June 6, 1944. A. J. BUSCH ET AL 2,350,873.

AUTOMATIC SWITCHING TELEPHONE SYSTEM

Filed Dec. 26, 1942 8 Sheets-Sheet 1

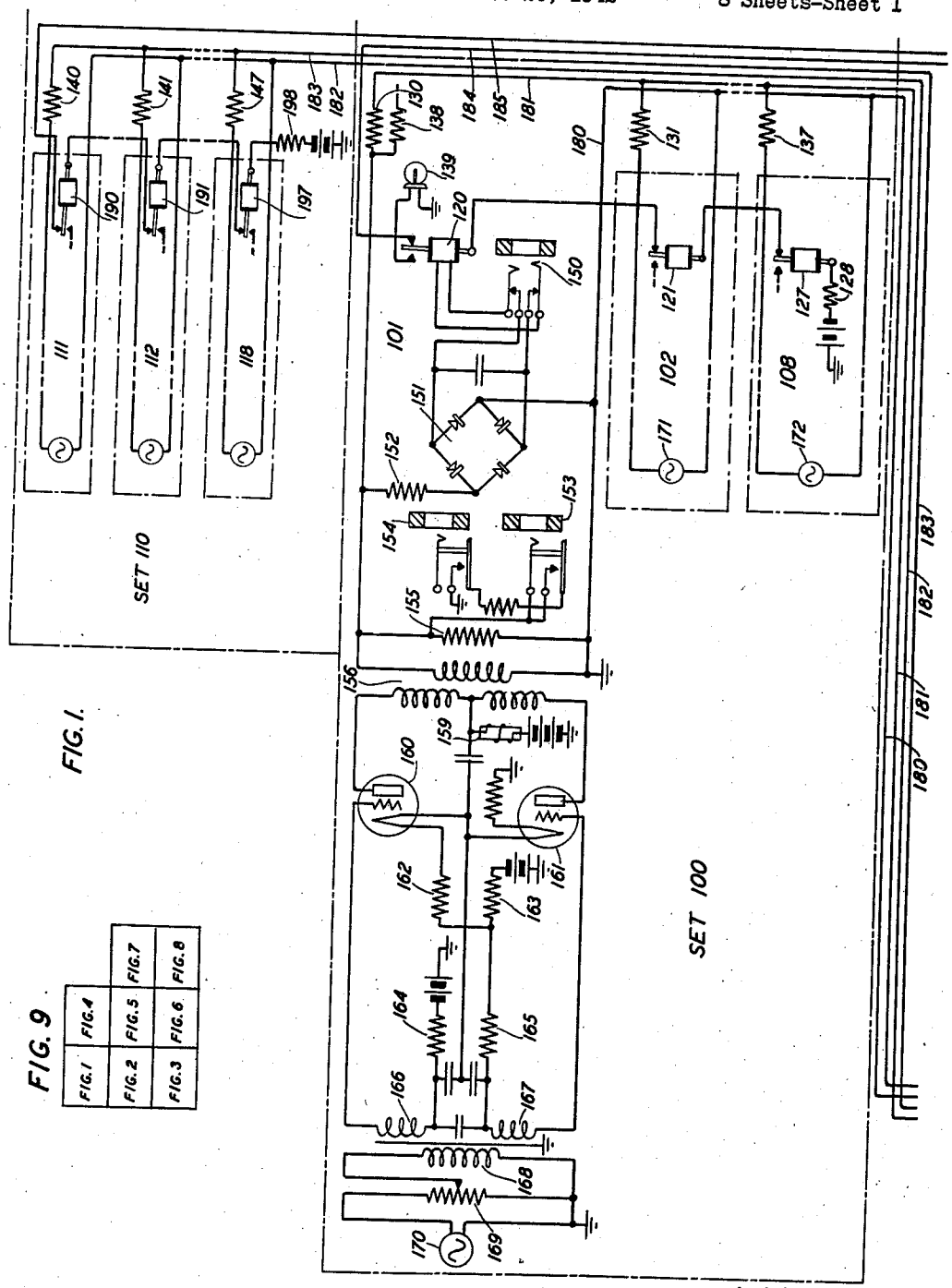

FIG. 1.

