT OFFICE

2,293,191

TELEPHONE SYSTEM

Aloysius J. Busch, Madison, N. J., and Frederick J. Scudder, Manhasset, N. Y., assignors to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application September 15, 1939, Serial No. 295,012

25 Claims. (Cl. 179—18)

This invention relates to telephone systems and, more particularly, to switching devices for interconnecting equipments of different characters in such systems.

The present invention relates to automatically operable links having a common group of selectable, adjustable link control circuits associated therewith which may be seized for temporary service by the links for selecting different characters of equipment under the direction of the links or trunks of the office or other control devices and for connecting said different characters of equipment to said trunks or for connecting said equipments together through trunk conductors.

The object of the invention is, therefore, to simplify the operations required in a telephone office, to obtain economies in the operation of the apparatus in a telephone office and in the space required for telephone equipment by providing a universal automatically operable switching mechanism available for interconnecting the majority of the operating equipments of the telephone office.

A feature of this invention is a system in which a link and a variably operable link control circuit are automatically responsive to different circuit connections with incoming and outgoing trunk circuits for successively selecting different characters of equipment, the circuit connections in the trunk circuit for signaling the link and link control circuit being varied responsive to its character of use.

Another and related feature is a system in which a link and link control circuit are automatically responsive to different circuit connections with trunk circuits for selecting any of a plurality of different characters of equipment according to the circuit connection established and for connecting the equipment selected with the signaling trunk circuit.

Another and related feature is a system in which a link and link control circuit are arranged to successively select different characters of equipment responsive to successive signals from a trunk circuit and successively associate the different equipments with the trunk circuit.

Another and related feature is a system in which a link is arranged to successively select a link control circuit for successively selecting different characters of equipment for a calling incoming trunk and a selected outgoing trunk for the same telephone connection.

Another and related feature is a system in which a link has primary switches with mating contacts connected to a plurality of trunks and a plurality of choices of secondary link switches with the mating contacts of the secondary link switches connected to a plurality of different characters of equipment, said link having access to a plurality of variably operable link control circuits for selecting idle equipments and for operating said primary and said secondary switches and said trunks having means for directing the operation of the link and link control circuits for selecting particular characters of equipment.

Another and related feature is a system in a telephone office for selecting voice current amplifying repeaters as directed by a marker which has means responsive to registrations providing the character of the calling incoming trunk and the character of the outgoing trunk required for a telephone connection and a second means responsive to the actuation of said first means for automatically determining whether a repeater is required for the telephone connection for controlling the actuation of a link for the selection of said repeater.

Another and related feature is a system in which links which are selectable by trunk circuits have switches connected with a plurality of different characters of equipment and adjustable link control circuits selectable by said links also, connected with said plurality of different characters of equipment, said control circuits being adjustable as directed by the trunk circuits for selecting an equipment of any particular character by testing a large plurality of such equipments and for operating the link switches connected therewith.

These and other features will be discussed more fully in the following description.

To illustrate the features of the invention, reference may be had to the accompanying drawings in which:

Figs. 1 and 7 illustrate a two-way incoming and outgoing intertoll trunk circuit, Fig. 3 an outgoing intertoll trunk circuit and Fig. 2 the automatic switches for interconnecting the trunk circuits for a telephone connection;

Figs. 8, 12 and 13 illustrate link switches and a link connector;

Figs. 17, 18, 19, 22, 23 and 24 illustrate a link control circuit;

Figs. 4, 5, 9, 10 and 11 illustrate an incoming sender;

Figs. 15, 16, 20 and 21 illustrate an outgoing sender;

Fig. 14 illustrates voice amplifying repeater for four-wire trunk;

Fig. 6 illustrates in detail the apparatus of a marker for determining whether a repeater is required for a telephone connection and illustrates other apparatus diagrammatically which are associated with the repeater controlling apparatus; and

Fig. 25 illustrates the elements of the link and link control system diagrammatically.

The drawings, when arranged as shown in Fig. 26, illustrate the detail structure of this link system.

General description

The general organization of circuits and equipment is shown diagrammatically in Fig. 25 in which a call from a distant toll office **2501** energizes the apparatus of an incoming intertoll trunk circuit **2502**. The energization of the incoming trunk circuit causes the selection of a link **2510** and link control circuit **2540** for associating an incoming sender **2515** with the incoming trunk through a primary switch **2511** and a secondary switch **2512** of the link. The incoming sender is equipped with registers which are set by impulses transmitted from the distant toll office **2501**. These impulses may be used for setting the code registers of the incoming sender or where necessary impulses are transmitted for setting both the code and numerical registers of this sender. The energization of the incoming sender associates a marker **2516** therewith and causes the transfer of the code registers from the sender to this marker. In response to the energization of the code registering equipment in the marker other equipment is operated for causing the selection of an idle outgoing trunk to the desired distant office such as **2508**. The outgoing trunks extending to this office are associated with trunk block relays shown diagrammatically as **2517**. The marker selects an idle outgoing trunk and causes the energization of switches **2503** to **2506** inclusive, for connecting the incoming and outgoing trunks together. The idle outgoing trunk selected is indicated as **2507**. For calls requiring the transmission of numerical digits an outgoing sender is selected and the numerical registrations of the incoming sender are transmitted to a selected outgoing sender such as **2518** or **2520**. The outgoing trunk energizes a circuit extending to a link and link control circuit causing the selection of this outgoing sender which after it is selected is connected through primary and secondary switches of the link circuit to the outgoing trunk. The numerical digits are transferred from the incoming sender **2515** through secondary switch contacts on level No. 2 through a secondary and a primary vertical of the link switches over level No. 1 of the primary switch through the incoming trunk **2502**, switches **2503**, **2504**, **2505** and **2506**, outgoing trunk circuit **2507** level No. 0 of the primary switch, over a vertical in the primary and secondary link switches to the registers of the outgoing sender **2518**. The numerical registrations received by the outgoing sender are transmitted to the distant office **2508** over a level of a secondary link switch, a vertical of the secondary and primary switches level 0 of the primary link switch, over the outgoing trunk conductors to the distant office.

A voice amplifying repeater is required for high quality transmission when the incoming trunk extending from the distant office **2501** to this toll office and the outgoing trunk extending from this toll office to the distant office **2508** are long trunks. This requirement is automatically registered by a class of trunk signal given to the marker by the incoming trunk and by the registrations from the calling distant office **2501** which gives the routing for the outgoing trunk to be selected. When these registrations are received by the marker the repeater selecting apparatus in the outgoing trunk is actuated before the incoming sender and marker are disengaged from the link switches. For this purpose the marker transmits a signal through the incoming sender and link switches to the incoming trunk **2502** thence over the switches **2503** to **2506**, inclusive, to the outgoing trunk. This energizes a repeater selecting relay in the outgoing trunk which is automatically locked to await the selection of an outgoing sender before indicating that a repeater is required. This outgoing trunk may have a single start lead which is successively energized for first, causing the selection of an outgoing sender and second, causing the selection of a repeater. In this case both the repeater and the outgoing sender may be engaged through the same primary link switch. The outgoing sender and repeater may be engaged through the same secondary link switch or through separate secondary link switches as shown. In certain instances the traffic load is sufficient to warrant a separate frame of link switches for the selection of repeaters. The link switch frame **2510** would then have incoming senders and outgoing senders associated therewith and connected to the different levels of the secondary link switches or different secondary link switches. The frame **2530** would contain separate primary and secondary link switches for the selection of repeaters only.

The intertoll trunk **2502** illustrated in Figs. 1 and 7 is a two-way intertoll trunk diagrammatically shown at **2502** in Fig. 25. This trunk may be used either as an incoming trunk from the distant office shown in Fig. 1 or an outgoing trunk for connecting calls from this office to the distant office. In the system disclosed herein this two-way intertoll trunk circuit is used only as an incoming trunk operated from signals transmitted by the distant office associated therewith. The energization of this incoming trunk establishes a start circuit for a link **2510** and a link control system **2540** for associating an incoming sender and marker with this incoming trunk. The energization of this start circuit establishes a circuit for apparatus in Figs. 13 and 12 known as a link connector and link connector control. This apparatus governs the selection of an idle link control circuit **2540** more fully illustrated in Figs. 17, 18, 19, 22, 23 and 24. The multicontact relays in the lower portion of Fig. 12 are energized for associating the circuit paths from the idle control circuit **2540** to a large plurality of incoming senders **2515** or **2536**, such as shown in Figs. 4, 5, 9, 10 and 11.

The link control circuit, Figs. 17 to 19 and 22 to 24, inclusive, may be used for selecting either an incoming sender, an outgoing sender, or a repeater. The type of equipment to be selected is governed by the intertoll trunk circuit. For example, when the two-way intertoll trunk circuit, Fig. 1 and Fig. 7, is used as an incoming intertoll trunk, a class signal is transmitted to the control circuit **2540** indicating that an idle incoming sender is required. The control circuit is then associated with a large plurality of incoming senders which are connected to certain levels of the secondary cross-bar switches **2512**, **2513** or **2514** shown more in detail in the right-hand portion of Fig. 8. Each control circuit

2540 may be connected to a different plurality of senders, some of which are the same as those connected to other control circuits. Assuming that there are one hundred and fifty incoming senders and ten control circuits, the one hundred and fifty senders are divided among the control circuits in any manner desired. An example may be assumed in which thirty senders may be simultaneously tested by the control circuit, which thirty senders are connected to thirty different levels of the secondary switches. An arrangement is provided, however, to prevent the test of senders which are busy. This busy condition is indicated by a ground connected to the hold magnet of switches associated with busy senders. When an idle sender is chosen the select magnet of the proper switch level is operated and the hold magnets of the proper verticals in both the primary link switch in the left portion of Fig. 8 and the secondary link switch in the right portion of Fig. 8 are operated. The incoming intertoll trunk of Fig. 1 is thus connected through the primary and secondary link switches to the idle incoming sender selected. A signal is transmitted to the distant calling operator that pulses may now be transmitted for setting the registers of the sender. During this period the apparatus of the incoming sender is energized for selecting an idle marker. This is accomplished through the energization of a marker connector in the manner fully described in patent application Serial No. 295,010 to King-McKim-Myers, filed Sept. 15, 1939, issued as Patent 2,236,246, March 25, 1941. Different class signals are transmitted to the link control circuit for causing the selection of an outgoing sender or a repeater when the two-way trunk, Figs. 1 and 7, is used as an outgoing trunk. The selection of outgoing senders or repeaters is made in the same manner as the selection of an incoming sender but over different classified channels.

In the connection being described both code and numerical pulses are transmitted for setting the registers of the incoming sender for making an outgoing call which requires the transmission of numerical digits. The code registrations are transmitted from the incoming sender to the marker for designating the character of the incoming call and the office or station to which connections should be made. This determines the group of outgoing trunks to be tested for selecting an outgoing trunk to the designated office. When the marker seizes an idle trunk in the manner fully described in the aforementioned application King et al., the cross-bar switches of Fig. 2 are energized for connecting the incoming trunk to the idle outgoing trunk selected. The idle outgoing trunk for the connection being described is shown in Fig. 3. This trunk is an outgoing toll switching trunk extending to an office which is a long enough distance away to require a repeater. The office also requires numerical pulses for indicating the wanted subscriber's station.

As previously stated, circuits are established in the marker responsive to registrations and through the energization of apparatus or the absence of energization of apparatus establish the character of the incoming and outgoing trunk so that the marker may automatically determine whether a voice amplifying repeater shall or shall not be inserted in the telephone line connection. If a repeater is required the circuit is established by the marker which extends through the incoming sender, the link switches of Fig. 8, the incoming intertoll trunk, thence over the cross-bar switches of Fig. 2 for operating the repeater relay in the outgoing trunk. This repeater relay locks in preparation for the selection of a repeater circuit following the selection of an outgoing sender. The repeater selection is, therefore, under the automatic control of the marker and the signal for this repeater selection is given immediately following the selection of an idle outgoing trunk and the operation of the switches of Fig. 2 so that the marker may be released at the earliest moment. The voice amplifying repeaters which are inserted in the talking conductors of the outgoing trunk are disclosed in Fig. 14. This repeater circuit is arranged for a four-wire toll system having transmission over a two-wire channel through a unidirectional repeater such as 411 in one direction and over a second two-wire channel and a unidirectional repeater such as 412 in the opposite direction. These voice amplifying repeaters may be of any well-known type known in the art. Pad circuits are also shown in Fig. 14 for use as required with the repeaters according to the trunk with which they are associated. This repeater circuit will be more fully described in the detailed description.

The outgoing trunk, Fig. 3, energizes a circuit for establishing connection with an outgoing sender. This circuit energizes apparatus of Fig. 13 for connecting the outgoing trunk with a link control circuit, such as Figs. 17, 18, 19, 22, 23 and 24. In this instance the apparatus shown in Fig. 13 may be the same as actuated by the incoming trunk or it may be a different circuit. The control circuit, Figs. 17 to 19, Figs. 22 to 24, inclusive, may be the same as used by the incoming trunk or another link control circuit in this common group of control circuits. When the link control circuit is associated with the outgoing trunk a signal circuit is established which causes the link control circuit 2540 to test a plurality of outgoing senders such as senders 2518, 2520 and 2537 in order to find an idle outgoing sender. The outgoing senders tested are associated with a particular plurality of levels of the secondary link switches such as 2512, 2513 and 2514, the same as described for incoming senders. When an idle outgoing sender is found, the proper select magnets and hold magnets of the primary link switch 2511 and the secondary link switch 2512, 2513 or 2514 are operated. This associates an outgoing sender with the outgoing trunk of Fig. 3 and since the incoming trunk is connected to an incoming sender, circuits are completed at this time for connecting the incoming sender to the outgoing sender. The circuits of the incoming sender are connected through one level and one horizontal of a secondary switch and one level and one horizontal of the primary switch shown in Fig. 8 through the circuit paths of the incoming trunk circuits of Figs. 1 and 7 over the cross-bar switches of Fig. 2, the outgoing trunk of Fig. 3, thence through a different level and horizontal of a primary and a secondary switch, Fig. 8, to the outgoing sender. A signal is given from the outgoing sender to the incoming sender that the connection has been completed and the numerical pulses are immediately transmitted for setting the registers of the outgoing sender. This ordinarily completes the services of the incoming sender and at this time this sender may be released, which releases the hold magnets of the switches, Fig. 8, which

associated the incoming sender with the incoming intertoll trunk.

The intertoll trunks are arranged for successive operations for the selection of outgoing sender and repeater when required. After the pulses have been transmitted, a relay in the outgoing trunk circuit is released which establishes a second circuit over the outgoing trunk start lead for again obtaining the services of a link and link control circuit for selecting an idle repeater and associating this repeater with the line connection. The start circuit energizes the apparatus such as shown in Fig. 13, as previously described, which causes the selection of an idle control circuit, Figs. 17 to 19, 22 to 24, inclusive. A signal is transmitted from the outgoing trunk to this control circuit which arranges the control circuit for the selection of a repeater. The difference in class signals is established by successive rearrangement of the apparatus in the outgoing trunk for successively causing the selection of the outgoing sender and later a repeater. A plurality of repeater circuits are tested in an effort to find an idle repeater in the same manner as previously described. The repeaters are connected to particular levels on secondary switches, Fig. 8, which are the same repeaters tested by the control circuit. When an idle repeater is found a secondary level and vertical are connected together by the operation of a select magnet and a hold magnet. The select magnets for the primary switch, Fig. 8, and the secondary switch, Fig. 8, are separately operated but the hold magnets are operated over a common circuit. When an idle repeater has been found apparatus in the outgoing trunk circuit is operated for extending the talking conductors through this idle repeater. After the insertion of this repeater the line connection is completed and conversation may be started.

Detailed description

The following detailed description describes the interconnection of a toll line or trunk incoming from a distant toll office **100** over the two channels of a four-wire system through an outgoing trunk extending to the telephone office **330** which is reached over a trunk long enough to require a voice amplifying repeater in each channel for talking transmission. As previously stated, various types of intertoll trunks are used with the circuit disclosed, incoming and outgoing from and to other toll offices and offices within the area of the toll office disclosed. These intertoll trunks are connected with toll offices using ring-down equipment, dial pulsing equipment or manually operable equipment. The arrangement of the circuit and apparatus disclosed is for receiving a call from a dial pulsing office in which a signal is originally transmitted from a distant office and thereafter pulses are transmitted for setting the registers in the equipment disclosed, which operates an automatic toll switching office in accordance with the character and number of the pulses transmitted. The intertoll trunks, such, for example, as shown in Figs. 1 and 7 or Fig. 3, may be one-way trunks or two-way trunks. A one-way incoming trunk cannot be used as an outgoing trunk. A two-way trunk, such as shown in Figs. 1 and 7, may be used either as an incoming or an outgoing trunk. In this disclosure the trunk circuit (Figs. 1 and 7) is used as an incoming trunk actuated in response to an incoming call from the distant toll office **100** but the features of the two-way trunk are incorporated to disclose its association with the link switches of Fig. 8 to demonstrate its adaptability in selecting either an incoming sender, an outgoing sender, or a repeater through the same switching structure.