FIG. 9

FIG. 1	FIG. 4	FIG. 5	FIG. 7
FIG. 2		FIG. 6	FIG. 8
FIG. 3			

INVENTORS: A. J. BUSCH
I. H. HENRY
C. F. SEIBEL

BY M. R. McInnes

ATTORNEY

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AUTOMATIC SWITCHING TELEPHONE SYSTEM

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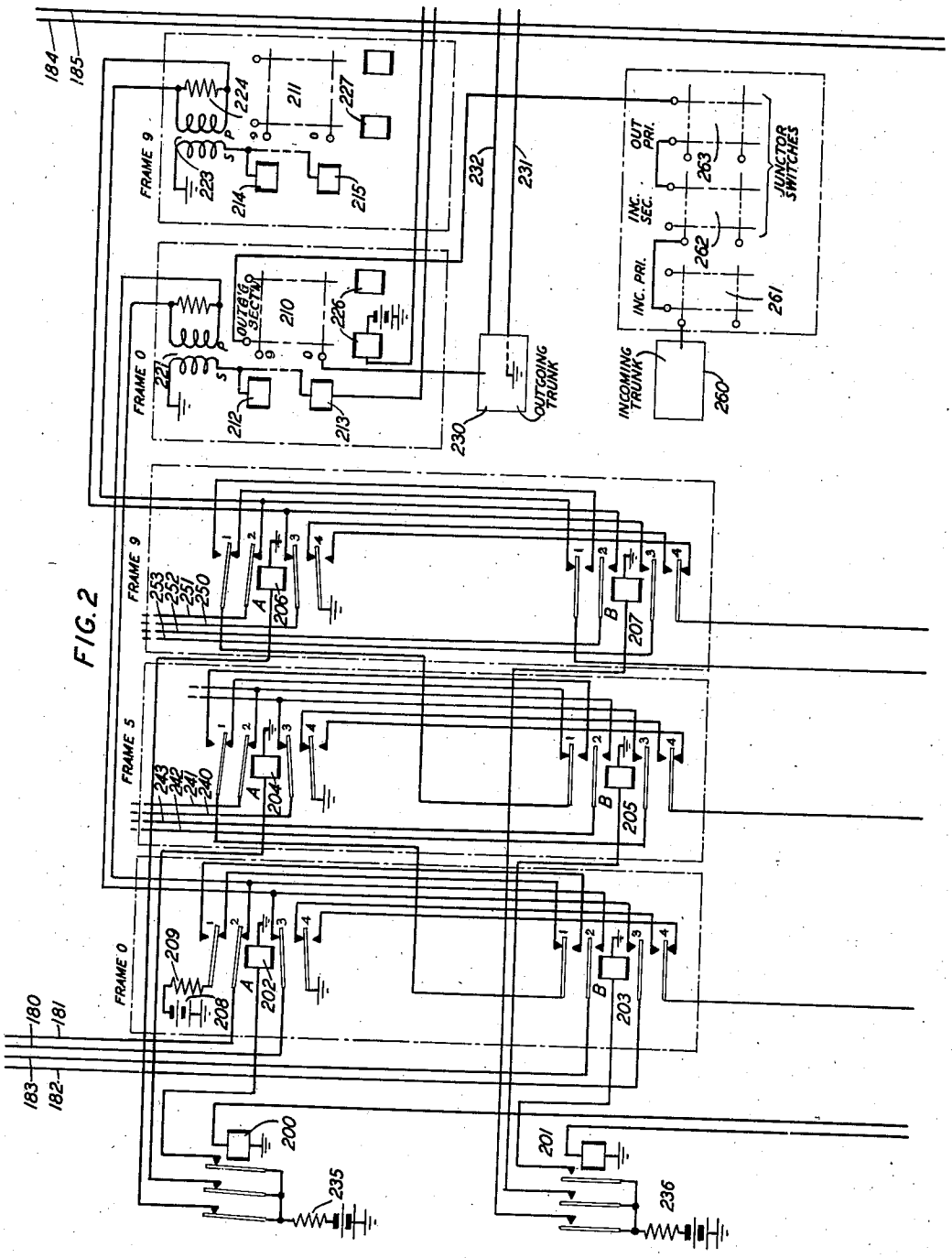