A call from the distant toll office **100** is initiated by the transmission of a signal to the incoming intertoll trunk circuit which enters the office on line conductor **113** and is extended over lead **120** for the operation of relays **704** and **719**. This signal may enter the office through a simplex signaling circuit (not shown) for placing a ground on lead **120** which extends through contact **9** of relay **722**, contact **7** of relay **716**, contact **1** of relay **709**, thence through the winding of relay **719** to battery. A branch of this circuit extends through contact **3** of relay **709**, winding of relay **704** to battery, operating both relays **704** and **719**. The operation of relay **704** disconnects ground from lead **121** and connects battery through lamp **702** to this lead. This may extend through a simplex signaling circuit (not shown) over the line as a signal over lead **112** to the office **100** for supervision and to prevent the apparatus in the office **100** from transmitting dialing impulses until an incoming sender has been selected and in readiness to receive the dialing impulses. Relay **719** through its contact **7** connects class lead **755** to class lead **753** to prepare a class indication for governing the operation of the link circuit, to be described later, so that this link circuit will select an incoming sender. Relay **719** also operates relays **706** and **107**. The circuit for relay **706** is obvious and need not be described. The circuit for relay **107** is also obvious since it extends directly to ground on contact **6** of relay **706**. Relay **716** is operated through contact **3** of relay **719**. The above relays are operated to open the short-circuiting paths for relay **104** extending to the talking conductors which later allow the marker to control circuits over these leads. Relay **107** also supplies ground from contact **5** to contact **12** of the splitting relay **104** to lead **204** for later use in holding and completing switching connections, and connects battery through the winding of relay **104** to lead **125** of the link circuit. Relay **719** is now connected directly to lead **120**, extending this signaling circuit path independent of relays **716** and **709** which are later operated. This circuit may be traced from battery through the winding of relay **719**, contact **3** of relay **706**, contact **9** of relay **722**, lead **720** to ground in the distant office over the signaling path. Relay **716** when operated establishes a locking circuit for itself through its contact **4**. The release of this relay is now under the control of the ionic tube **712** and the ionic tube timing circuit. Relay **716** also establishes locking circuits for relays **706** and **107** and supplies ground over lead **750** for later use by the marker and to establish this circuit as busy to other markers. This circuit may be traced from ground associated with contact **6** of relay **722**, contact **5** of relay **716**, contact **4** of relay **709**, contact **2** of relay **710**, thence over relay **750** acting as a busy ground to all markers. This is required in a trunk of this character since markers may at any time test this trunk for use as an outgoing trunk. The above operations necessarily precede the energization of a link circuit which now takes place from ground on contact **6** of relay **716** extending through contact **5** of relay **719** over lead **751**, contact **2** of relay **1310**, winding of start relay **1311** to battery.

The operation of relay 1311 establishes circuits for energizing a connector unit for controlling this connection in an effort to associate the incoming trunk with a link control circuit shown in Figs. 17, 18, 19, 22, 23 and 24, inclusive.

The control circuit shown in the latter figures is used for the selection and operation of a combination of link switches shown in Fig. 8 for connecting an incoming trunk with an incoming sender or when this same trunk is used as a two-way trunk, the switches are selected for connecting the trunk with an outgoing sender or a repeater. The control circuit may be used successively by a trunk circuit acting in the capacity of an incoming trunk and later, if idle, by the same trunk acting in the capacity of an outgoing trunk circuit. This makes possible the use of a common group of such control circuits for use with any type of circuit entering the office or any type of circuit used for establishing connections to an outgoing office. The cross-bar switches of the link disclosed in Fig. 8 are representative of the switches used for making various connections between trunks and senders or repeater circuits. The switching contacts 800 to 806, inclusive, comprise a portion of a primary link switch. Each switch of this character ordinarily has ten separate levels, two of which are shown, and a large plurality of verticals, three of which are shown. In this instance, the incoming trunk is connected to the lower vertical and the switch is arranged to connect this incoming trunk to a secondary switch by the operation of select magnet 807 and the hold magnet 810. In practice this incoming trunk may be associated with various secondary switches through a number of different verticals on this switch, making a large plurality of choices of apparatus for extending a call from the incoming trunk to the apparatus of the switching office. Other verticals may be operated by the hold magnets for associating this trunk with an outgoing sender or repeater if the trunk is used as an outgoing trunk. This arrangement of associating the apparatus of the two-way trunk with the apparatus of the telephone office will be clearly understood by a later explanation of the association of the connections made between the outgoing trunk (Fig. 3) through this switch to an outgoing sender and a repeater. The secondary verticals 820, 823 and 826 may be on a single cross-bar switch or on separate cross-bar switches, depending upon the choice of connection which is best suited for use. The secondary switch points shown may therefore be considered as one level of any vertical on a single cross-bar switch or one level of any vertical on any of a large plurality of cross-bar switches.

The multicontact relay 1314, the multicontact relay 1206 and the relays shown in the upper portion of Fig. 12 constitute an arrangement for giving an incoming trunk a plurality of choices in obtaining the services of a link control circuit which may be associated therewith by the operation of the multicontact relay 1207 which must test idle before seizure. There are a plurality of relays 1314 for each group of incoming trunks. This plurality of relays are connected to a plurality of relays 1206 which are interconnected when strapped as shown. There are a plurality of relays 1207 for each connector extending between the contacts of relays 1314 and the contacts of relay 1207. Each control circuit has a representative relay in each connector so that any one of the control circuits may be associated when idle with any of the connectors between the trunk groups and the control circuits.

The operation of start relay 1311 by a circuit established in the incoming trunk previously described, initiates the selection of an idle control circuit. A circuit is first established from battery through resistance 1313, contact 1 of relay 1311, contact 3 of relay 1315, contact of relay 1316, winding of relay 1201, to ground through contact 1 of relay 1202. There is a chain of such relays used to prevent the actuation of a connector by more than one trunk. The energization of relay 1201 seizes an idle connector and makes this connector busy to other trunk circuits until such time as it has finished its services in selecting an idle cross-bar switch connection. A circuit is also established from ground through contact 2 of relay 1311 for use when the multicontact relays 1206 and 1207 have been operated. A third circuit is established through contact 3 for energizing timing relay 1317 which associates the timing interrupter with a timing circuit 1340 in order to release a control circuit in trouble. This is diagrammatically shown and may operate in the same manner as many timing circuits. The energization of relay 1201 establishes a circuit for relay 1205 from ground through its winding, contact 3 of relay 1201, resistance 1204 to battery. Relay 1205 establishes an obvious circuit through its contact 1 and contact 2 for energizing the magnet 1206 which controls the armatures of the multicontact relay. The energization of relay 1206 establishes a circuit through its contact 1 for relay 1208 which establishes circuits through the apparatus shown in the left portion of Fig. 12 for associating the connector with an idle control circuit. For this purpose a circuit is first established from the relay 1201 which is assumed to be operated in the chain control circuit. This circuit may be traced from battery through resistance 1203, contact 4 of relay 1201 and through the winding of relays 1209, 1210 or 1211, whichever relay is associated with an idle control circuit. It will be seen that this circuit is extended through contact 1 of relays 1212, 1213 or 1214, which represent three of a large plurality of relays in a chain equivalent to the number of control circuits used. If relay 1212 is normal, the circuit extends through the winding of relay 1209, contact 2 of relay 1210 to ground on contact 2 of relay 1211. Relay 1212 when operated shows that the control circuit associated therewith has been taken for use through another connector and the circuit from battery on contact 4 of relay 1201 then extends through contact 1 of relay 1212, contact 1 of relay 1213 normal, winding of relay 1210 to ground on contact 2 of relay 1211 to obtain the services of another control circuit. In this instance it may be assumed that relay 1212 is normal and the circuit extended through the winding of relay 1209 to ground, operating relay 1209. This establishes an obvious circuit for the operation of the multicontact relay 1207 for associating a control circuit with the apparatus of the incoming trunk. The energization of relay 1207 establishes a circuit for the make-busy relay 1701 of the control circuit from battery through its winding, lead 1221, contact 4 of relay 1207 to ground. The energization of the make-busy relay 1701 associates ground with a plurality of conductors equivalent to the number of relays used in the chain circuit of the upper left portion of Fig. 12. These ground circuits extend through the upper windings of all of the relays 1212, 1213 and 1214 which

all operate with the exception of the one associated with the control circuit in use. The operation of relay 1212 associated with the control circuit in use is prevented by a shunt circuit extending from contact 1 of relay 1207 to a point connecting resistance 1216 to the winding of relay 1212, thus shunting the battery connection from the winding of this relay and maintaining it normal. The control circuit taken for use is therefore not available to other connectors. It may thus be assumed that the control circuit (Figs. 17, 18, 19, 22, 23 and 24) is prepared to operate for testing cross-bar switches to make the connection between the incoming trunk and an incoming sender.

The organization of the link switching arrangement and the control circuits is such that a choice is made from a large number of senders or repeaters associated with the apparatus of the control circuit. In some instances a number of idle senders or repeaters are simultaneously associated with the control circuit and only one of these is selected. This slection is made by signaling the control circuit which level of a particular secondary link switch is connected to a preferred idle sender or repeater. Fundamentally, the arrangement is as follows: A class signal is transmitted to the control circuit for the selection of an incoming sender, an outgoing sender or repeater, which operates a class relay combination for directing the control circuit. In the control circuit relays 2201, 2203 and 2205 are each associated with a different switch combination comprising a vertical on a primary switch and a vertical on a secondary switch, each having a plurality of levels. A plurality of verticals on the primary switch are connected to verticals on a plurality of secondary link switches. The verticals of the secondary link switches have associated therewith a plurality of levels each of which is connected to a different sender or repeater. The hold magnet of a vertical on a primary link switch and the hold magnet of a vertical on a secondary link switch are in multiple so that they may be operated simultaneously. Each relay, such as 2201, has as many contacts, such as 3 and 4, as there are levels on a secondary link switch connected to senders or repeaters to be tested. There are as many relays, such as 2202, as there are secondary link switch levels in a switching combination connected to senders or repeaters to be tested. This plurality of relays, such as 2202, are operable through the plurality of contacts on each relay, such as 2201. In view of the above, the operation of any particular relay 2202, 2204 or 2206, of which there are a large plurality, indicates the association of the control circuit with an idle sender on a particular level of a secondary link switch of a particular switching combination. Relays 1805, 1809 and 1810 are operated according to the switch level on which the idle sender or repeater is found. There are, consequently, as many of these relays as there are levels on any secondary link switch. Relays 1320, 1321, 3122, 1323 and 1324 also are operated according to the level on which the idle sender or repeater is found. There are as many of these relays as there are levels on any secondary switch. Relays 1330, 1331 and 1332 are operated according to a class indication transmitted to the link control circuit. The contacts of relay 1330 are connected to a large plurality of outgoing senders, contacts of relay 1331 are connected to a large plurality of incoming senders and the contacts of relay 1332 are connected to a large plurality of repeaters. It will be noted that there is a direct circuit between the link control circuit and the senders or repeaters through the contacts of these relays which is for testing purposes to determine whether the senders or repeaters are idle or busy. All of the idle senders or repeaters which are found may be connected to an equivalent number of relays 2202, 2204 and 2206 and operate all such relays. There is a chain circuit running through the latter relays so that a particular idle sender or repeater may be selected. This chain circuit arrangement may be different in each control circuit having the same senders or repeaters connected thereto in order that different senders or repeaters are constantly selected for use. The circuit arrangement is such that if an idle sender is indicated to the control circuit and instantaneously this idle sender is seized by another control circuit, a busy indication is immediately transmitted to the link control circuit so that the next idle sender connected to a relay in the chain circuit may be selected. After a particular sender or repeater is indicated to the control circuit as being idle, one of the relays 1320 to 1324 is operated corresponding to the level on which the idle sender or repeater is found and a secondary test of this sender or repeater is made and, if satisfactory, the sender or repeater is seized for use. The combination of circuits and equipment as described for the control circuit is such that signals have been transmitted indicating the level of a particular secondary switch to which this sender is connected and a circuit is immediately established to operate the select magnets of the primary and secondary switches corresponding to these levels and also the circuit is established for energizing the hold magnet of the verticals in the primary switch and the vertical in the secondary switch corresponding to this switch combination. In this manner a particular idle sender or repeater is chosen from a large group and connected to an incoming or an outgoing trunk circuit.

Relay 1207 in operating connects a large number of leads between the link control circuit and the other apparatus of the office and ground is connected over three leads 1220, 1221 and 1222. An obvious circuit is established over lead 1220 for energizing relay 1902. The circuit over lead 1221 operates relay 1701. The circuit established over lead 1222 establishes a locking circuit for relay 1703 which is used after this relay has been operated as explained later. The operation of relay 1701 completes a circuit for the operation of relays 1213 and 1214 for marking this control circuit busy to all other connectors as previously explained. The operation of relay 1902 establishes an obvious circuit for relay 2404 and an operating circuit for relay 1709 from battery through resistance 1912, contact 4 of relay 1902, contact 5 of relay 1903, contact 3 of relay 1809, contact 4 of relay 1910, winding of relay 1709 to ground on the contact of relay 1801. Relay 1709 locks to ground on its contact 3. This control circuit has now been actuated for controlling the selection of available facilities for establishing a connection between the calling incoming toll trunk circuit, Figs. 1 and 7, and an unavailable incoming sender under the control of the incoming trunk circuit.

A group of links and link control circuits serve a plurality of groups of trunks which may be known as subgroups of trunks within the larger group. When a particular trunk within a sub-

group of trunks actuates a link circuit, it is necessary to identify the subgroup with which it is associated. The link control circuit is therefore provided with a plurality of relays 2214 to 2212 equivalent to the number of trunk subgroups served through the contacts of the associated connector relays. In this instance it may be assumed that a circuit is established for the group relay 2214 to show the subgroup of trunks requiring service. This circuit may be traced from battery through the winding of relay 2214, contact 1 of relay 2305, lead 1249, contact of the multicontact relay 1207 and corresponding contact 29 of relay 1206 to ground on contact 2 of relay 1311. Relay 2214 in operating locks through contact 2 to lead 1249. It should be noted that the locking circuit does not extend through the contact of relay 2305. A circuit is now established for relay 2213 extending from battery through its winding, contact 1 of relay 2214 to the locking ground for relay 2214. Relay 2213 in operating establishes an obvious circuit for relay 2305 which locks to ground on relay 2214. The operation of relay 2305 opens the operating circuit for relays 2214 to 2212 and relay 2214 remains operated over its holding circuit. A circuit is thus established for the multicontact relay 1314 which may be traced from ground through its winding, contact 27 of multicontact relay 2206 and a corresponding contact on relay 2207, thence over lead 1247 through contact 4 of relay 2214, contact 1 of relay 2213, resistance 2216, contact 2 of relay 1704, contact 4 of relay 2305 to battery. There are a plurality of trunks in each subgroup served by the same start relay 1311. These are represented in the control circuit by relays 1706 to 1710. It will be remembered that a start ground was placed on the conductor 751 of the incoming trunk by the operation of start relay 106. This ground originally operated start relay 1311 but at the same time extends ground through all of the contacts in multiple on relay 1310 associated with the subgroup. These leads extend through an equivalent number of contacts on relay 1314 represented by the contacts 8 and 9 of this relay. The circuit also extends through contact 15 of relay 1314 to energize the relay 1705 in the control circuit. The trunk subgroup relays 1706 to 1710 representing all the trunks in the group are also energized. Relay 1705 is energized over lead 1236 which extends through the contact of the multicontact relays 1207 and 1206 to ground in the incoming trunk circuit through contact 15 of relay 1314. The circuits for relays 1706 to 1710 are traced from battery through their windings, contacts 3 and 4 of relay 1711, leads 1229 and 1230 extending through the contacts of multicontact relays 1207 and 1206 to contacts 7 and 8 of relay 1314, contacts 1 and 2 of relay 1310 to ground on the start conductor 751. All of the relays 1706 to 1710 now operate and are locked over their associated operating circuits independent of the contacts on relay 1711. Relay 1703 now operates from battery through its winding over a series circuit through contact 1 of relays 1710 to 1706, contact of relay 1705, contact 5 of relay 1710 to ground over lead 1229. The operation of relay 1703 establishes a circuit for relays 1702 and 1310 from battery and contact 2 of relay 1703, winding of relay 1702, lead 1223, contacts of relays 1207 and 1206, contact 2 of relay 1314, winding of relay 1310 to ground. The operation of relay 1310 individualizing the incoming trunk ground circuit so that only one relay of the series of relays 1706 to 1710 remains operated, this ground being extended from lead 751 to contact 8 of relay 1314, lead 1229 which locks relay 1710 in position. All of the other relays release since their locking circuits were opened. It is therefore established that the trunk associated with relay 1710 is the calling incoming trunk with which a sender should be associated. This establishes the level of the primary switch to which the incoming trunk is connected. The operation of relay 1310 also opens the operating circuit for relay 1705 which now releases and establishes a circuit for relay 1707. This circuit may be traced from battery through its winding, contact 4 of relay 1703, contact of relay 1705 to ground on the locking circuit of relay 1710. Relay 1707 establishes an obvious operating circuit for relay 1711 through its contact 2 and also partly establishes an operating circuit for relay 2304 which will be completed later.