FIG. 2

INVENTORS: A. J. BUSCH
I. H. HENRY
C. F. SEIBEL

BY W. T. McKinney

ATTORNEY

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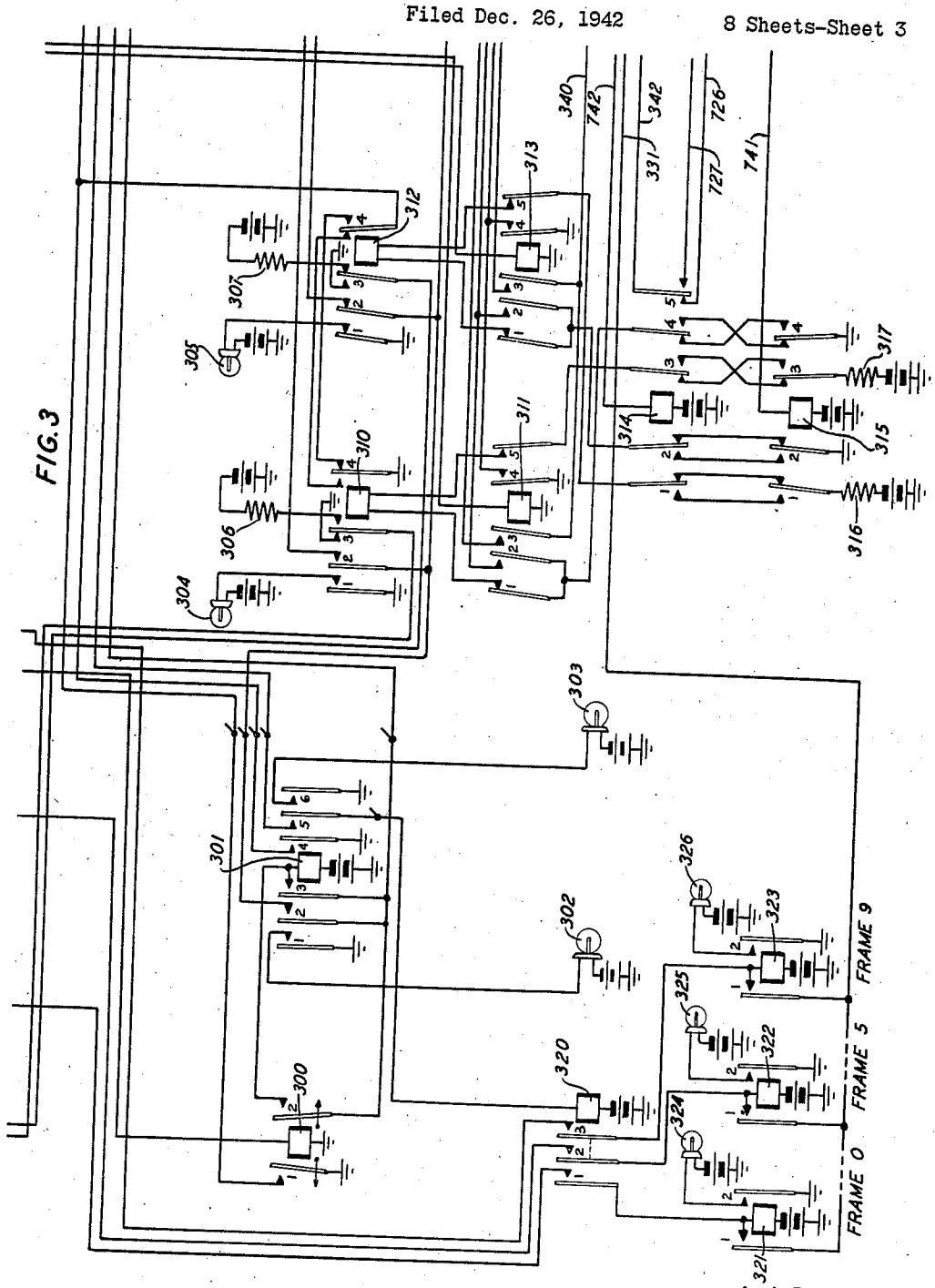
FIG. 3