Since the control circuit serves to select either an incoming sender, an outgoing sender or a repeater, it is necessary for a class signal to be transmitted from the trunk circuit to indicate what character of equipment should be selected. In the description of the incoming trunk when the call was originated, the operation of relay 719 established the class of circuit to be connected with this incoming trunk by associating lead 753 with lead 755 which now operates a class relay in the control circuit which in this instance is class relay 1806. The circuit for this relay may be traced from battery through its winding over lead 1234 through the contacts of multicontact relays 1207 and 1206 to contact 13 of relay 1314, thence over lead 753 through the contacts of relay 719 returning over lead 755 through contact 10 of relay 1314, contacts of the multicontact relays 1206 and 1207 to lead 1231 which extends through contact 7 of relay 1710, contact 2 of relay 1711, contact 2 of relay 2303 to ground. This operates relay 1806 and indicates to the control circuit that an incoming sender shall be connected with the incoming trunk. In the circuit traced for the class lead it should be noted that each trunk has an individual class lead carried through the contacts of the windings 1706 to 1710 to the operating circuit for the class relay. These individual leads from the trunk circuit may be used simultaneously by different trunks if they are associated with different control circuits in the common group of control circuits. Other class relays in the control circuit will be explained later, for example, relay 1804 is another class relay which when operated by an outgoing trunk circuit indicates that an outgoing sender shall be associated therewith. Relay 1210 is also a class relay and when operated indicates that a repeater shall be associated with the trunk circuit which may be a two-way trunk or a one-way trunk extending to a called station. A large plurality of leads are now connected between the control circuit and an equivalent plurality of incoming senders in order that these senders may be tested to find an idle sender for association with the incoming trunk. This connection is made by the operation of relay 1331 which has the test conductors of this large plurality of senders connected to its contact and extends these test leads from the senders to the control circuit. The circuit for operating this relay may be traced from ground through the winding of relay 1331, contact 17 of relay 1314, contacts of the multicontact relays 1206 and 1207 to conductor 1238 which extends through contact 5 of relay

1709, contact 2 of class relay 2210, which is normal, contact 2 of class relay 1806 which is operated, contact 1 of class relay 1804 which is normal, and thence through contact 4 of relay 2304 to battery on contact 10 of relay 2402.

As previously stated, a large number of senders are simultaneously associated with the link control circuit for test. The operating circuits of these senders are connected to a plurality of switch levels on a plurality of secondary link switches. Each secondary link switch is associated with a different vertical of the same primary link switch connected with the calling incoming trunk. This makes available a large number of senders for an incoming call so that if a plurality of the senders are busy one may be found which is idle. Usually more than one of the available senders are idle but the first idle one in the choice is seized. The combination of secondary and primary switches in links is such that the hold magnets controlling verticals on the primary switch are connected to hold magnets of the vertical on a secondary switch and all of the incoming senders connected to the levels of these secondary switches are available for connection to the incoming trunk, if idle. The incoming senders to be tested may be connected to any number of the levels in these secondary verticals and may be connected to all such levels. Certain verticals of the secondary switch may have incoming senders associated with several levels, outgoing senders associated with other levels, and repeaters associated with other levels. The above-mentioned verticals and levels of the switches are available to other link control circuits and, therefore, when a test is made to obtain the services of an idle sender, a check must be made to ascertain which links are available for tests, that is, which links have not been taken for use by other control circuits. When a link has been taken for use by another control circuit, a ground would have been applied to the winding of the hold magnet to operate the hold magnet of the primary and secondary switches. The leads from all of the hold magnets are carried from the link switches through contacts, such as 3, 4 and 5 of relay 1314 and similar contacts on the multicontact relays 1206 and 1207 to conductors, such as 1224, 1225 and 1226. In each case there are as many such leads as there are available links for use in selecting senders or repeaters and these leads from all such hold magnets are carried through the contacts of relay 2306 to the left windings of relays, such as 2201, 2203 and 2205. If any verticals have ground associated with their hold magnets, a circuit for such busy links establishes an operating path for the aforementioned relays 2201, 2203 and 2205 to prevent a test of the senders associated with busy secondary switches. The operation of any of these relays opens the operating circuit for relays, such as 2202, 2204 and 2206. There are as many of the latter relays as there are senders available, but only those associated with unoperated relays 2201, 2203 and 2205 are tested. Assuming that relays 2201, 2203 and 2205 remained normal, all relays, such as 2202, 2204 and 2206, are associated with an operating path extending over the test circuit to incoming senders. One such circuit may be traced from battery through the left winding of relay 2206, contact of relay 2205, conductor 1260, thence through the contact of relay 1207 and associated contact 40 of relay 1206, contact 2 of relay 1331, to the busy test lead of an incoming sender. It will be remembered that relay 1331 was operated over a circuit established by class relay 1806 of the control circuit, indicating that incoming senders are the ones to be tested. If all of the rleays 2201, 2203, 2205 and other similar relays remain normal, a large plurality of senders are tested. If, however, all relays, such as 2201, 2203 and 2205, are operated, indicating that all available paths are busy, a ground is connected from contact 1 of relay 1903 over a chain circuit through the contacts 2 for operating a timing circuit under the control of relays 1906 and 1907. This ground extends through contact 2 of relay 2205 to contact 6 of relay 2406, contact 1 of relay 2402, contact 5 of relay 2307 to the armature of interrupter 1911. The operation of relays 1906 and 1907 will ultimately establish a circuit for releasing the control circuit in a manner to be described later if an idle link does not become available in a given period of time. Circuits for relays 2204 and 2202 and similar relays are established to paths over circuits as traced for relay 2206 using conductor 1261 or 1262 or similar conductors extending through other contacts of relay 1331 to incoming senders. Since only one incoming sender is disclosed in this drawing, one test lead is carried through contact 2 of relay 1331 to this sender. This incoming sender is shown on Sheets 15, 16, 18, 19 and 20. The lead from contact 2 of relay 1331 is connected to contact 1 of relay 918. When this sender is in use, relay 918 is operated and, therefore, a busy sender is indicated by an open circuit and an idle sender is indicated by ground associated with the lead connected to the contacts of relay 1331. If there are a number of idle senders associated through the contacts of relay 1331, a circuit is established for an equivalent number of relays 2202, 2204, 2206. The circuit for relay 2206 was traced through the contact of relay 1331 and from there is extended to ground on contact 1 of relay 918.

Since there may be a number of idle circuits available, it is now necessary to select one such idle sender. The operation of any of the relays 2202, 2204 or 2206 establishes a circuit from ground through contact 3, winding of relay 2307 to battery. The operation of this relay establishes a circuit for relay 2406 from battery through its winding, contact 10 of relay 2402 to ground through contact 4 of relay 2307. The operation of relay 2307 also establishes a circuit from ground through its contact 2, winding of relay 1802 to battery which operates the latter relay. A circuit is also established through contact 1 of relay 2307 for operating relay 2207.

When an idle incoming sender has been found, relay 2406 is operated as previously described which establishes circuits for operating all of the relays 2201, 2203 and 2205, including other relays of this character. This establishes a circuit for relay 2211 which may be traced from battery through its winding, contact 6 of relay 2406, contacts 2 of relays 2205, 2203 and 2201 to ground on contact 1 of relay 1903. The operation of relay 2211 establishes a circuit for a relay corresponding to the level of the secondary link switch connected to the idle sender. In this case it may be assumed that this is the zero level and a circuit is established for relay 1805 which may be traced from battery through its winding, contact 1 of relay 1901, contact 1 of relay 2206 to ground on contact 2 of relay 2211. Relay 2209 was operated from battery associated with contact 2 of relay 1709 and a circuit is now established for

making a double test of the sender which has been found idle. For this purpose a circuit is established for relay 1320 which may be traced from ground through its winding, contact 37 of relay 1206 and the corresponding contact of relay 1207, over lead 1257, contact 1 of relay 2209, contact 3 of relay 1805, contact 5 of relay 1805, contact 1 of relay 1809, thence through contacts of other similar relays corresponding to other secondary switch levels through contact 1 of relay 1810 to battery. The operation of relay 1320 connects a testing circuit in the link control circuit with the idle incoming sender and also connects ground to a test circuit relay 1901 in the control circuit. The circuit for relay 1901 may be traced from ground on contact 4 of relay 1320, contact 20 of relay 1206 and a similar contact on relay 1207, lead 1241, winding of relay 1901 to battery. The control test circuit is associated with relay 918 in the sender, extending from the control circuit to the armature and associated contacts on this relay. With relay 918 normal, indicating the incoming sender to be idle, battery is associated with the test lead. When the incoming sender is busy ground is associated with this lead since relay 918 is operated. This lead extends through contact 3 of relay 1320, contact 34 of relay 1206 and a similar contact of relay 1207 to lead 1254 in the control circuit, thence through contact 6 of relay 2206, contact 1 of relay 2211, winding of test relay 2403, tube 2410 to battery through contact 4 of relay 1901. The winding of test relay 2405 is also connected in this tube testing circuit. This may be traced from battery through contact 4 of relay 2402, winding of relay 2405, contact 7 of relay 2406 to the tube 2410. At this point the test relays of the tube testing circuit in Fig. 24 are connected to the sender for making a test. The sender lead presents battery voltage of a particular value to the tube of such character that if no other control circuit is attempting to select this sender, the plate resistance of tube 2410 will instantly drop, causing the operation of relays 2403 and 2405. If at this time another control circuit is attempting to seize this sender or has seized the sender, relay 2405 will not operate. Assuming that this relay operates, a circuit is established for relay 2402 from battery through its winding, contact of relay 2405 to ground. A circuit is also closed for locking relay 2206 which may be traced from battery through the right winding of relay 2206, contact 5 of relay 2211 to ground through the contact of relay 2405. Upon the operation of relay 2402 this locking ground is substituted through contact 5 of relay 2402 to contact 4 of relay 2406 and ground connected thereto. If relay 2403 of the testing circuit operates and relay 2405 does not operate, a circuit is not established for relay 2402 but a circuit is established for the timing interrupter extending from ground on contact 3 of relay 2402, contact of relay 2403 to the armature of interrupter 1911. This establishes a circuit for operating relays 1906 and 1907 which after a period of time operates an alarm circuit. However, under normal circumstances a different incoming sender would be taken for test. When two control circuits attempt to seize the same sender, the tube circuits in both control circuits do not function until one of the circuits has seized the sender. When this sender is seized, a ground is removed from the lead extending to one of the relays 2202, 2204 or 2206 and in this instance will be removed from relay 2206 which would release. If there are other idle senders associated with the control circuit at this time, the next sender in the order of the chain through relays 2206, 2204, 2202 would be selected and the sender tested. The purpose in operating the timing circuit from the contact of relay 2203 is to transfer the facilities of the control circuit for a second choice when the test of one control circuit conflicts with another. The operation of the vacuum tube 2410 is instantaneous and such irregularities are very rare.

Assuming that the test originally made was successful, the incoming sender disclosed herein is made busy by the operation of the vacuum tube 2410 and is seized through the switch contacts as follows. The operation of relay 2402 establishes circuits for select magnets associated with the level connected to this incoming sender. Relay 2402 establishes a circuit for relay 1803, which circuit may be traced from battery through its winding, contact 2 of relay 1802, contact 4 of relay 2402, contact 3 of relay 2303 to ground. Relay 2402 also opens the circuit for class relay at its contact 10, causing the release of relay 1331 which disconnects the large group of senders from the control circuit. This opens all of the circuits for relays 2202, 2204, 2206, which constitutes a number of relays equivalent to the number of senders associated with the control circuit. Relay 2206 remains operated since it is locked locally in the control circuit, as previously described. A circuit is established for relay 2306 from battery through its winding, contact 8 of relay 2402 to ground on contact 3 of relay 1903. A circuit is established for relay 1708 from ground through its winding, contact 1 of relay 1709, contact 1 of relay 2207, contact 6 of relay 2402 to battery on contact 7 of relay 1903. The circuit for relay 2403 is also opened at contact 3 of relay 2402 in order to make relay 2403 ineffective. Relay 1803, in operating, establishes a holding circuit for the trunk relay 1710 so that it will not release when its operating circuit is opened. Relay 1803 establishes a circuit for the operation of the primary select magnet 807 for connecting the incoming trunk circuit to the proper secondary link switch level. This circuit may be traced from ground through the select magnet 807, contact 23 of relay 1206 and a corresponding contact of relay 1207, thence over conductor 1243 to contact 3 of relay 1802, contact 1 of relay 1803, contact 2 of relay 1710 to battery, through resistance 1730. A circuit is also established for the operation of the secondary switch select magnet associated with the level of the secondary switch which is connected to the incoming sender chosen. In this case it may be assumed as select magnet 821 which is energized from ground through its winding, contact 31 of relay 1206 and the corresponding contact of relay 1207, thence over lead 1251, contact 3 of relay 2207, contact 3 of relay 1708, contact 7 of relay 1805 to battery on contact 5 of relay 1901. With the primary select magnet operated a circuit is established for relay 2302. This may be traced from ground on contact of select magnet 807, contact 25 of relay 1206 and a similar contact of relay 1207, thence over conductor 1245 to the winding 2302 to battery. The operation of the secondary select magnet establishes a circuit for relay 2301, traced from battery through its winding over lead 1246, contact of relay 1207, contact 26 of relay 1206 to ground through the contact of select magnet 821. With relays 2301 and 2302 operated, a circuit is established for the hold magnets of the link switch combination

selected. This circuit may be traced from battery through the winding of hold magnet 810 and the winding of hold magnet 822 in parallel through contact 3 of relay 1314, contact 3 of relay 1206 and the corresponding contact of relay 1207, over lead 1224, contact 3 of relay 2306, which is now operated, contact 2 of relay 2206, contact 6 of relay 2211, contact 2 of relay 2301, contact 1 of relay 2302 to ground on contact 1 of relay 2303. The operation of the select magnets and the hold magnets closes the cross-point of primary switch 806 and the cross-points of secondary switch 820 for connecting the incoming trunk with the selected incoming sender. This establishes a circuit for relay 2304 in the control circuit and relay 918 in the incoming sender.

The ground applied to the windings of the hold magnets for their operation now extends through contact 3 of secondary switch 820 over lead 842 through the winding of sender relay 918 to battery operating the latter relay. This ground also extends through contact 3 of primary switch 806, contact 6 of relay 1314, contact 6 of relay 1206 and corresponding contact of relay 1207, thence over lead 1227 through contact 6 of relay 1710, contact 1 of relay 1707, winding of relay 2304 to battery, operating the latter relay. A circuit is then established for relay 2303 from battery through its winding, contact 2 of relay 2402, contact 1 of relay 2301, contact 2 of relay 2302 to ground and contact 2 of relay 2304. A locking circuit is established for relay 2303 traced from battery through its winding contact 2 of relay 2402, contact 3 of relay 2303 to ground. The operation of relay 2303 releases relays 1806 and 1803 which opens the operating circuit for the primary select magnet 807 which disassociates ground from the select magnet contact and causes the release of relays 2302 and 1710. Referring to the incoming sender the operation of relay 918 disconnects ground from contact 1 which indicates to other control circuits that the sender is busy. Contact 4 of relay 918 disconnects battery from the armature and connects ground to the armature which extends over the test circuit to the link control circuit. Relay 924 of this sender is now energized by a circuit extending through the incoming trunk, Figs. 1 and 7. This circuit may be traced from battery through the winding of the splitting relay 104, contact 7 of relay 107, contact 5 of relay 105, lead 125 through the contacts of the primary and secondary link switches to lead 845, contact 1 of relay 912 through the right and left windings of relay 924, contact 3 of relay 920 to ground on contact 2 of relay 918. Relay 924 operates in the circuit traced but the high resistance of this relay prevents the operation of relay 104. The operation of relay 924 establishes a circuit for relay 921 traced from battery through its winding, contact of relay 924 to ground and contact 1 of relay 428. The operation of relay 921 establishes an obvious circuit for relay 922 and an obvious circuit for relay 920 which locks to ground on contact 2 of relay 918. The operation of relay 921 places ground on lead 842 for maintaining the hold magnets of the primary and secondary switches operated and also connects ground through its contact 2 to lead 851 for operating the incoming trunk relay 709. This circuit may be traced from ground on contact 2 of relay 921 through contacts 12 of the secondary and primary switches to lead 131, contact 4 of relay 105, winding of relay 709 to battery. The operation of relay 709 opens the link start circuit lead 751, causing the release of relay 1707 in link control circuit, which causes the release of relay 2304. Relay 918 of the sender, as stated, opened the test circuit, causing the release of relay 2405 which now establishes a circuit for the control circuit release relay 1903. The circuit for this release relay may be traced from battery through its winding, contact 1 of relay 2304, contact of relay 2401, contact of relay 2405 to ground. The operation of relay 1903 establishes a locking circuit for itself through the contacts of all relays which now remain operated and also causes the progressive release of these relays, which releases relay 1903 after the other relays have been released, preparing the link control circuit for seizure by another incoming trunk, outgoing trunk or repeater.