INVENTORS: A. J. BUSCH
I. H. HENRY
C. F. SEIBEL

BY M. R. McKenney

ATTORNEY

June 6, 1944. A. J. BUSCH ET AL. 2,350,873

AUTOMATIC SWITCHING TELEPHONE SYSTEM

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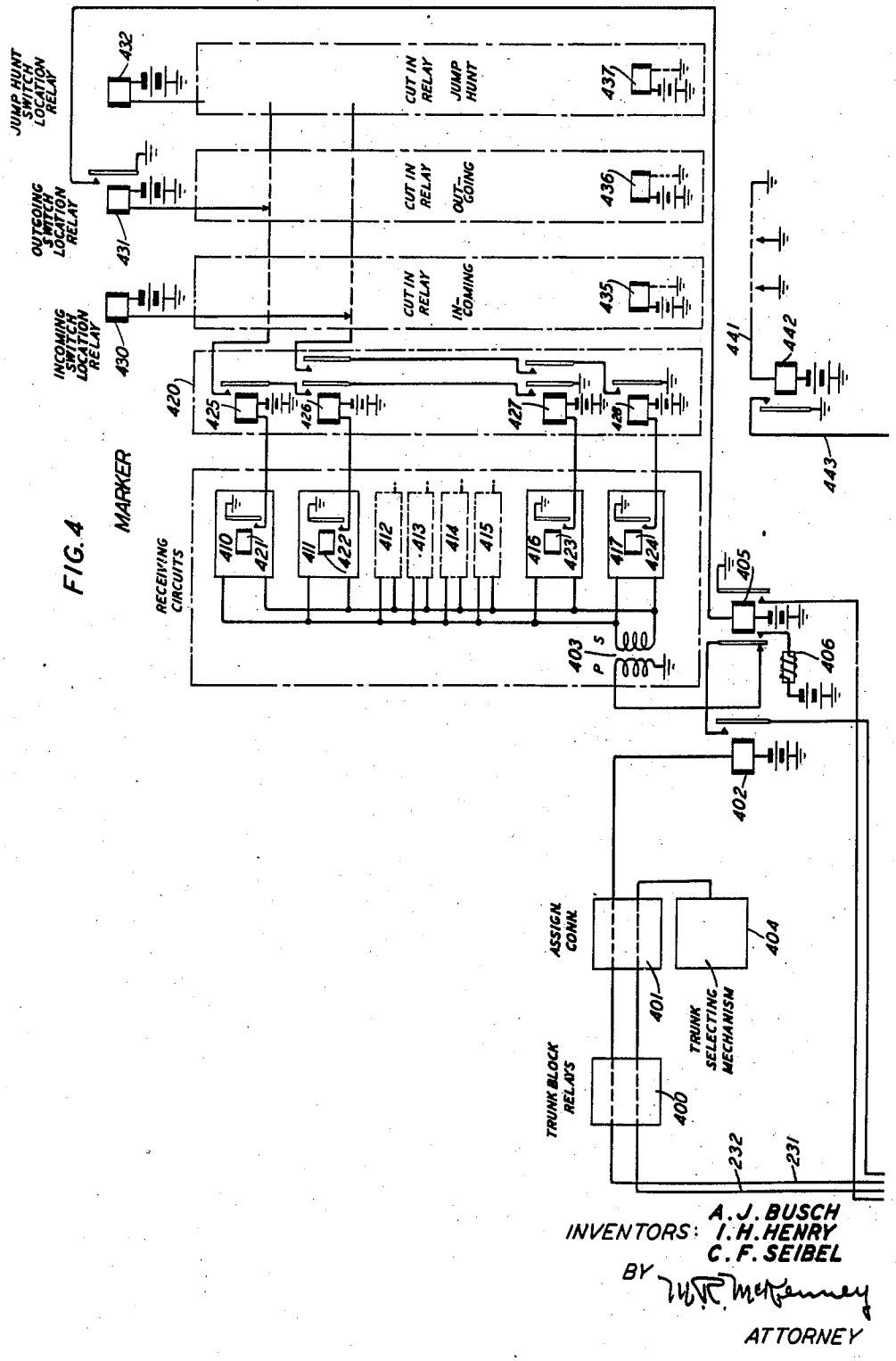

FIG. 4

INVENTORS: A. J. BUSCH
I. H. HENRY
C. F. SEIBEL

BY W. R. McGarvey

ATTORNEY

June 6, 1944. A. J. BUSCH ET AL 2,350,873

AUTOMATIC SWITCHING TELEPHONE SYSTEM

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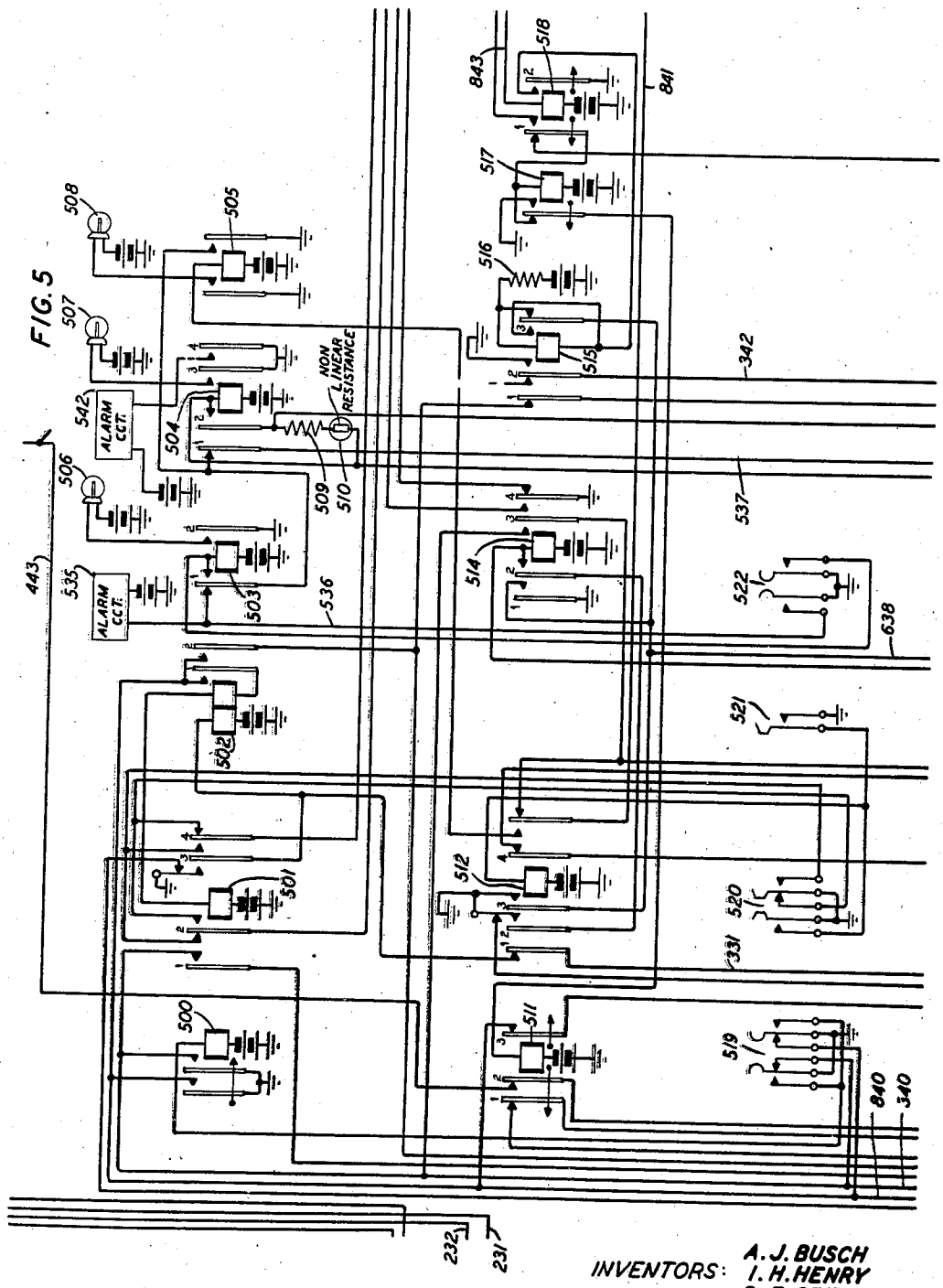
FIG. 5



INVENTORS: A. J. BUSCH
I. H. HENRY
C. F. SEIBEL

BY W. R. McKinney

ATTORNEY

June 6, 1944. A. J. BUSCH ET AL 2,350,873

AUTOMATIC SWITCHING TELEPHONE SYSTEM

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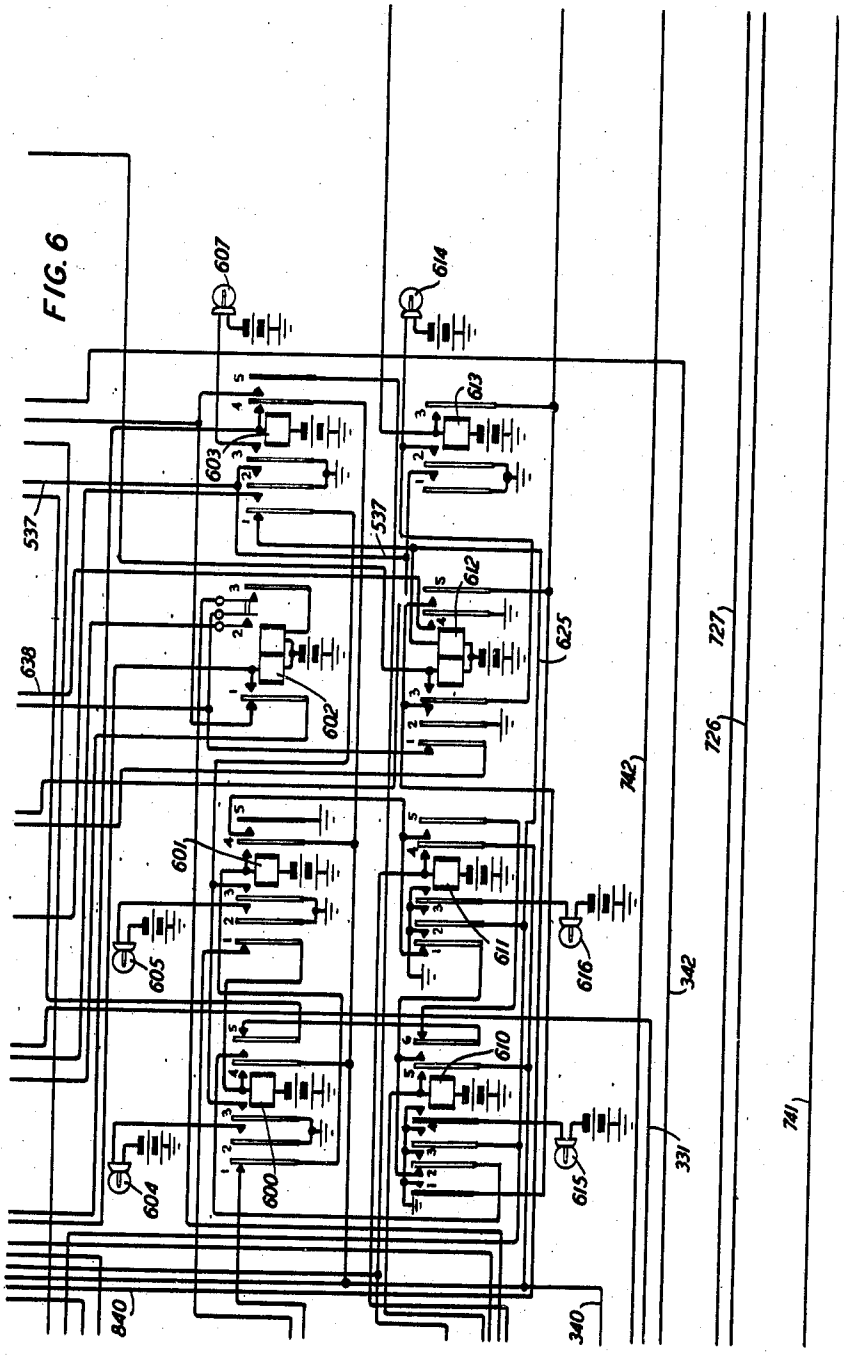
FIG. 6