Incoming sender

The apparatus of the incoming sender which was operated according to the description in the preceding paragraph is that used for releasing the control circuit and starting the operation of the selected sender. The circuits and apparatus of the incoming sender are now operated in preparation for receiving code and numerical digits from the calling distant toll office. The operation of the primary link switch 806 and the secondary switch 820 connects leads 840, 841 and 843 to 851, inclusive, from the sender to leads 121 to 131 of the incoming trunk. Lead 842, as previously described, extends from the incoming sender to the hold magnets of the link switches and to the control circuit. One circuit is established at this time to energize relay 906. This circuit may be traced from ground on contact 5 of relay 107, through contact 12 of relay 104, contact 3 of relay 105 over lead 128, thence through contact 9 of the primary and secondary link switches, lead 848, contact 3 of relay 918, contact 2 of relay 1003, winding of relay 906 to battery. Relay 906 locks to ground on contact 1 of relay 920 and extends this ground over the circuit traced through leads 848 and 128 to conductor 204 for maintaining ground on this conductor whenever relay 104 is operated. The operation of relay 921, as previously described, establishes an obvious circuit for relay 913. The operation of relay 913 arranges the sender for receiving optional class information. Battery through contact 1 of relay 913 extends through the windings of relays 915, 910, 907, resistance 1002, contact 6 of relay 1000, lead 846 through contact 7 of the secondary and primary link switches, lead 126, contact 10 of relay 105, contact 6 of relay 104, contact 6 of relay 706, resistance 724 to ground. Battery may also be traced from contact 2 of relay 913, windings of relays 916, 911 and 908, resistance 1001, contact 1 of relay 1000, lead 847, contact 8 of the secondary and primary link switches, lead 127, contact 9 of relay 105, contact 4 of relay 104, contact 1 of relay 706, resistance 705 to ground. Relay 913 establishes a holding ground for relay 918 and the class information relays and connects ground to lead 851, which supplements the ground applied to this lead by relay 921 extending through the winding of relay 709, as previously described. Relay 1011 is operated from ground on the contact of relay 915 and relay 1010 is operated from ground on the contact of relay 916. Either of these relays may be operated over the circuits traced, depending upon the class of the incoming trunk used for the call, and, consequently, on the connection to contacts 1 and 6 of relay 706,

Either of these relays when operated establishes a locking circuit for itself to ground on contact 3 of relay 913. The operation of either one of these relays establishes the type of marker to be used for the connection, as will be described herein. The operation of either relay also establishes a circuit for relay 1009 traced from battery through its winding, contact 2 of relay 1010 or contact 2 of relay 1011 to ground of relay 915 or 916, depending upon the relay operated. The operation of relay 1009 causes the operation of relay 914 from battery through its winding to ground on contact 3 of relay 1009. Relay 914 now short-circuits the high resistance winding of relay 924. The short circuit extends from ground on contact 1 of relay 921, contact 1 of relay 914 to the mid-point between the two windings of relay 924. The opposite side of the left winding has ground associated therewith also through contact 1 of relay 921. This removes the high resistance path from the circuit previously traced through the winding of the incoming trunk relay 104 which now causes the operation of the latter relay. The operation of relay 104 opens the circuit for relays 915 and 916 which release. The release of relays 915 and 916 removes the shunt from the winding of relay 1000 which now operates in series with relay 1009. This circuit may be traced from ground on contact 5 of relay 913, winding of relay 1000, contact 2 of relay 1009, winding of relay 1009 to battery. The operation of relay 1000 connects the contacts of relays 915 and 916 to the contacts of steering relays 514, 516, 518, 522, 1110 and 1114. The operation of relay 1000 also closes a circuit for the operation of relays 514 and 515 in preparation for recording the incoming pulses from the distant office and disconnects leads 846 and 847 from relays 915 and 916 and the other pulsing relays in series therewith. The circuit for relays 514 and 515 may be traced from battery through the windings of both relays in series, contact 1 of relay 517, contact 2 of relay 923 to ground, and contact 3 of relay 1000. Relay 514 locks to ground over its operating circuit through its contact 2 connected directly to ground on relay 1000. Relay 514 establishes an operating circuit for relay 923 from battery through the winding of relay 923, contact 2 of relay 514 to ground on contact 3 of relay 1000. The operation of relay 923 establishes a circuit for relay 1004 from ground to contact 2 of relay 922, contact 1 of relay 923, winding of relay 1004, contact 2 of relay 1004, contact 4 of relay 903, contact 1 of relay 901, lead 841, thence through contact 2 of the secondary link switch and contact 2 of the primary link switch to lead 122 of the incoming trunk circuit, thence through contact 7 of relay 105, contact 4 of relay 706, contact 3 of relay 706, contact 9 of relay 722 to the ring conductor 113 extending from the distant office 100 and from contact 4 of relay 706 to battery through the winding of relay 719, thus establishing an operating circuit for relay 1004. Relay 1004 locks to battery on its contact 2 and connects pulsing relays 915, 910 and 907 to the tip lead 840 and pulsing relays 916, 911 and 907 through the ring lead 841. These leads extend through contacts 1 and 2 of the secondary and primary link switches to leads 121 and 122 of the incoming trunk circuit and thence to the tip and ring conductors to the distant office. Relay 1004 also opens the path from the tip and ring leads 840 and 841 through resistance 904 and condenser 905. On all classes of service a code pulse is transmitted and, therefore, on all classes of service relays 514 and 515 are operated as soon as the sender is seized. The circuit for these relays was previously traced.

The pulses are transmitted from the distant office 100 by impressing 48-volt battery or ground through either high or low resistances, which is transmitted to the sender over leads 840 and 841 for selectively operating relays 915, 910, 907, 916, 911 and 908. These relays operate the registers shown in Figs. 5 and 11, according to the following chart.

		Z 0	1	ABC 2	DEF 3	GHI 4	JKL 5	MNO 6	PRS 7	TUV 8	WXY 9	Start
Lead	"T"	L+	H+	L−	H−	L+	L+	H+	L−	H−	L+	H+
Lead	"R"					L−	H+	H+	H+	H+	H−	L−
Pulsing relays	915	X	X	X	X	X	X	X	X	X	X	X
	916					X	X	X	X	X	X	X
	910		X		X			X		X		X
	911						X	X	X	X	X	
	907			X	X				X	X		
	908					X					X	X
Register relays	1st		X		X			X		X		X
	2nd			X	X				X	X		
	3rd					X					X	X
	4th						X	X	X	X	X	

H+ indicates low resistance ground.
H− indicates low resistance 48 v. battery.
L+ indicates high resistance ground.
L− indicates high resistance 48 v. battery.
X indicates relay operated.

The A register relays comprise relays 502, 503, 504 and 505, relay 502 being designated in the chart as the first register relay and relay 505 as the fourth. The B register relays comprise relays 506, 507, 508 and 509 and the C register relays comprise relays 510, 511, 512 and 513. The foregoing A, B and C registers comprise the code registers of the sender. The numerical registers are shown in Fig. 11. Only two numerical registers are shown, the first numerical register comprising relays 1100, 1101, 1102 and 1103, and the last numerical register comprises relays 1104, 1105, 1106 and 1107. There may be as many numerical registers as required, the intermediate registers are the same as the first and last registers and therefore need not be shown. The steering relays for transferring the pulse leads from one register to another comprise the relays shown in the left portion of Figs. 5 and 11 connecting with the various register relays. Let it be assumed, for example, that pulses are transmitted from the distant office 100 for registering the code and number CH3–1379. The transmission of a pulse for operating register 2 is first transmitted to indicate the code letter C. This connects high resistance 48-volt battery to the tip lead 840 which causes the operation of relays 915 and 907. Relay 915 operates steering relay 516. Relay 517 does not operate at this time as it is short-cir-

cuited. Relay 907 operates the A register relay 503 which locks to off-normal ground on contact 2 of relay 922. When this impulse has terminated, relays 915 and 907 are released. Relay 915 removes the short circuit from relay 517 which operates in series with relay 516. The operation of relay 517 opens the locking circuit for relays 514 and 515 which release. Relay 517 when operated closes the leads from the contacts of relays 907, 910, 908 and 911 to B register relays 506 to 509, inclusive. The release of relay 514 closes the circuit from the contacts of relays 915 and 916 to the relay 518. The release of relay 515 opens the leads from contacts of relays 907, 910, 908 and 911 extending to the A register relays. A pulse is now transmitted for the letter H which is the same as for the numeral 4. This connects high resistance ground to the tip conductor 840 and high resistance 48-volt battery to the ring conductor 841. This causes the operation of relays 915, 916 and 903. The operation of relays 915 and 916 establishes a circuit for relay 518 and the operation of relay 918 operates B register relay 508 which locks to off-normal ground. Relay 518 operated prepares a path for operating relay 519 which operates when relays 915 and 907 release at the termination of the impulse. The transmission of impulses continues for operating the C code registers and numerical registers as described. The value of battery or ground impulse transmitted for these digits is apparent by reference to the above chart and need not be described therein.

After the transmission of the code and numerical impulses is completed the start impulse is transmitted over the tip conductor connecting high resistance 48-volt battery to the ring conductor which causes the operation of relays 915, 916, 910 and 911. It will be noted that relay 917 is permanently connected to the contacts of relays 910 and 908 so that relay 917 will respond whenever relays 908 and 910 operate. When relay 917 is operated a circuit is established for relay 909. Relay 909 locks to ground on contact 2 of relay 922. When the start relay impulse has ceased, relays 917 releases which establishes the circuit for the start relay 1006. The operation of relays 910 and 908 operate the start registers 1120 and 1121 which lock to ground on contact 2 of relay 922.

Upon the completion of impulse transmission from the distant office, a readjustment of the circuit and apparatus at the distant end takes place and polarized relays are connected across the tip and ring conductors of the distant office. The operation of relay 1006 operates relay 901. The operation of the latter relay connects battery through resistance 902 to the conductor 841 which extends over the trunk conductor to the distant office. The right winding of relay 1005 is also connected to conductor 840 extending over the trunk conductor to the distant office. This energizes polarized relays in the distant office but relay 1005 does not operate under this condition since it is marginal and will not operate in series with the polarized relays in the distant office. The polarized relays operate as an indication to the pulsing circuit in the distant office that the incoming sender has operated satisfactorily. When the polarized relays in the distant office operate they associate a direct ground with the sender on conductor 840 which operates relay 1005. Relay 903 now operates in series with the left winding of relay 1005 to ground on contact 4 of relay 1009. The operation of relay 903 causes the release of relay 901 which reconnects the terminal resistance and condensers 904 and 905 across the tip and ring conductors. This signals the distant office that the closing impulse was properly transmitted from the distant office to the incoming sender.

Marker

After the registers of the sender have been set a marker connector is actuated and an idle marker selected for finding an idle trunk and for setting the switches between the calling incoming trunk and the selected outgoing trunk. Apparatus in the marker is also operated for signaling the outgoing trunk whether a repeater is required in the telephone connection. Preparatory to selecting an idle marker connector, diagrammatically shown as 610, relay 522 is operated in the steering relay circuit after the third code register has been set. The circuit for relay 522 may be traced from battery through its winding contact 1 of relay 518, contact 1 of relay 516, contact 1 of relay 515, contact 2 or 5 of relay 1000 to ground on the contact of either relay 915 or 916. A circuit is thus established for relay 413 which may be traced from battery through the winding of relay 413, contact 2 of relay 522, contact 1 of relay 423, contact 2 of relay 419 to ground through contact 1 of relay 922. Relay 413 locks through the winding of relay 414, contact 3 of relay 415 to ground on contact 1 of relay 922. The operation of relay 413 releases relay 422 which was previously operated from ground on contact 1 of relay 922 and locks relay 413 through the winding of relay 414, contact 4 of relay 413 to ground on contact 1 of relay 922. Relay 415 is operated from battery through its winding, contact 2 of relay 417, contact 2 of relay 413 to ground on the contact of relay 422. Relay 413 also associated battery through its contact 1 and contact 1 of relay 416 to the winding of relay 411 which operates if the preferred connector is busy since ground is associated with the upper winding of relay 411 when a busy connector is encountered. Assuming that relay 411 remains normal, a circuit is established for starting the energization of the marker connector 610 which operates in the same manner as fully described in the aforementioned Patent 2,236,246 to King-McKim-Myers. The sender is arranged for selecting either a toll marker or a marker which is used for completing connections within the area of the toll office by the operation of relay 1122 or relay 1123 which are under the control of relays 1010 and 1011 selectively operated by circuits established in the calling incoming trunk circuit as previously described. When a combined toll and terminating marker is used a single start circuit is employed. For this circuit explanation let it be assumed that the toll relay 1123 is energized because relay 1010 was energized by a calling incoming trunk and that a start circuit is established through the contact of this relay. When relay 415 is energized this start circuit may be traced from battery through contact 1 of relay 415, contact 4 of relay 416, contact of relay 1123 over conductor 1131 to a start relay in the marker connector. A large plurality of leads are now connected from the incoming sender to the selected marker.

When the sender and marker are first connected together a plurality of leads are grounded so that all of the marker register relays connected to the sender leads are operated. This causes a chain circuit to be closed through regis-

tering apparatus in the marker for operating the marker start relays. This opens a common operating circuit and releases all marker relays except those which are operated over leads grounded in the sender by apparatus selectively operated by the calling incoming trunk. The effect of operating all the relays in the marker and then releasing those which are not desired is to check all of the leads for continuity and for freedom from extraneous grounds or crosses. The code registrations and other registrations are now transferred from the sender to the marker to supply the marker with data for selecting an idle outgoing trunk extending to a particular office. A particular route relay is selected according to these registrations and the switches shown in Fig. 2 are set for connecting the incoming trunk to the outgoing trunk selected. Two of the registrations transferred from the incoming sender to the marker indicates whether a repeater is required for this telephone connection.

Repeater selection by the marker

As previously stated a voice amplifying repeater is required for good transmission when the incoming trunk is a long trunk and the outgoing trunk is also a long trunk and consequently the marker requires a signal indication of the character of both the incoming and the outgoing trunks for automatically determining whether a repeater should be selected and introduced in the outgoing trunk talking conductors. In the systems disclosed, uni-directional voice amplifying repeaters are shown for each channel in the four-wire transmission system extending through the equipment of the office. These two channels may be connected to a two-wire toll line or trunk extending to a distant office through windings of hybrid coils as shown in the left portion of the outgoing trunk circuit Fig. 3 or the two channels of the system may be connected directly to the equipment of the distant toll office in which case the hybrid coils are not required. As previously stated, voice amplifying repeaters are inserted in each transmission channel of the outgoing trunks under the control of the marker when the trunk lines connected together are of sufficient length to require voice amplification. When shorter trunks are connected together voice amplifying repeaters are not required and consequently the marker indicates that repeaters shall not be included in the talking conductors of the trunk. The system is adaptable to a two-wire transmission system as well as the four-wire transmission system disclosed. A long incoming trunk has ground as shown, connected on contact **9** of relay **104** for establishing a circuit to the sender giving the character of trunk associated therewith. The following series of operations take place as soon as the link switches of Fig. 8 have established a connection between the incoming trunk, Figs. 1 and 7 and the incoming sender, Figs. 4, 5, 9, 10 and 11. A circuit is thus established for relay **520** of this incoming sender known as the long incoming trunk relay. This circuit extends from ground on contact **9** of the incoming trunk relay **104**, contact **1** of relay **105**, lead **123**, through contact **4** of the primary and secondary link switches to conductor **843**, contact **2** of relay **914**, winding of the long incoming trunk relay **520** to battery. Relay **520** establishes the locking circuit to ground on contact **1** of relay **922**. It will be remembered that relays **104** and **914** were normal when the sender was seized by the link and connected with the incoming trunk but were later operated. The operation of relay **914** opens the operating circuit for relay **520** but the latter relay remains operated over its locking circuit. After the seizure of an idle marker, a circuit is completed to the marker for operating relay **600** also known as the long incoming trunk relay. This circuit is traced from contact **2** of relay **520** through the marker connector to lead **619**, winding of relay **600** to battery. Subsequently the registers of the marker are operated according to the registrations transmitted to the sender from the calling incoming trunk and a route relay, such as **602**, is selected through the contacts of the registers diagrammatically shown as **601**. The route relay selected indicates the character of the outgoing trunk to be used for completing the telephone connection by either establishing a circuit for relay **606** through the contact of relay **600** or by leaving this circuit open. Consequently, we have the character of both trunks now indicated to the marker. The circuit connections from this route relay (not shown) may be assumed as the same as that established in the aforementioned patent application of King et al., with the exception of the contacts shown for completing the repeater selecting circuit when a repeater is required. If the outgoing trunk used is not long enough to require a repeater this repeater selecting circuit is not established by the route relay thus relay **600** may be operated to indicate a long incoming trunk but if a short outgoing trunk is used for completing the connection, the repeater selecting circuit remains disestablished. In the present instance it may be assumed that a repeater is required for the telephone lines or trunks to be connected together and an obvious circuit is established for relay **606** from ground through the contacts of relays **602** and **600** to battery to the winding of relay **606**. As described in the aforementioned patent to King et al. connector circuits are used between the marker and the primary and secondary switches such as shown in Fig. 2, in order to select an idle path between the switches connected with the selected outgoing trunk and the calling incoming trunk. Until such time as an idle outgoing trunk has been found and seized and paths created for its proper operation certain circuits of the marker are maintained open. As shown in Fig. 6 one such circuit extends between the outgoing link connector **604** to what is known as an outgoing relay **603**. This circuit is, however, established as soon as an idle outgoing trunk is found and made busy for use in a telephone connection. A circuit is thus established for relay **605** to operate a relay in the outgoing trunk circuit later used for repeater selection. The marker thus automatically creates a start circuit for the selection of a repeater. This circuit may be traced from battery through both windings of relays **608**, contact of relay **606**, both contacts **1** and **2** of relay **605**, thence over conductors **620** and **621** through the incoming sender, the incoming trunk to the outgoing trunk. Lead **620** may be traced through the marker connector, contact **2** of relay **423**, lead **843**, through contact **4** of the secondary and primary link switches to lead **123** of the incoming trunk, contact **1** of relay **105**, contact **10** of relay **104** thence over lead **203** through the incoming and outgoing primary and secondary connecting switches **210**, **211**, **213** and **214**, lead **303**, contact **5** of outgoing trunk relay **306**, lower winding of retard coil **307**, contact **6** of relay **308**, contact **2** of repeater relay **322** to ground through its lower

winding. This circuit is simplexed and over the tip and ring talking conductors and therefore, lead 621 should also be traced through the marker connector to the incoming sender, contact 3 of relay 423, lead 844, contact 5 of the secondary and primary link switches to lead 124, contact 2 of relay 105, contact 8 of relay 104, conductor 202, thence through the connecting switches 210, 211, 213 and 214, lead 302, contact 3 of relay 306, upper winding of retard coil 307, contact 6 of relay 308, contact 2 of relay 322, lower winding of relay 322 to ground. In the circuit above traced the outgoing trunk relay 322 does not operate due to the high resistance of the lower windings of relay 608. Relay 608, however, operates in the circuit traced and associates an operating circuit with relay 607 from battery through the winding of the latter relay, contact of relay 608 to ground on contact 2 of relay 603. The operation of relay 607 establishes a locking circuit for itself through its contact 2 and a short-circuiting path through its contact 1. The lower winding of relay 608 is thus shunted and a circuit is established from battery through the upper winding of relay 608, contact 1 of relay 607, contact of relay 606 to leads 620 and 621 which causes the operation of the repeater relay 322 in the outgoing trunk circuit. The latter relay in energizing establishes a locking circuit for itself from battery through its upper winding, contact 3 of relay 308 to ground on contact 4 of relay 319 which operates as soon as this outgoing trunk is seized. The operating circuit for relay 319 extends from battery through its winding, contact 3 of relay 320, contact 7 of relay 305 thence over test conductor 340, trunk block relays 609 of the marker to ground over the trunk testing circuit of the marker as explained in the aforementioned patent to King et al. As will be seen by later description a progressive circuit arrangement is provided in the outgoing trunk circuit, Fig. 3, so that on outgoing sender and a repeater may be successively selected. The repeater relay 322 remains locked until after the outgoing sender has been selected by the link circuit and has transmitted the impulses to a distant office. This succession of operations is injected into the system in order that the marker and incoming sender may be released at the earliest possible moment. The marker having transmitted a signal to the outgoing trunk operating apparatus which will cause the selection of a repeater has completed its functions since previous to this the outgoing trunk was selected and the switches operated between the calling incoming trunk and the outgoing trunk. As soon as an outgoing sender has been associated with the incoming sender through the outgoing trunk circuit and the numerical digits have been transmitted from the incoming sender to the outgoing sender, this incoming sender may be released.