INVENTORS: A. J. BUSCH
I. H. HENRY
C. F. SEIBEL

BY W. T. McKenney

ATTORNEY

June 6, 1944. A. J. BUSCH ET AL 2,350,873

AUTOMATIC SWITCHING TELEPHONE SYSTEM

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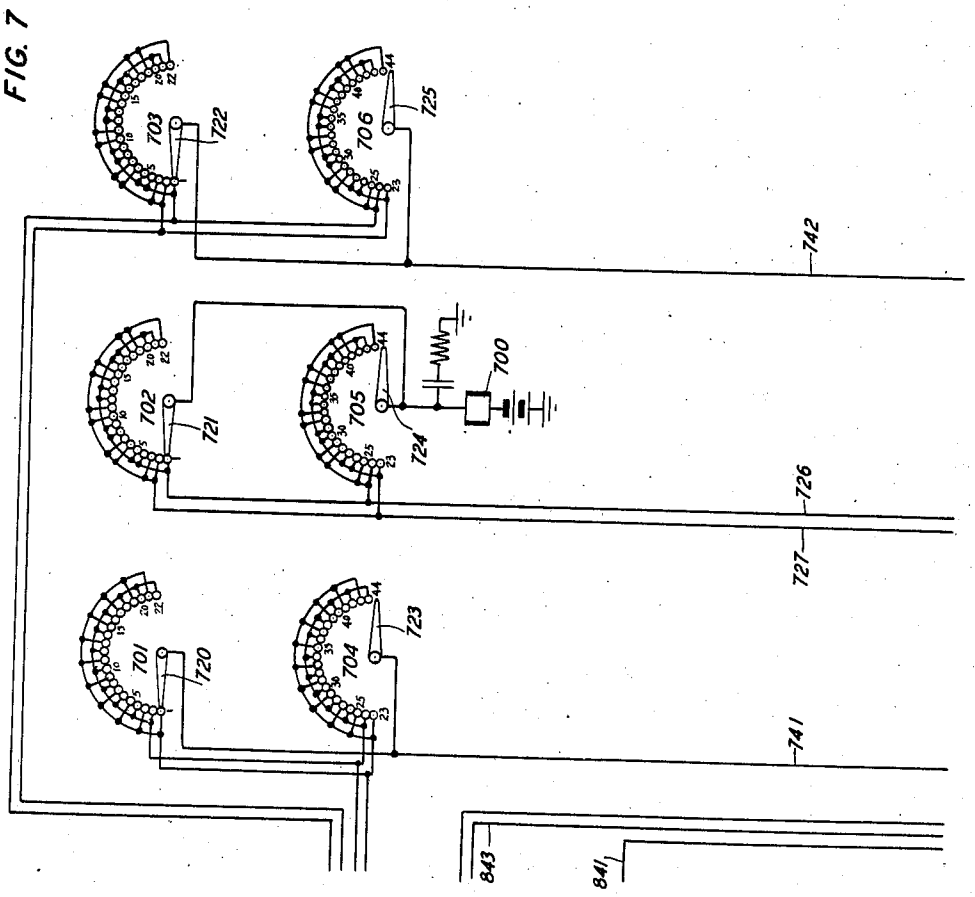
FIG. 7