Link selection serving outgoing trunk

As previously stated the marker tests a plurality of outgoing trunks over trunk test leads such as 340. When an idle trunk is found the marker connects a low resistance ground to this lead for making the trunk busy and for operating relay 319. The circuit for operating this relay is as previously traced. The operation of relay 319 immediately associates ground with the start circuit of a link for finding an outgoing sender. This circuit is established before the marker has finished setting the switches of Fig. 2. The link start circuit may be traced from ground on contact 3 of relay 319, contact 3 of relay 320 thence over lead 331, contact 1 of relay 1310, winding of link start relay 1311 to battery. The class signal for directing the operation of the link is established through contact 4 of relay 320 when this relay is normal, thus leads 333 and 334 are connected together which later operate apparatus in the link control circuit directing it to select an outgoing sender. This will be described in detail after the link control circuit has been selected.

The operation of relay 1311 establishes circuits for energizing a connector unit in an effort to associate the outgoing trunk with an idle link control circuit shown in Figs. 17, 18, 19, 22, 23 and 24, inclusive. The control circuit in the latter figures is used for the selection and operation of a combination of link switches shown in Fig. 8 for connecting the outgoing trunk with an outgoing sender, in the same manner as described for the selection of an incoming sender and the association of this incoming sender with the incoming trunk. The outgoing trunk, Fig. 3, as disclosed is connected with one of the horizontal levels of a primary link switch which may be operably associated with a secondary link switch by the operation of the select magnet 803 for this horizontal level and the operation of the hold magnet 809 controlling a certain vertical. The primary switch may have a plurality of verticals associated with different secondary switches for connecting this outgoing trunk with an outgoing sender. One primary vertical is shown for connecting this outgoing trunk with the level 823 of the secondary switch controlled by the hold magnet 825 of a particular vertical. This will be known herein as a switch combination which was fully described in connection with the selection of an incoming sender.

The operation of the start relay 1311 establishes a circuit for finding an idle control circuit as previously described which ultimately operates multicontact relays 1206 and 1207 for associating an idle control circuit with the outgoing trunk circuit, Fig. 3. The energization of relay 1207 establishes a circuit for make-busy relay 1701 in the control circuit which associates ground with a plurality of conductors equivalent to the number of relays used in the chain circuit in the upper left portion of Fig. 12. As previously described, the control circuit selected is now indicated as busy to all other connector circuits and is taken for use to connect the outgoing sender with the outgoing trunk. The organization of the link switching arrangement and the control circuits is such that a choice is made from a large number of outgoing senders associated with the apparatus of the control circuit. In some instances a number of idle outgoing senders are simultaneously associated with the control circuit but only one of these outgoing senders is selected for use. This selection is made by signaling the control circuit which level of a particular secondary link switch is connected to a preferred idle outgoing sender. As stated earlier in the description the control circuit relays 2201, 2203 and 2205 are each associated with a different switch combination comprising a vertical on a primary switch and a vertical on a secondary switch each having a plurality of levels. The contacts of these relays are connected with the large plurality of outgoing senders. The windings of relays 2202, 2204 and 2206 are connected with this large plurality of outgoing senders to the contacts of relays 2201, 2203 and 2205. There

are as many relays 2202, 2204 and 2205 as there are outgoing senders simultanetously associated with the control circuit and all such relays associated with idle outgoing senders are operated. This operation, however, takes place after the last indication has been transmitted from the outgoing trunk to the control circuit.

When a particular trunk within the subgroup of trunks actuates a link, it is first necessary to identify the subgroup with which it is associated. The link control circuit is provided with a plurality of relays 2214 to 2212 equivalent to the number of trunk subgroups. In this instance the outgoing trunk is in the same subgroup as the incoming trunk, Figs. 1 and 7 and thus relay 2214 is operated to indicate the subgroup of trunks requiring service. The circuit for this relay is the same as previously described. A circuit is thus established for the multicontact relay 1314 which is the relay serving this subgroup of trunks. There are a plurality of trunks in each subgroup served by the same start relay 1311. These are represented in the control circuit by relays 1706 to 1710. The start ground which operated relay 1311 extends through all of the contacts of relay 1310. After the operation of relay 1314 this ground extends through as many contacts of relays 1310 and 1314 as there are trunks in the subgroup. This ground also extends through contact 15 of relay 1314 to energize the start relay 1705 in the control circuit. The trunk subgroup relays 1706 to 1710 representing all the trunks in the group are now energized. Relay 1703 now operates over a chain circuit through the contacts of relays 1710 to 1706 which establishes a circuit for relays 1702 and 1310. The operation of relay 1310 removes the start circuit ground from all conductors and all contacts except the contact of relay 1314 associated with the start ground in the outgoing trunk being served which causes the release of all relays 1706 to 1710 except the one associated with the outgoing trunk circuit, Fig. 3, which is represented by relay 1706. The latter relay is thus locked in position. The operation of relay 1310 also opens the operating circuit for relay 1705 which now releases and establishes a circuit for relay 1707.

Since the control circuit may select either an incoming sender, an outgoing sender or a repeater, a class signal must be transmitted from the trunk to direct the character of equipment to be selected by the link control circuit. This class signal is given over outgoing trunk leads 333 and 334. Lead 334 is individual to the trunk being served. Lead 333 is associated with a particular class of service relay in the link control circuit. In this instance the class relay operated is 1804 and the circuit for this relay may be traced as follows: Battery through the winding of relay 1804 over lead 1233 through the contacts of relays 1207 and 1206, contact 12 of relay 1314, lead 333, contact 5 of relay 320, lead 334, contact 11 of relay 1314 thence through the contacts of the multicontact relays 1206 and 1207 to the lead 1232 which extends through contact 7 of relay 1706 operated, through similar contacts of the normal relays for other trunks, contact 7 of the normal relay 1710, contact 2 of relay 1711 which is operated, to ground through contact 2 of relay 2303. The class of circuit to be selected is thus given to the link control circuit which in this case is an outgoing sender represented by relay 1804. A connection is now made for associating a large plurality of outgoing senders with the control circuit by the operation of relay 1330. A circuit for operating this relay may be traced from ground to the winding of relay 1330, contact 16 of relay 1314, contacts of relays 1206 and 1207, conductor 1237, contact 4 of relay 1709 which is operated, contact 3 of class relay 2210 which is normal, contact 3 of class relay 1806 which is normal, contact 3 of class relay 1804 which is operated, contact 4 of relay 2304 which is normal to battery to contact 9 of relay 2402 which is normal. Relay 1330 is operated in the circuit traced for associating the test leads of a large plurality of outgoing senders with the apparatus of the control circuit. One of these testing circuits is shown connected to contact 1 of relay 1330 extending over lead 1538 through contact 8 of relay 1500 in the outgoing sender. Relay 1500 is normal in an idle outgoing sender and operated in a busy outgoing sender, therefore, lead 1538 is either associated with ground on contact 1 of relay 1501 when the circuit is idle, and open when it is busy. Relay 1539 is a second test lead which is associated with battery through contact 2 of relay 1501 and resistance 1502 when the circuit is idle and associated with ground on contact 1 of relay 1500 when the circuit is busy. These two leads are used in testing the outgoing sender. The operating circuits for the senders tested are connected to a plurality of switch levels on a plurality of secondary link switches such as 823. Each secondary link switch level is associated with a different vertical of a primary link switch which is connected to the outgoing trunk. This makes available a large number of outgoing senders for selection so that ordinarily one or more are found to be idle.

Certain verticals of the secondary link switches may have outgoing senders associated with several levels, incoming senders associated with other levels and repeaters associated with other levels and may be associated with the primary switch through respective mating contacts. The above-mentioned vertical and horizontal levels of the switches are available to other link control circuits and therefore when a test is made to obtain the service of an idle outgoing sender, a check is made to ascertain which links are available for test, i. e., which links have not been taken for use by other control circuits. When a link has been taken for use by another control circuit a ground is applied to the winding of the hold magnet to operate the hold magnet of the primary and secondary link switches. The leads from all of the hold magnets are carried from the link switches through contacts, such as 3, 4 and 5 of relay 1314 and similar contacts of the multicontact relays 1206 and 1207 to conductors, such as 1224, 1225 and 1226. In each case there are as many such leads as there are available links for use in selecting outgoing senders, and these leads from all such hold magnets are carried through the contacts of relay 2306 to the left windings of relay such as 2201, 2203 and 2205. If any verticals have ground associated with their hold magnets a circuit for such busy links establishes an operating path for the aforementioned relays 2201, 2203 and 2205 to prevent a test of the senders associated with busy secondary switches. The operation of any of these relays opens the operating circuit for relays 2202, 2204 and 2206. There are as many of the latter relays as there are outgoing senders available for test but only those associated with unoperated relays 2201, 2203 and 2205 are tested. Assuming

that none of these relays are operated, relays 2202, 2204 and 2206 are associated with the test leads extending to the outgoing senders and all relays associated with idle senders are operated by ground from relays such as 1501 in the outgoing senders connected over circuits such as 1538. This circuit may be traced through contact 2 of relay 1330, contacts of multicontact relays 1206 and 1207 to lead 1261 to contact 3 of relay 2203, left winding of relay 2204 to battery. Circuits for other similar relays are established to paths over circuits as traced using conductors such as 1260 and 1262 extending to other contacts of relay 1330 to outgoing senders. A chain circuit through the contacts of relays such as 2202, 2204 and 2206 automatically chooses the idle sender to be selected. When this idle outgoing sender has been chosen relay 2406 is operated over a circuit previously described which establishes circuits for operating all of the relays such as 2201, 2203 and 2205. This establishes a circuit for relay 2211 as previously traced to ground on contact 1 of relay 1903. The operation of relay 2211 establishes a circuit for a relay corresponding to the level of the secondary link switch connected to the idle sender. This circuit may be traced from ground to contact 2 of relay 2211 over a chain circuit through contacts 1 of the unoperated relays 2202, 2204 and 2206 to contact 1 of the first operated relay in the chain which in this case may be assumed as relay 2204 which extends the circuit through contact 2 of relay 1901, winding of relay 1809 to battery which represents the level of the secondary switch to which the outgoing sender is connected. Relay 2209 was operated from battery associated to contact 2 of relay 1709 and a circuit is now established for making a double test of the sender which has been tested as idle. For this purpose a circuit is established for relay 1321 which may be traced from ground through its winding contact 38 of relay 1206 and a similar contact of relay 1207 over lead 1258, contact 2 of relay 2209, contact 3 of relay 1809, contact 2 of relay 1805, contact 5 of relay 1805 which is normal, contact 5 of relay 1809 which is operated to battery through contact 1 of relay 1810 which is normal. Relays 1321 and 1809 correspond to the level of the secondary link switch connected to the idle sender. The operation of relay 1321 connects ground through its contact 4 to the control circuit for operating relay 1901. Relay 1809 is connected from the outgoing sender through contact 2 of relay 1321 to a testing circuit in the link control circuit. This test circuit comprises vacuum tube 2410 and relays 2405 and 2403. The sender associates a voltage of particular value with the tube 2410 in the control circuit of such character that if no other control circuit is attempting to select this outgoing sender the plate resistance of the tube will instantly drop causing the operation of relays 2403 and 2405. Assuming in this case that the outgoing sender is idle and that no attempt is being made by another control circuit to seize these sender relays 2403 and 2405 may be assumed as operated establishing a circuit for relay 2402. Upon the operation of relay 2402 a locking ground is established for relay 2406. If the outgoing sender, which was tested and found idle, is seized by another control circuit before this double test is made, another idle outgoing sender is selected in the same manner as described for incoming senders.

A circuit for relay 1803 is now established as previously described for the operation of the primary select magnet 803. This circuit may be traced from ground to the secondary switch magnet 803, contact 24 of relay 1206 and a similar contact of relay 1207, conductor 1244, contact 4 of relay 1802, contact 2 of relay 1803, contact 2 of relay 1706 operated to battery on contact 3 of normal relay 1710. A circuit is also established for the operation of the secondary switch select magnet associated with the level of the secondary switch connected to the outgoing sender chosen. In this case it may be assumed that select magnet 824 is operated from ground through its winding, contact 32 of relay 1206 and a similar contact of relay 1207, conductor 1252, contact 4 of relay 2207 which is operated, contact 2 of relay 1708 which is operated, contact 7 of relay 1809 which is operated to indicate the horizontal level of the secondary switch, contact 6 of relay 1805, normal contact 5 of relay 1901 to battery. The circuits established through the contacts of the primary select magnet and secondary select magnet are the same as described for the incoming sender selection for establishing operating circuits for relays 2302 and 2301. With the latter two relays operated, a circuit is established for the hold magnets of the link switch combination selected. This circuit may be traced from battery through the windings of hold magnets 809 and 825 in parallel through contact 4 of relay 1314, contacts of relays 1206 and 1207 to lead 1245 of the control circuit thence through contact 2 of relay 2306 operated, contact 2 of relay 2204 operated, contact 2 of relay 2206 normal, contact 6 of relay 2211 operated, contact 2 of relay 2301, contact 1 of relay 2302 to ground on contact 1 of relay 2303. The operation of the select magnets and the hold magnets close the cross-points or mating contacts of the primary switch 801 and the secondary switch 823 for connecting the outgoing trunk circuit, Fig. 3, with the select outgoing sender.

The ground applied to the windings of the hold magnets for their operation now extends through contact 3 of the secondary switch 823 over conductor 1532, winding of relay 1500 to battery which operates this relay and replaces the busy ground held on the contact of this relay by the control circuit. The operation of relay 1500 associates ground with lead 1539 and opens lead 1538 so that the outgoing sender is made busy independent of the control circuit. The ground applied to the hold magnets also extends to contact 3 of the primary switch 801, contact 7 of relay 1314, contacts of relay 1206 and a corresponding contact of relay 1207 over lead 1228 through contact 6 of relay 1706 which is operated, contacts of other normal relays and through contact 6 of relay 1710 normal, contact 1 of relay 1707 winding of relay 2304 to battery operating the latter relay. A circuit is then established for relay 2303 from battery through its winding to ground on contact 2 of relay 2304 and a locking circuit is established for relay 2303 to ground on its contact 3. The operation of relay 2303 opens the operating circuit for the primary select magnet and releases other relays including relay 1706.

Referring now to the operation of apparatus in the outgoing sender as it relates to the link control circuit, the operation of relay 1500 disconnects battery from lead 1539 and connects ground thereto. This reverses the current in the test circuit of the control circuit and releases relay 2405. The link start circuit is opened by the outgoing trunk circuit by the operation of trunk relay 320 as explained later. A circuit is

thus established for the control circuit release relay 1903 which may be traced from battery through its winding, contact 1 of relay 2304, contact of relay 2401, contact of relay 2405 to ground. The operation of the control circuit release relay 1903 establishes a locking circuit for itself and causes the control circuit to restore to normal so that it may be seized for establishing another connection. A circuit for relay 1509 may be traced from ground through its winding, contact 1 of relay 1514, contact 2 of relay 1512, contact 2 of relay 1500 thence over lead 1533 to contact 6 of the secondary and primary link switches 823 and 801, lead 356 contact 6 of outgoing trunk relay 321, winding of relay 306 to battery. Relay 1509 operates in a circuit traced but the high resistance of this relay prevents the operation of relay 306. Circuits are established by operation in the outgoing sender which takes place progressively after the sender is seized and other relays operated, for example, the operation of relay 1599 connects ground to its contact 2, winding of relay 1504 to battery also connects ground to its contact 1 for locking relay 1500. Relay 1505 is operated from ground on contact 2 of relay 1504. Relay 1501 is operated over an obvious circuit to contact 6 of relay 1500. Relay 1513 is operated from battery through its winding, contact 3 of relay 1512, contact 1 of relay 1504 to ground on contact 1 of relay 1503; thus the circuit is established for relay 1514 from battery through its winding, contact 3 of relay 1513 to ground on contact 1 of relay 1501. At this time relay 320 in the outgoing trunk is operated over a circuit which may be traced from battery through its winding, contact 7 of relay 321, lead 350 through contacts 12 of primary switch 801 and secondary switch 823, lead 1537 to ground on contact 2 of relay 1514. The operation of relay 1320 over the circuit traced opens the start circuit for the link extending through its contact 4 and establishes a locking circuit for itself to ground on contact 3 of relay 319.

Outgoing sender

Relay 1500 connects battery to circuits including the windings of relays 2006 to 2013, inclusive, for receiving class information from the outgoing trunk to determine the class of service required. The circuit from these relays extends to contacts 1 and 2 of relay 1524, resistances 1522 and 1523, contacts 1 and 5 of relay 1521, contacts 2 and 3 of relay 1506, thence over leads 1534 and 1535, contacts 7 and 8 of the secondary and primary link switches, leads 357 and 358 of the outgoing trunk, contacts 3 and 5 of relay 321 to contacts 1 and 4 of relay 306. In this instance, the class of the trunk is indicated by ground connected through resistance 325 to contact 4 of relay 306 which establishes a circuit over lead 357. The other circuit traced remains open. Relay 2006 in the outgoing sender is therefore operated to indicate the class of the outgoing trunk connected thereto. This establishes a circuit from ground through its contact, contact 1 of relay 1517, winding of relay 2000 to battery which operates and locks to ground on contact 6 of relay 1500. There are a large plurality of classes of trunks to be indicated to the outgoing sender which accounts for the relays 2000 to 2005 which are operated under different conditions through the contacts of relays 2006 to 2008 and 2010 to 2012, inclusive. A circuit is established by relay 2000 for operating relay 1510 traced from battery through the winding of relay 1510, contact 1 of relay 2000 to ground through the contact of relay 2006. An obvious circuit is established for relay 1524 to ground on contact 2 of relay 1510. Relay 1524 opens the circuit extending over leads 1534 and 1535 and thus releases the class relay 2006 operated over this circuit. Relay 1511 operates in series with the locking circuit for relay 1510, from battery through the winding of relay 1510, contact 3 of relay 1510, winding of relay 1511 to ground on contact 6 of relay 1500. Relay 1511 establishes a circuit for relay 1517 from battery through the winding of the latter relay to ground through contact 1 of relay 1511 and the operation of relay 1517 transfers a plurality of leads extending from the contacts of relays 2006 to 2013, inclusive, to the contacts of the steering relays and to the register relays of Fig. 16. A class registration is now made through the contact of relay 2000 which was locked in position. In this case the class registered was for loop dialing and a circuit was established for relay 2113 from battery through its windings, contact 3 of relay 2009, operated, and over a series circuit through the contacts of relays 2001, 2002, 2003, 2004, 2005 which are normal, to ground on contact 2 of relay 1511. Relay 2113 in operating establishes a circuit for relay 2100 which in operating connects ground to its contact 5 through the winding of relay 2026 to battery for operating the latter relay. This relay establishes an obvious circuit for relay 2025. Relays 1600 and 1601 are operated over a circuit including contact 3 of relay 2024 normal and contact 2 of relay 2025 operated as later traced. Relay 2024 is operated from battery through its winding, contact 2 of relay 1500 to ground on contact 2 of relay 1505.

A circuit is now established for relay 1509 through its low resistance right winding for operating relay 306 in the outgoing trunk circuit in order to disconnect the class information leads and establish pulsing circuits from the incoming sender as will be described. The circuit for the right winding of relay 1509 is traced from ground through contact 1 of relay 2024, contact 1 of relay 2025, winding of relay 1509, contact 3 of relay 1509, contact 2 of relay 1512, contact 3 of relay 1500 thence over lead 1533 as previously traced to battery through the winding of relay 306 of the outgoing trunk circuit. It will be remembered that when relay 306 was first connected to the left winding of relay 1509, relay 1509 operated but relay 306 did not operate due to the high resistance of the left winding of relay 1509. Relay 306 now operates and establishes several circuits, one of which connects the winding of relay 305 through contact 6 of relay 306 to the simplexed circuit through retard coil 304 over the conductors 300 and 301. The switches of Fig. 2 having been operated by the marker, a circuit is now established for relay 305 over leads 300 and 301 through the switches of Fig. 2, contacts 3 and 5 of relay 104, operated, leads 126 and 127 thence through the link primary and secondary switches to leads 846 and 847, contacts of relay 1000 in the incoming sender, contacts 3 and 4 of relay 912, lower winding of relay 409 to ground. Incoming sender relay 409 operates but relay 305 does not operate due to the high resistance of the lower winding of relay 409. The operation of relay 409 establishes a circuit for relay 410 to ground on contact 6 of relay 416. Relay 410 locks to its operating ground and connects ground through the upper winding of relay 409 over the circuit traced to the outgoing trunk relay 305 which now operates since the upper

winding of relay 409 is of low resistance. Relay 305 in operating opens the circuit for relay 409 which now releases and in releasing establishes a circuit for relay 423 from battery through the winding of relay 423, contact of relay 414, contact 1 of relay 424, contact 1 of relay 425, contact 2 of relay 410, contact of relay 409 to ground on contact 6 of relay 416. Relay 423 connects the incoming sender pulsing circuit to leads 844 and 845 extending to the outgoing sender as will be traced later in establishing the pulsing circuit. With outgoing trunk relay 305 operated battery is connected through resistance 326, contact 3 of relay 305, contact 8 of relay 321 thence over lead 353 through contact 9 of the primary and secondary link switches to lead 1536 in the outgoing sender, winding of relay 1508 to ground operating the latter relay. The operation of relay 1508 indicates that the outgoing trunk and the outgoing sender are in readiness for the transmission of impulses from the incoming sender to the outgoing sender and now establishes a circuit for relay 1515 from the circuit also established in the incoming sender by the operation of relay 423. Relay 423 connects battery through resistance 1026, contact 3 of relay 1019, contact 2 of relay 423 to lead 844 which extends through contact 4 of the incoming secondary and primary switches to lead 124, contact 2 of relay 105, contact 8 of relay 104, lead 202 to lead 302, contact 4 of relay 306, contact 5 of relay 321 thence over lead 357 through the outgoing primary and secondary link switches, lead 1535 to the outgoing sender, contact 2 of relay 1506, contact 3 of relay 1515, winding of relay 1515, contact 3 of relay 1507, contact 4 of relay 1506, contact of relay 1508 to ground on contact 3 of relay 1505 which operates relay 1515 and indicates that all circuits are prepared for transferring the impulses from the incoming sender to the outgoing sender. Relay 1515 locks under control of relays 1505, 1506 and 1507.

The operation of relay 1515 connects the pulsing relays 2006 to 2013 to pulsing leads 1534 and 1535. Battery is connected to lead 1534 from relay 1509 for operating relay 1018 in the incoming sender. This circuit extends through relays 2010 to 2013 but none of these relays operate in the circuit traced. This circuit enters the incoming sender on lead 843, extends through contact 2 of relay 423, winding of relay 1018 to ground on contact 2 of relay 922. Relay 1018 locks to battery through resistance 1026 and operates relay 1019 over an obvious circuit. This extends the pulsing leads 843 and 844 to the contacts of pulsing relay 1020. The operation of the aforementioned relay 423 transfers the leads which are normally associated with relays 516, 518 and 521 for the operation of relay 413 to the windings of the steering relays for starting the outgoing pulses from the numerical register. The outgoing pulses start from the register relays for various areas depending upon the last steering relay which was operated for transmitting registrations to the marker. Assuming that relay 413 was operated through contacts of relay 522, as earlier described, for a three digit code, relay 522 operates for closing a circuit to operate relay 521. These relays are associated with the successive register relays. When relay 521 operates it locks and closes a circuit for the operation of relay 419. Relay 419 locks and opens the operating ground for relay 521 which prepares a path for the operation of relay 1020 and connects ground from contact 3 of relay 1000 through contact 1 of relay 419 to the pulsing generating circuit. The steering relay associates the outward pulsing relays 400, 401, 406 and 408 of the incoming sender with the first register relay to transmit pulses to the outgoing sender, such for example as the first horizontal row of registers shown in Fig. 11.

The common outward pulsing relays 400, 401, 406 and 408 are associated with all of the steering relays and register relays and are used for decoding the combinations as registered, into high and low resistance ground and 48 volt battery pulses via leads 843 and 844 to operate relays in the outgoing sender circuit. The relay combinations and pulses transmitted for various digits are as follows:

	Digit										Start
	0	1	2	3	4	5 J	6 M	7 R	8	9 W	
Pulses lead 843	L+	H+	L−	H−	L+	L+	H+	L−	H−	L+	H+
Transmitted lead 844					L−	H+	H+	H+	H+	H−	L−
Register relays—First		X		X			X	X	X		X
Register relays—Second			X	X					X		
Register relays—Third					X					X	X
Register relays—Fourth						X	X	X	X	X	

H+ indicates low resistance ground.
H− indicates low resistance 48 volt battery.
L+ indicates high resistance ground.
L− indicates high resistance 48 volt battery.
X indicates relay operated.

Relay 1015 is a non-biased condenser-timed polarized relay. It cannot be said to operate or release, but it closes its front contact when energized in one direction by its primary winding or closes its back contact when energized in the opposite direction by its primary winding. It also may remain on either or neither contact when not energized. When current is first closed through the primary winding in either direction its force is neutralized by an opposing current in the secondary winding. The source of the opposing current is the charge or discharge from the timing condenser 1027. When the condenser has been charged or discharged current ceases to flow in the secondary winding. The primary winding then causes the armature to move from one contact to the other. The time of operation averages approximately .065 second per single operation. When relay 1015 closes its front contact with relay 1021 operated, it shunts the 300 ohm battery associated therewith and starts opposing currents in the two windings. When this condition is started the effect of the secondary winding is stronger and the front contact is held closed but as the condenser discharges its current the value of current in the secondary winding decreases until the

effect of the primary winding becomes stronger. The relay then breaks its front contact and closes its back contact. With the relay contact in this position battery to 300 ohms establishes a current in the two windings in directions which are the registration from the previously established. Under this circuit condition the value in the secondary winding is stronger at first and the back contact is held closed. The condenser is now charged which diminishes the current in the secondary winding until the value in the primary winding becomes stronger than the value in the secondary winding. The relay then breaks its back contact and closes its front contact. This cycle continues in a successive order.

The pulse generating circuit consists of pulse start relay **1021** and pulse generating relays **1015** and **1020**. In sending out pulses the relay **1015** operates as previously described with relay **1020** operating each time relay **1015** closes its back contact. The pulsing must start with the timing condenser **1027** discharged and with relays **1015** and **1020** in a definite condition, **1015** having its back contact closed and **1020** should be operated. This is accomplished by discharge of the condenser when battery is applied to the resistance when a sender is seized. Relay **1015** closes its back contact immediately after relay **419** is operated and causes the operation of relay **1020**. The operation of relay **1020** extends leads **843** and **844** to relay **1021** which extends these leads to the outward pulsing relays **400**, **401**, **406** and **408**. Relay **1021** opens a path for shunting its own winding and closes a lead from ground to the front contact of relay **1020** for advancing the steering relays and starts continuous pulsing from relays **1015** and **1020**.

The outward pulsing relays **400**, **401**, **406** and **408** are now operated for the first pulse from the numerical register shown in the upper horizontal row in Fig. 16. And the contacts of these relays connect high or low battery or ground to leads **843** and **844** when relay **1020** is operated. At the same time the steering lead from relay **1020** operates the next succeeding steering relay associated with the next set of register relays. When relay **1020** releases the next succeeding steering relay operates in the manner previously described in series with the upward steering relay thereby releasing the preceding relay used for transmitting from the first set of register relays. During the open period of pulsing, relays **400**, **401**, **406** and **408** take their settings for the transmission of the next digit. Pulsing continues in this manner until the pulsing relays recognize a signal that the pulses have been transmitted to the outgoing sender. This signal may be transmitted with relays **400** and **406** operated. A circuit is established for the operation of the final pulse relay **1007** which locks and operates synchronizing relay **1008**. When the pulsing relay **1015** operates following the transmission of the final pulse its pulsing circuit through its front contact is opened at the contact of relay **1008**, consequently condenser **1027** will remain charged and relay **1015** will cease pulsing.

When the outgoing sender receives the final pulse, it establishes a circuit as explained later for operating polarized relays **1013** and **1014** associated with the incoming sender pulsing leads. When both of these relays are operated a circuit is established for operating relay **1012** which locks and connects ground to the outgoing sender via lead **843**. The outgoing sender as later described in detail opens both pulsing leads resulting in the release of relays **1013** and **1014**. The release of relay **1014** operates relay 424 indicating that the outgoing sender has accepted the final pulse signal.

Registrations in outgoing sender

The pulses transmitted from the incoming sender are recorded by the outgoing sender as outlined in the following description. After the operation of the loop dialing relay **2100**, as hereinbefore described, a circuit is established for relays **1600** and **1601** of the control of a succession of steering relays. This circuit may be traced from battery through the winding of relay **1600**, winding of relay **1601**, contact **1** of relay **1609**, contact **2** of relay **2100**, contact **3** of relay **2024** normal, contact **2** of relay **2025** operated to ground on contact **2** of relay **1505**. Relays **1600** and **1601** close the pulse registration leads from relays **2011**, **2012**, **2007** and **2008** to the register relays **1602**, **1603**, **1604** and **1605**. Relay **1600** locks through its contact **2** to ground on contact **2** of relay **1505** and establishes an operating circuit for relay **2024** as previously described. As previously stated, relays **1600** and **1601** after operation are maintained independent of relay **2024** so as to prevent their reoperation after being released by the next successive steering relay following the first registration of digits.

When the incoming sender closes the pulsing circuit, circuits are established from 48 volt battery over ground through either high or low resistances which are connected to the outgoing sender over leads **1534** and **1535**, operating the pulsing relays in accordance with a table given below. These relays operate register relays also according to the table given below.

		Key										Start
		0	1	2	3	4	5 J	6 M	7 R	8	9 W	
Lead	1535	L+	H+	L−	H−	L+	L+	H+	L−	H−	L+	H+
	1534					L−	H+	H+	H+	H+	H−	L−
Pulsing relays	2010	√	√	√	√	√	√	√	√	√	√	√
	2006					√	√	√	√	√	√	√
	2012 or 2013		√		√			√		√		√
	2008 or 2009						√	√	√	√	√	
	2011			√	√				√	√		
	2077					√					√	√
Register relays	First		√		√			√		√		√
	Second			√	√				√	√		
	Third					√					√	√
	Fourth						√	√	√	√	√	

H+ indicates low resistance ground.
H− indicates low resistance 48 volt battery.
L+ indicates high resistance ground.
L− indicates high resistance 48 volt battery.
√ indicates relay operated.

As previously assumed, number 1379 is given as an example of the registration. The closure of the numerical pulse 1 in the incoming sender will connect low resistance ground to lead 1534 and operate relays 2010 and 2012. Relay 2010, when operated, operates the next steering relay following relay 1600. This relay is in a chain and may be assumed to be the same as relay 1608. A steering relay, such as 1609, does not operate at this time as it is short-circuited by the contacts of the preceding steering relay. Relay 1220 operates the register relay 1602 which locks to ground on contact 2 of relay 1505. When the pulse is removed from the pulsing lead, relays 2010 and 2012 release. The release of relay 2010 removes the short circuit from a steering relay, such as relay 1609, allowing it to operate in series with a steering relay such as 1608. When the relay, such as 1609, is operated, it opens the locking circuit for relays 1600 and 1601 which release. The relay, such as 1609, also closes the leads from the contacts of the pulsing relays 2006, 2013, connecting them to the second horizontal row of register relays. When relay 1600 releases it closes the leads from the contacts of relays 2006 and 2010 to the steering relays, such as 1608. The release of relay 1601 opens the leads from the contacts of the pulsing relays extending to the first horizontal row of register relays. The closure of pulse 3 in the incoming sender connects low resistance battery to lead 1534 which causes the operation of pulsing relays 2010, 2011 and 2012. The registrations proceed in this manner until the numerical registers of the outgoing sender are set according to the pulses transmitted from the incoming sender. When the incoming sender has completed transmitting pulses, a special pulse of low resistance ground is connected to lead 1534 and a high resistance 48 volt battery to lead 1534 to signal the outgoing sender that the pulses for setting the registers of the outgoing sender have all been transmitted. This special pulse operates relays 2010, 2006, 2012 and 2007. The operation of the latter relay establishes a circuit for relay 2022. This relay is connected to the contacts of relays 2012 and 2007 so that the operation of both relays establishes a circuit for relay 2022. The operation of relay 2022 establishes a circuit for operating relay 2023 which locks to ground on contact 1 of relay 1505. When the special pulse is opened, relay 2022 releases which now establishes a circuit for operating the start relay 1520 for sending outward pulses from the outgoing sender over the trunk conductors to a distant station.

The operation of relay 1520 establishes a circuit for operating relay 1506 which releases relay 1515 which, it will be remembered, was operated as a pulse receiving signal for the outgoing sender. Relay 1506 also connects the windings of relays 2027 and 2028 to the pulsing leads 1534 and 1535. This establishes circuits for the polarized relays 1013 and 1014 in the incoming sender, as previously explained, to indicate to the incoming sender that the final pulse signal was properly received by the outgoing sender. Relays 2027 and 2028 in the outgoing sender are marginal and do not operate under this condition. The polarized relays in the incoming sender operate and transmit a signal to the outgoing sender. This is a direct ground signal over lead 1535 and 1534, operating relays 2028 or 2027 which establishes a circuit for relay 1507. Relay 1507 operates and locks under the control of relay 1520, and in so doing releases relay 1506. The release of relay 1506 opens the pulsing leads 1534 and 1535 from relays 2027 and 2028, releasing them. The incoming sender pulse equipment is now disconnected from the pulsing leads 1534 and 1535.