INVENTORS: A. J. BUSCH
I. H. HENRY
C. F. SEIBEL

BY M. F. McKenney

ATTORNEY

June 6, 1944. A. J. BUSCH ET AL 2,350,873

AUTOMATIC SWITCHING TELEPHONE SYSTEM

Filed Dec. 26, 1942 8 Sheets-Sheet 8

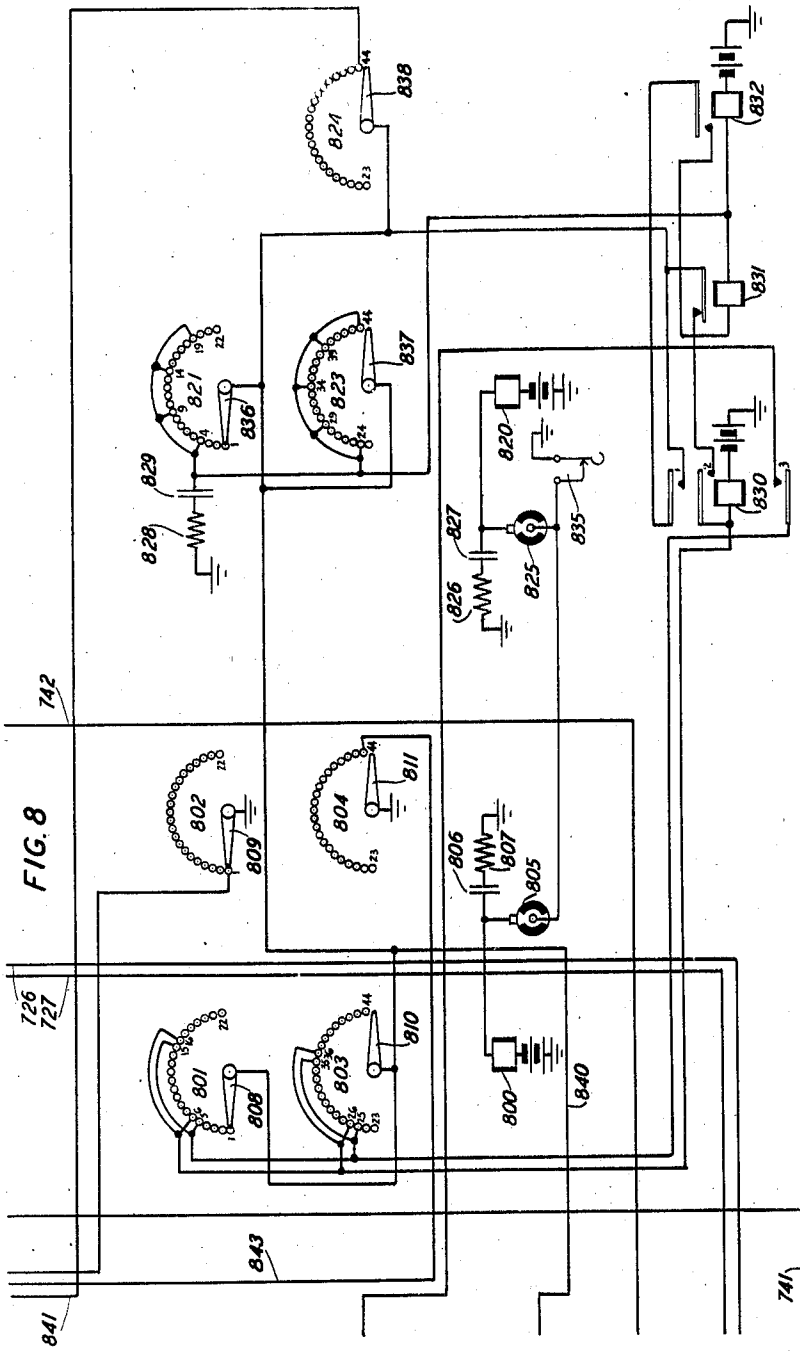


FIG. 8

INVENTORS: A. J. BUSCH
I. H. HENRY
C. F. SEIBEL

BY

ATTORNEY

Patented June 6, 1944 2,350,873

UNITED STATES PATENT OFFICE

2,350,873

AUTOMATIC SWITCHING TELEPHONE SYSTEM

Aloysius J. Busch, Madison, Israel H. Henry, East Orange, and Charles F. Seibel, Glen Rock, N. J., assignors to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application December 26, 1942, Serial No. 470,234

11 Claims. (Cl. 179—27)

This invention relates to automatic switching telephone systems and more particularly to multifrequency signaling devices for such systems.

The object of the invention is to obtain greater efficiency in telephone systems in which connections from incoming to outgoing trunks are completed by the control and operation of automatic switches mounted on a plurality of frames in a telephone office, to simplify the completion of connections in a minimum time period, and to provide a signaling system common to said incoming and outgoing trunks for determining the locations of switches connected to individual trunks.

According to the present invention a multifrequency signaling system is provided having duplicate multifrequency current supply sets arranged for alternate connection with the switches of an automatic switching system by a control mechanism for progressively transmitting signals of different combinations of currents of different frequencies to a plurality of tuned receiving circuits in markers, for effecting the operation of switch locating devices in said markers to direct the operation of the markers for locating and operating switches connected with selected incoming and outgoing trunks and intermediate junctor switches for completing telephone connections.