Outward pulses to distant office

Loop dialing pulses are now transmitted over leads 1530 and 1531, which pulsing circuit may be traced through the secondary and primary link switches 623 and 601 to leads 360 and 361, thence through contacts 1 and 2 of relay 321, to the tip and ring conductors of the outgoing trunk extending to the telephone office 330. As previously stated, relay 2100 is operated for loop dialing either over an intertoll or a toll switching trunk and, therefore, relay 2115 operates from battery and ground over the outgoing trunk conductors. Relay 2115 operates relay 2114 which operates relay 1606. The operation of relay 1606 establishes an operating circuit for relay 2019 which opens the shunt from relay 1607, causing its operation. This establishes a circuit for relay 2014 which operates and connects ground to relay 2017 to cause its operation and start selections and pulsing to the distant office. Relay 2017 in operating also establishes a circuit for operating relay 2016. The operation of relay 2017 removes ground previously applied to the winding of relay 2120 which is connected in a network for operating and releasing this relay in this timed network. Relays 2118 and 2119 are in series with relay 2120 which operate and release in unison with relay 2120. Relay 2019 when initially operated operates relay 2112 and when it releases establishes an operating circuit for relay 2111. The operation of relay 2120 again operates relays 2119 and 2118. Relay 2119 in operating operates relay 2117 and also one of the common relays 2146, 2144, 2142, 2140, 2138. Relay 2107 in operating arranged the contacts of relay 2118 so that relays 2115 and 2116 are removed from the pulsing circuit. Assuming that relay 2142 was operated when relay 2119 initially operated, the successive release and reoperation of relay 2119 will cause the operation of relay 2141 and then 2144 and 2143 ultimately operating 2146 and 2145. The operation of relay 2145 prepares a circuit path for the operation of relay 2105 as soon as relay 2119 reoperates, thus removing the contacts of relay 2118 from the pulsing circuit so that further operation and release of relay 2118 will not affect the trunk conductors. Relays 2115 and 2116 are also connected across pulsing leads 1530 and 1531.

After relay 2145 operated, the next operation and release of relay 2119 operates relays 2127 and 2130 and, consequently, operates relays 2126 and 2129. Relay 2129 releases relay 2107. It should be noted at this time that the operation of each pair of relays 2144 and 2143, 2146 and 2145 up to 2126 and 2129 releases the preceding pair of relays. The operation of relays 2129 transfers the front contacts of relay 2119 from relay 2130 to relay 2145 so that the next operation of relay 2119 will reoperate relay 2112 and the release of relay 2119 will operate relay 2111. The operation of relay 2130 releases relay 2109 and the operation of relay 2129 maintained the release of relay 2109. When relay 2111 operated the second time and relay 2119 reoperates, then relay 2107 does not operate but relay 2142 operates. The release of relay 2119 causes the operation of relay 2141. Successive operating and releasing relay 2119 will operate pairs of relays

2144 and 2143, 2146 and 2145, 2145 and 2128 which opens the circuit from the contact of relay 2119. After the pulses for the last digit have been completely transmitted, relays 2115 and 2116 are connected across the outgoing trunk conductors. This may be traced from conductor 1530 through contact 1 of relay 2117, winding of relay 2116, winding of relay 2115, contact 4 of relay 2100, contact 2 of relay 2105, contact 1 of relay 2107, contact 2 of relay 2117 to conductor 1531. It will be remembered that conductors 1530 and 1531 are connected to the trunk conductors extending to the distant office 330. Relay 2115 establishes a circuit for operating relay 2103, assuming that relay 2118 is operated, which occurs if the special pulse has been received. This special pulse may be received in any digit position and consists of a combination which operates the first and third register relays of any given register when relay 2020 operates to operate any of the relays 1606, 1607 to 1614, 1615 associated with particular register relays. As previously stated, relay 2018 operates from the circuit established and establishes a circuit for operating relay 1512. The latter relay opens lead 1533 which causes the release of the outgoing trunk relay 306 as a signal to the outgoing trunk to cut through or when a repeater is required to cause the selection of a repeater to be inserted in the talking conductors. The opening of lead 1533 releases the outgoing sender relay 1509 which successively releases the relays of the outgoing sender.

Repeater selection

The condition of the apparatus in the outgoing trunk, Fig. 3, may be reviewed at this time before establishing circuits therein for the selection of a repeater. Relay 319 was operated when the outgoing trunk was selected and was locked in position or maintained operated over the conductor 204 extending through the switches from the incoming trunk. A circuit for relay 320 was established by the outgoing sender and this relay locked to ground on relay 319. Relay 306 was operated by the outgoing sender for the transmission of impulses and has now been released by the outgoing sender since these pulses have been transmitted. Relay 305 was operated by a circuit established from the outgoing sender over line conductors after the operation of relay 306 and was locked to contact 1 of relay 320. Repeater relay 322 was operated by the marker and locked to ground on contact 4 of relay 319. The circuit is thus established for making a transfer of control to the repeater selecting link circuits. This is accomplished by the operation of relay 321 from battery through its winding, contact 9 of relay 305, contact 7 of relay 306 to ground on contact 6 of relay 305. Relay 321 later establishes a locking circuit for itself through its contact 4. The release of relay 306 also establishes a start circuit for the link which associates a link control circuit therewith for the selection of an idle repeater. This start circuit may be traced from the operating ground for relay 321 on contact 6 of relay 305 through contact 7 of relay 306, contact 3 of repeater relay 322, thence over lead 331 through contact 1 of relay 1310 of the link circuit, winding of the link start relay 1311 to battery. It will be remembered that this start lead 331 was also used for energizing the link start relay 1311 for the selection of a link control circuit which associated the outgoing sender with the outgoing trunk circuit and the incoming sender. This start relay was, however, released as soon as the outgoing sender was selected so that the link control circuit and link connector could be used for making other connections. At that time the start circuit was opened by energization of relay 320 which disassociated the start ground from the start relay 1311.

The operation of the link start relay 1311 establishes circuits as herein explained in connection with seizing the incoming sender and an outgoing sender which select an idle control circuit, Figs. 17, 18, 19, 22, 23 and 24. This is done through the operation of selective relays shown in the upper portion of Fig. 12 and the operation of the multicontact relays 1206 and 1207, as previously described. After a series of operations in the link control circuit for determining the group in which the outgoing trunk of Fig. 3 is located, relay 1314 is operated for associating the leads from this group of trunks with the control circuit through the multicontact relays 1206 and 1207, also as previously described. The outgoing trunk leads are thus connected with the idle link control circuit selected through the contacts of relay 1314. This includes class leads 334 and 332 which in this case are connected together by relay 320 for directing the control circuit to select an idle repeater. It will be remembered that leads 334 and 333 were connected together through the contacts of relay 320 normal for operating a class relay in the link control circuit which directed the control circuit to select an idle outgoing sender. With relay 320 operated by the outgoing sender, class leads 334 and 332 are now connected to energize class relay 2210. This circuit may be traced from battery through the winding of relay 2210, lead 1235, contacts of relays 1207 and 1206, contact 14 of relay 1314, lead 752, thence to lead 332, contact 4 of relay 320, lead 334, contact 11 of relay 1314 through the contacts of relays 1206 and 1207 over lead 1232, contact 7 of relay 1706, which in this case is operated, contact 7 of relay 1710, which is normal, contact 2 of relay 1711 to ground on contact 2 of relay 2303. Each trunk has an individual class lead, such as 334, which must be extended through a relay in the link control circuit, such as 1706, operated to indicate the trunk position in a subgroup of trunks. Relay 1706 was also operated for this same trunk for the selection of an outgoing sender to be associated with this trunk, as previously described. For the selection of an outgoing sender it will be remembered that class relay 804 was operated whereas in this case for the selection of a repeater class relay 2210 is operated. The operation of this class relay establishes a circuit for relay 1332 for associating a large plurality of repeater circuits, such as shown in Fig. 14, with the control circuit. The circuit for relay 1332 may be traced from ground through its winding, contact 18 of relay 1314, contacts of relays 1206 and 1207, thence over lead 1239 through contact 6 of relay 1709, which is operated, contact 1 of relay 2210 operated, contact 1 of relay 1806 normal, contact 1 of relay 1804 normal, contact 4 of relay 2304 normal, to battery on contact 9 of relay 2402 normal. The operation of relay 1332 connects a plurality of test leads from a plurality of repeaters to the link control circuit. Only one such lead is shown connected through contact 1 of relay 1332 to test lead 1442 of the repeater through contact of jack 1413, contact 1 of relay 1414 to ground on relay 1418. This condition indicates an idle repeater circuit. When a repeater circuit is busy, this lead is opened. It will be noted that relay 1418

of the repeater circuit is normally operated from battery through its winding to ground on contact 6 of relay 1414. When the repeater becomes busy, relay 1414 is operated, as hereinafter described, which releases relay 1418, disconnecting the ground on contact 3 from the test lead. All repeaters which have ground connected with their lead 1442 extend through the contacts of relay 1332 to the windings of relays such as 2202, 2204 and 2206 in the same manner as described for the incoming sender and outgoing sender. Therefore, the selection of an idle repeater is made in the same manner as previously described and location of a level of a secondary link switch to which this idle repeater is connected is obtained by circuits established through the relay in the control circuit which is operated over this test lead. Relay 1324 is thus operated according to the level on which the idle repeater was found. The circuit for relay 1324 may be traced from ground through its winding, contact 39 of relay 1206 and a corresponding contact on relay 1207, thence over lead 1259 to contact 3 of relay 2209 which is operated, contact 3 of relay 1810 which was operated to indicate the level of the switch, contact 2 of relay 1809 normal, contact 2 of relay 1805 normal, contact 5 of relay 1805, contact 5 of relay 1809, contact 5 of relay 1810 to battery through resistance 1826. The operation of relay 1324 associates ground through its contact 4 with the control circuit for operating the double test relay 1901. This energizes circuits, as described in the selection of the incoming sender, and a double test of the idle repeater circuit is made to guard against a double connection. Contact 1 of relay 1324 is connected with lead 1443 of the repeater circuit which extends through the lower contact of jack 1413 to battery through resistance 1415. If no double connection exists, the test is completed by the energization of tube 2410 in the link control circuit and circuits are established for energizing the select magnets and the hold magnets of the primary and secondary switch to which this idle repeater is connected. It may be assumed that switch 826 is the horizontal level of the secondary link switch to which the idle repeater is connected and is under the control of select magnet 827 and the hold magnet 828. The primary link switch vertical through which the repeater is connected to the outgoing trunk is switch level 803 under the control of select magnet 803 and hold magnet 808. Circuits are established for these select magnets and hold magnets in the same manner as previously described which now connects the repeater circuit, Fig. 14, through the matching contacts of the secondary lamp switch 826, primary link switch 800 to the outgoing trunk, Fig. 3. The ground associating the hold magnets 828 and 808 also extends through contact 3 of switch 826 to battery through the winding of relay 1414, operating the latter relay. The operation of this relay opens the ground connected to lead 1442 and connects ground to lead 1443, making this repeater busy to other link control circuits. This lead also extends to conductor 359 in the outgoing trunk circuit. This completes the function of the link control circuit so far as repeater selection is concerned and extending the conductors from this repeater to the outgoing trunk circuit so that the repeater may be inserted in the talking conductors. The control circuit may, therefore, be released as soon as the start circuit extending from the outgoing trunk circuit is opened, which occurs as soon as relay 308 is operated.

The seizure of the repeater circuit and the association of this repeater with the outgoing trunk circuit establishes circuits in the repeater which, as stated, operate relay 1414 and at the same time energize relay 1416. Relay 1416 is energized through contact 2 of relay 1418, winding of relay 1416 to battery. The circuit for relay 1418 is opened through contact 6 of relay 1414 but relay 1418 is slow to release and allow sufficient time for the operation of relay 1416. A potentiometer circuit is established through contact 5 of relay 1414 consisting of resistance 1420 and resistance 1421 to ground. The ground for operating relay 1416 extends from contact 4 on relay 319 of the outgoing trunk through contact 8 of relay 321, thence over lead 359 to contact 12 of primary switch 800, contact 12 of the secondary switch 826 over lead 1441 to the winding of relay 1416, as traced. This ground also extends to contact 7 of relay 1414, returning to the outgoing trunk circuit over lead 1435, contact 6 of the secondary link switch 826, contact 6 of the primary link switch 800, lead 356, contact 6 of relay 321, winding of relay 308 to battery, operating the latter relay. The operation of this relay opens the locking circuit for the repeater relay 322 which now releases and opens the start circuit to the link control circuit which now releases as previously described. Relay 1416 locks to ground in the outgoing trunk circuit over lead 1441, as traced. The circuit through relay 1400 extends through the switches to conductor 353, contact 7 of relay 321, contact 6 of relay 308 to retard coil 307. This circuit is used for cutting in the repeater independent of the pad circuit or insertion of the pad circuit in the repeater circuit. Repeaters 1411 and 1412 are inserted in the telephone connection by the operation of relay 308 which now remains operated for the completion of the call. The repeater leads between the outgoing trunk and the repeaters through the link switches are all obvious and need not be traced.

Two-way trunk as outgoing trunk

When the two-way trunk, Figs. 1 and 7, is seized by a marker and used as an outgoing trunk, circuits may be established for selecting an outgoing sender and a repeater in the manner described for the outgoing trunk in Fig. 3. When this trunk is seized by the marker to be used as an outgoing trunk, relay 722 is operated in the manner described for the operation of relay 319. In this case, the marker makes the test of the trunk over lead 750 and, if this trunk is idle, the marker operates relay 722. The operation of relay 722 establishes an energizing circuit for relay 716 and relay 716 connects ground to start lead 751 for energizing the link by operating relay 1311. This start lead may be traced from ground through contact 6 of relay 716, contact 5 of relay 709, conductor 751, contact 2 of relay 1310, winding of start relay 1311 to battery. The operation of relay 722 also establishes the class circuit for directing the link control circuit to select an outgoing sender in the manner previously described for the selection of an outgoing sender. For this directing signal, lead 755 is connected to lead 754 through contact 9 of relay 722 which, as previously described, operates class relay 1804 in the link control circuit.

If the marker determines automatically from

the character of the calling incoming trunk and the character of the outgoing trunk used for the connection that a repeater is required, a signal is transmitted from the marker to the outgoing trunk in the manner previously described for transmitting this signal through the outgoing trunk of Fig. 3. In this case, a signal is transmitted to the two-way trunk of Fig. 1 for operating the repeater relay 101 in the trunk circuit. This signal is transmitted over the tip and ring conductors in the same manner as previously described, entering the trunk circuit through the upper and lower windings of relay coil 103, thence through the left and right windings of relay 703, contact 3 of relay 722, contact 3 of relay 107, contact 10 of relay 707, contact 11 of relay 104, contact 3 of relay 102, lower winding of relay 101 to ground. The repeater relay 101 locks in its operated position and awaits the selection of the outgoing sender after which relay 105 is operated for associating a repeater with the trunk. The link start circuit is again energized for the selection of this repeater. This circuit may be traced over lead 751 which in this case extends to ground from the contact of relay 106 since, as previously described, relay 709 is operated during the operation of the outgoing sender associated with the circuits of the outgoing trunk. The class registration for directing the link control circuit is also altered since in this case lead 755 is connected to lead 752 for directing the link control circuit to select the repeater. This connection is made through contact 3 of relay 106. A repeater is thus selected and the link switches operated for connecting this repeater to the talking conductors, as described for the outgoing trunk of Fig. 3. This two-way trunk is, therefore, arranged to transmit three different classes of signals to a link control circuit for directing the control circuit to select either an incoming sender, an outgoing sender or a repeater which are all connected through the same contacts of the primary link switch connected to the trunk, each connection being made through different mating contacts on different verticals of the switch, these verticals being associated with various voices of secondary link switches. In some cases the choice of secondary switch for selecting an incoming sender may be the same for selecting an outgoing sender since incoming senders and outgoing senders or repeaters may be connected to different horizontal levels of the same secondary switch. Various choices within the switch are available through the verticals of the secondary switches associated with the verticals of the primary link switch.

What is claimed is:

1. In a telephone system, an automatic switching toll telephone office having incoming toll trunks, outgoing toll trunks, incoming senders, outgoing senders, repeaters, a link having primary switches connected to a plurality of said incoming and outgoing trunks and secondary switches connected to said incoming senders, outgoing senders and repeaters, a common group of link control circuits each connected to a plurality of said incoming senders, outgoing senders and repeaters, means in an incoming trunk responsive to an incoming call for signaling a link to select an idle link control circuit, means in said incoming trunk for directing said link control circuit to select an incoming sender, means in said link control circuit responsive to said directing signal for selecting an idle incoming sender and for operating the secondary link switch connected thereto and a primary link switch for connecting said incoming sender to said incoming trunk, means responsive to signals over said calling incoming trunk for setting registers in said incoming sender, markers, means in said incoming sender for selecting an idle marker, registers in said marker set according to registrations in said incoming sender, means in said marker for selecting an idle outgoing toll trunk according to said registrations and for operating switches to connect said incoming trunk with the selected outgoing trunk, means operable in said marker for recording the character of the incoming and outgoing trunk for determining when a repeater is required for the telephone connection over said trunks, means in said marker responsive to the operation of said determining means for transmitting a signal to the outgoing trunk, means in said outgoing trunk circuit for transmitting successive signals to said link circuit directing the successive selection of an outgoing sender and a repeater, means in said link circuit for successively associating a link control circuit therewith for the selection of an idle outgoing sender and an idle repeater and for successively operating secondary switches and a primary switch for connecting said outgoing sender and repeater to the conductors of said outgoing trunk, means in said incoming sender responsive to the selection of an outgoing sender for transmitting digit impulses from the registers of said incoming sender to set the registers of said outgoing sender, said transmitting circuit being carried through said link switches, means in said outgoing sender responsive to a signal from said incoming sender for readjusting the outgoing trunk circuit and for transmitting the digit impulses over the outgoing trunk conductors to a distant station and means in said outgoing trunk circuit responsive to a signal from said outgoing sender for connecting the selected repeater in the transmission circuit of the telephone connection through the contacts of said link switches.

2. In a telephone system, an automatic switching toll telephone office having incoming toll trunks, outgoing toll trunks, incoming senders, outgoing senders, repeaters, a link having primary switches connected to a plurality of said incoming and outgoing trunks and secondary switches connected to said incoming senders, outgoing senders and repeaters, a link control circuit for selecting an idle incoming sender, outgoing sender or repeater, means in an incoming trunk responsive to an incoming call for signaling the link and link control circuit to select an incoming sender, means in said link control circuit responsive to said signal for selecting an idle incoming sender and for operating a secondary and primary switch for connecting said incoming sender to said incoming trunk, means responsive to signals over said incoming trunk for setting registers in said incoming sender, means in said incoming sender for selecting an idle marker, registers in said marker set according to registrations in said incoming sender, means in said marker for selecting an idle outgoing trunk according to said registrations and for operating switches to connect said incoming and outgoing trunk, means operable in said marker for recording the character of the incoming and outgoing trunk for determining when a repeater is required for the telephone connection over said trunks, means in said marker responsive to the operation of said determining means in said

marker for transmitting a signal for the selection of a repeater, means in said outgoing trunk circuit for directing said link in the selection of said repeater means in said outgoing trunk circuit for directing said link in the selection of an idle outgoing sender, and means in said link and link control circuit responsive to said signals from said incoming and outgoing trunks for operating said link switches in combinations to connect the incoming sender and outgoing sender and repeater in a coordinated manner in said telephone connection.

3. In a telephone system, an automatic switching toll office having incoming toll trunks, outgoing toll trunks, incoming senders, outgoing senders, repeaters, a link having primary switches connected to a plurality of said incoming and outgoing trunks and secondary switches connected to said incoming senders, outgoing senders and repeaters, a link control circuit for selecting an idle incoming sender, outgoing sender or repeater, means in an incoming trunk responsive to an incoming call for signaling the link and link control circuit to select an incoming sender, means in said link control circuit responsive to said signal for selecting an idle incoming sender and for operating a secondary and a primary switch for connecting said incoming sender to said incoming trunk, means for setting registers in said incoming sender according to signals over said incoming trunk, means in said incoming sender for selecting an idle marker, registers in said marker set according to registrations in said incoming sender, means in said marker for selecting an idle outgoing trunk according to said registrations and for operating switches to connect said incoming and outgoing trunk, means operable in said marker for recording the character of the incoming and outgoing trunk for determining when a repeater is required for the telephone connection of said trunks, means in said marker responsive to the operation of said determining means for transmitting a signal to the outgoing trunk and means in said outgoing trunk circuit for transmitting successive signals to said link circuit directing the successive selection of an outgoing sender and a repeater, means in said link circuit for successively associating a link control circuit therewith for the selection of an idle outgoing sender and an idle repeater and for successively operating secondary switches and a primary switch for connecting said outgoing sender and repeater to the conductors of said outgoing trunk.

4. In a telephone system, an automatic switching toll telephone office having incoming toll trunks, outgoing toll trunks, incoming senders, outgoing senders, repeaters, a link having primary switches connected to a plurality of said incoming and outgoing trunks and secondary switches connected to said incoming senders, outgoing senders and repeaters, a link control circuit for selecting an incoming sender, outgoing sender or repeater, means in a trunk circuit for signaling to the link control circuit which character of equipment shall be selected and means in said control circuit for selecting an incoming sender, an outgoing sender or a repeater as directed by the trunk circuit, and other means in said control circuit for operating the secondary switch connected to the selected equipment and a primary switch connected to the signaling trunk for connecting the selected equipment with the signaling trunk.

5. In a telephone system, an automatic switching telephone office, a link, a plurality of incoming and outgoing trunks of different character connected to said link, a plurality of equipments of different character accessible to said link, a plurality of selectable link control circuits each variably operable for selecting said different equipments, means in a trunk circuit for energizing a link to cause the selection of an idle link control circuit, a plurality of selectively operable devices in said control circuit, means in said trunk circuit for operating one of said devices for designating the selection of a particular character of equipment accessible to said link, means in said control circuit responsive to the operation of said device for selecting an idle equipment of the character designated and for operatively connecting it to said link and means in said control circuit responsive to the connection of said equipment to said link for operating said link to connect said selected equipment to said trunk.

6. In a telephone system, an automatic switching telephone office, incoming trunks, outgoing trunks, different characters of equipments, a link having a primary switch connected to a plurality of said incoming and outgoing trunks and secondary switches having access to a plurality of said different characters of equipment, link control circuits, means in a trunk circuit for transmitting successive signals to said link and a link control circuit directing the successive selection of different characters of equipment, means in said link circuit responsive to said signals for successively associating a link control circuit therewith, means in said link control circuit responsive to said signals for successively selecting different characters of said equipments and means in said control circuit for operating said secondary and primary switches for associating said different characters of equipment with said signaling trunk through the contacts of said link switches.

7. In a telephone office, operating circuits, a plurality of different characters of equipment, links having switches connected with said plurality of different characters of equipment, a plurality of adjustable link control circuits connected to said plurality of different characters of equipment, means in an operating circuit for operating a link, means in said link for selecting a link control circuit, signaling means in said operating circuit for the different characters of equipment to be selected, means for establishing a signaling circuit, means in said link control circuit responsive to said signal from said operating circuit for adjusting its operating method for selecting an equipment of the particular character signaled and for operating the link switches connected thereto for connecting the selected equipment with the operating circuit.

8. In a telephone office, trunk circuits, a plurality of incoming senders, outgoing senders and repeaters, links having switches connected with said incoming senders, outgoing senders and repeaters, a plurality of adjustable link control circuits connected to said incoming senders, outgoing senders and repeaters, means in said trunk circuits for operating the link, means in said link for selecting a link control circuit, signaling means in each of said trunk circuits for the different characters of equipment to be selected, means in a trunk circuit for establishing a signaling circuit, means in said link control circuit for adjusting its operating method as signaled

by said trunk circuit for selecting an incoming sender, an outgoing sender or a repeater and for operating the link switches connected thereto for connecting the selected sender or repeater with said trunk circuit.

9. In a telephone office, trunks, a plurality of different characters of equipment, a link having primary switches and secondary switches with the mating contacts of the primary switches connected to a plurality of trunks and a plurality of choices of secondary link switches with the mating contacts of the secondary link switches connected to a plurality of said different characters of equipment, means in said trunks for directing the operation of the link for selecting equipment of any particular character and means in said link for selecting the different equipment as directed and connecting said equipment through the choice of mating contacts to the directing trunk.

10. In an automatic switching telephone office, trunks, incoming senders, outgoing senders and repeaters, a link having primary switches and secondary switches with the mating contacts of the primary switches connected to a plurality of trunks and a plurality of choices of secondary link switches with the mating contacts of these secondary link switches connected to a plurality of said incoming senders, outgoing senders or repeaters, means in said trunks for directing the operation of the link for selecting an incoming sender, an outgoing sender or a repeater, and means in said link for selecting said equipment as directed and connecting it through a choice of mating contacts to the directing trunk.

11. In a telephone office, trunks, a link including a primary link switch having sets of trunk contacts connected to a plurality of said trunks and primary mating contacts connected with contacts of a plurality of secondary link switches, there being a plurality of primary mating contact choices connected to secondary link switches for each set of trunk contacts, a plurality of secondary mating contacts connected to different characters of equipment, there being a plurality of secondary mating contact choices having said equipment connected thereto, link control circuits, means in a trunk for starting the operation of a link for selecting and seizing an idle link control circuit, means in said trunk for transmitting a signal to the selected link control circuit directing the control circuit to select a particular character of equipment, means in said control circuit responsive to said signal for selecting an idle equipment as directed, means operable in said control circuit responsive to said selection for giving the location of the secondary switch mating contact choice to which the selected equipment is connected and for operating the primary and secondary switch combination for closing said located secondary switch contacts and a choice of contacts on said primary switch for connecting the selected equipment with said trunk.

12. In a telephone office, trunks, a link including a primary link switch having sets of trunk contacts connected to a plurality of said trunks and primary mating contacts connected with contacts of a plurality of secondary link switches, there being a plurality of primary mating contact choices connected to secondary link switches for each set of trunk contacts, a plurality of secondary mating contacts connected to different characters of equipment, there being a plurality of secondary mating contact choices having said equipment connected thereto, link control circuits, means in a trunk for transmitting successive signals to said link for successively seizing a control circuit for the selection of different characters of said equipment, means in said trunk circuit for directing the sequence with which said different characters of equipment shall be selected, means in the control circuit operably responsive to said directing signals for selecting said equipments as directed, means operable in the control circuit responsive to each different selection for giving the location of the secondary switch mating contact choice to which the selected equipment is connected and for operating a primary and secondary switch combination after each selection for closing the located secondary switch contacts and a choice of contacts on said primary switch for connecting the selected equipments with said trunk through a set of trunk contacts on said primary link switch to which said trunk is connected.

13. In a telephone office, an adjustable link, a plurality of each of incoming senders, outgoing senders and repeaters available for selection by said link, a trunk circuit, means in said trunk circuit for actuating said link, character discriminating means in said trunk for signaling said link for the selection of either an incoming sender, an outgoing sender or a repeater, and means in said link responsive to said signal for adjusting its selecting equipment to restrict the selection to either an idle incoming sender, an idle outgoing sender or an idle repeater according to the character of said discriminating signal.

14. In a telephone office, an adjustable link having circuit-connecting switches, different characters of equipments available for selection by said link, other equipment units, means in an equipment unit for actuating said link, character discriminating means in said unit for signaling said link for the selection of a particular character of equipment, means in said link responsive to said character discriminating signal from said equipment unit for variably adjusting said link to select one of said different characters of equipment and means responsive to the selection of an equipment of said particular character to operate the link switches to connect the equipment selected with the equipment unit actuating said link.

15. In a telephone office, an adjustable link having a plurality of switches, different characters of equipment available for selection by said link, trunk circuits, means in a trunk circuit for successively actuating said link, means in said trunk circuit for successively sending different character discriminating signals to said link for the successive selection of different characters of equipment, means in said link responsive to said successive discriminating signals from said trunk circuit for successively adjusting said link for successively selecting different characters of equipment and means responsive to the successive selections to operate different switches in said link to successively connect said different characters of equipment with said trunk circuit.

16. In a telephone system, an automatic switching toll office, incoming toll trunks, outgoing toll trunks, a marker in said office having registers and routing devices, means in said marker including said registers for recording a routing for a telephone trunk connection according to signals transmitted over a calling trunk and for selecting a routing device governing the character of an outgoing trunk for said connec-

tion, means in said marker for registering the character of the calling incoming trunk responsive to a signal transmitted by the actuation of said trunk, a common group of voice amplifying repeaters for selection as required in certain toll trunk connections, and means in said marker operably responsive to said registrations for determining whether a repeater is required for insertion in the outgoing trunk talking conductors for said telephone connection.

17. In a telephone office, incoming trunks, outgoing trunks divided into groups, automatic switches for interconnecting said trunks, a variably operable marker common to said switches, route relays in said marker individual to the different trunk groups, means associated with said incoming lines for governing the action of said marker in operating particular route relays, and means responsive to the operation of a route relay for determining whether a repeater shall be selected for an outgoing trunk of the associated group and for selecting an idle outgoing trunk of said group, means operably responsive to said selection for operating said automatic switches to connect a calling incoming trunk with a selected outgoing trunk, and means thereafter operably responsive to said determining means for selecting an idle repeater for said outgoing trunk.

18. In a telephone system, an automatic switching telephone office, incoming trunks, outgoing trunks, a common control device for automatically completing connection between a calling incoming trunk and an outgoing trunk, means in said control device for recording the character of a calling incoming trunk and the character of the outgoing trunk to be selected responsive to signals transmitted thereto, voice amplifying repeaters for the outgoing trunk of said telephone connection, means in said control device responsive to said recordings for successively determining whether a repeater is required for the outgoing trunk, selecting the outgoing trunk and transmitting a signal to the selected outgoing line controlling the selection of an idle repeater for said outgoing trunk.

19. In a telephone system, an automatic switching telephone office, a link, a plurality of incoming and outgoing trunks of different character connected to said link, a plurality of equipments of different character accessible to said link, a plurality of selectable link control circuits each variably operable for selecting said different equipments, means in a trunk circuit for energizing a link to cause the selection of an idle link control circuit, a plurality of selectively operable devices in said control circuit, means in said trunk circuit for operating one of said devices for designating the selection of a particular character of equipment accessible to said link, means in said control circuit responsive to the operation of said devices for simultaneously testing a large plurality of equipments of said particular character and for selecting an idle one of said equipments and for operatively connecting said idle equipment to said link and means in said control circuit responsive to the connection of said equipment to said link for operating said link to connect said selected equipment to said trunk.

20. In a telephone system, an automatic switching telephone office, incoming trunks, outgoing trunks, different characters of equipment, a link having a primary switch connected to a plurality of said incoming and said outgoing trunks and secondary switches having access to a plurality of said different characters of equipment, a plurality of selectable link control circuits each variably operable for selecting said different equipments, means in a trunk circuit for energizing a link to cause the selection of an idle link control circuit, a plurality of selectively operable devices in said control circuit, means in said trunk circuit for operating one of said devices for designating the selection of a particular character of equipment accessible to the secondary switches of said link, means in said control circuit responsive to the operation of said devices for simultaneously testing a large plurality of equipments of the character designated by said trunk and for selecting an idle one of said equipments and for operatively connecting said idle equipment to the secondary link switch associated therewith, means in said control circuit responsive to the connection of said equipment to said secondary link switch for operating the primary and secondary switches of said link for connecting the selected equipment with said trunk circuit.

21. In a telephone system, an automatic switching telephone office, a link, a plurality of incoming and outgoing trunks of different character connected to said link, a plurality of incoming senders, a plurality of outgoing senders and a plurality of voice repeaters accessible to said link, a plurality of selectable link control circuits each variably operable for selecting said incoming senders, outgoing senders and repeaters, means in a trunk circuit for energizing a link to cause the selection of an idle link control circuit, a plurality of selectively operable devices in said control circuit, means in said trunk for operating one of said devices for designating the selection of an incoming sender, an outgoing sender or a repeater, means in said control circuit responsive to the operation of said device for selecting an idle incoming sender, outgoing sender or repeater as designated and for operatively connecting it to said link and means in said control circuit responsive to the connection of said incoming sender, outgoing sender or repeater to said link for operating said link to connect it to said trunk.

22. In a telephone system, an automatic switching telephone office, incoming trunks, groups of outgoing trunks, switches for interconnecting an incoming and an outgoing trunk for a telephone connection, a marker in said office, registers in said marker which are set for controlling the selection of an outgoing trunk of a particular character, devices in said marker operably responsive to said register setting for designating when a voice amplifying repeater shall be inserted in the talking conductors of an outgoing trunk, means in said marker for selecting and operating switches for interconnecting a calling incoming trunk to a selected outgoing trunk, means in said marker responsive to the operation of said switches for signaling said outgoing trunk to select a voice amplifying repeater, means operable in said outgoing trunk responsive to said signal for selecting said repeater and means in said outgoing trunk responsive to the selection of said repeater for inserting said repeater in the talking conductors of said outgoing trunk.

23. In a telephone system, automatic switches for establishing connections, an adjustable link, incoming senders and outgoing senders for controlling said switches, telephone repeaters, trunk

circuits, means in each trunk circuit for seizing said link for use, and other means in said trunk circuit for selectively operating said seized link to select an incoming sender, an outgoing sender or a repeater and to connect the same to said trunk circuit.

24. In a telephone system, an automatic switching telephone office, incoming trunks, outgoing trunks, a link switching mechanism connected to said trunks, a variably operable link switch controlling circuit, incoming senders, outgoing senders and repeaters available for selection by said link switch controlling circuit and for connection to said link switch mechanism, means responsive to the actuation of an incoming trunk for directing said link switch controlling circuit to select an incoming sender, means in said switch controlling circuit for operating said link switch mechanism to connect the selected sender to said incoming trunk, means in said incoming sender to register digits for controlling a telephone connection, means for selecting an outgoing trunk according to said registrations, means responsive to the actuation of said outgoing trunk for successively actuating said link switch controlling circuit and directing it to select an outgoing sender and a repeater and means in said link controlling circuit to operate said link switching mechanism for connecting the selected outgoing sender and the selected repeater to said outgoing trunk for completing said telephone connection.

25. In a telephone office, trunk circuits, a plurality of different characters of equipments, there being a plurality of equipments of each character, a link circuit having switches connected to said trunk circuit and other switches connected to each equipment of said different characters, a plurality of link-control circuits having selecting means for each character of equipment, means in said trunk circuit for actuating said link, means independent of said link switches for selecting a link-control circuit, means in said trunk circuit for transmitting a character discriminating signal to the selected link-control circuit, means in said control circuit responsive to said discriminating signal for selecting an idle equipment of the character signaled and means responsive to said selection for operating the link switches connected to the selected equipment and connected to the signaling trunk circuit for connecting said equipment with said trunk circuit.

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