A feature of the invention resides in an automatically operable controlled mechanism for periodically connecting alternate duplicate multifrequency signaling current supply sets to the mechanism of an automatic switching system, with automatically operable means provided to nullify the periodic transfer when a failure occurs in the multifrequency system and place the alternate signaling current supply set in use with the mechanism of the switching system.

Another and related feature of the invention resides in a fault analyzing circuit associated with the automatically operable control mechanism and the switching system, combined with a signaling current supply set transfer mechanism and so arranged that a visible signal is energized to give the location of a fault in the multifrequency signaling system responsive to a failure in said multifrequency signaling system.

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:

Fig. 1 illustrates duplicate multifrequency current supply sets;

Fig. 2 the frame equipment for the multifrequency current sets and the switching system;

Fig. 4 illustrates diagrammatically a marker with a plurality of receiving circuits therein associated with the multifrequency current supply sets and switch locating devices;

Figs. 3, 5, 6, 7 and 8 illustrate control mechanism for controlling the association of alternate multifrequency current supply sets with the switching system in which Figs. 7 and 8 illustrate switches for controlling the periodic transfer of the multifrequency current supply sets; and

Figs. 3, 5 and 6 illustrate devices for nullifying the periodic transfer mechanism and causing an arbitrary transfer from one multifrequency current supply set having a fault therein to the alternate multifrequency current supply set.

The system chosen to illustrate features of this invention is in general similar to the one disclosed in Patent 2,236,246 to G. V. King et al., March 25, 1941. In the present system automatic switches of the cross bar type are disclosed for selectively establishing the desired connections and these switches are controlled by common register senders and common markers. The cross bar switches, the senders and markers for controlling said switches, the marker connectors for connecting the markers to said senders and the frame connectors which serve to associate the markers with the cross bar switch frames and the methods whereby the switches are controlled in their selective operations may be the same as disclosed in the aforementioned patent to King et al. For a better understanding of the detail structure and operation of the cross bar switch itself, reference is made to the patent to Reynolds, 2,021,329 of November 19, 1935.

General description

The multifrequency signaling system shown in Patent 2,236,246 issued March 25, 1941, to G. V. King, J. B. McKim, and O. Myers is in general of the same character as the multifrequency system shown herein along with the control circuit and control mechanism of the invention. The system disclosed in the patent, however, depends upon one current source supply set of a plurality of frequencies instead of duplicate current source supply sets such as 100 and 110 herein shown which are controlled in a manner to prevent the possibility of incomplete telephone connections because of failures in any part of the multifrequency signaling system. The telephone switching system may be of the same character as shown

and described in the aforementioned patent to King et al. The following is a brief outline of the multifrequency signaling system as it is associated and cooperates with the automatic telephone switching devices for completing telephone selections.

By reference to Patent 2,236,246, it will be seen that an incoming call energizes an incoming trunk circuit for the actuation of a link system which associates the incoming line with a sender in which registrations are recorded as transmitted over the line from a distant subscriber or a distant telephone office. The code registration recorded by the sender is transferred to a marker for the selection of one outgoing trunk and the operation of the switches. Let it be assumed, for example, that a registration has been made for connecting an incoming trunk from a distant office to an outgoing trunk extending to another distant office. The code registration for the selection of this outgoing trunk is set up in the marker by the sender which has been selected for this purpose. A route relay in the marker is thus actuated which will bring about the selection of an idle outgoing trunk extending to this particular office by associating the marker with a group of terminals with which these outgoing trunks are associated. To accomplish this a connector is energized for associating the marker with particular trunk block relays which may be connected to the group or groups of outgoing trunks extending to an office for which the call has been registered. When an idle outgoing trunk to this particular office is available, information is transmitted by signals to the marker which makes successive operations for completing the connection.

Any character of incoming trunk from various types of offices or subscribers may be connected to any character of outgoing trunk in this automatic switching telephone office. In view of the many characteristics of the different trunks and in view of the number of groups and subgroups into which these trunks must necessarily be divided, considerable information must be transmitted to the marker from various sources to guide the marker in completing a connection from an incoming trunk of a particular character, connected to a cross bar switch mounted on one of a large plurality of incoming trunk switch frames, to an outgoing trunk of the same or different character connected to a cross bar switch mounted on an outgoing trunk switch frame.

Due to the complexities of a mechanical switching system and the flexibilities required, no permanent connection is made between the marker and the cross bar switches. Frame connector units are used for connecting a large number of incoming secondary cross bar switches and outgoing primary cross bar switches with the marker for establishing circuit paths over leads between an incoming primary cross bar switch to which a calling incoming trunk is connected and an outgoing secondary cross bar switch to which an idle outgoing trunk is connected. These frame connector units are, however, selected by the marker through the aforementioned connectors according to the location of the incoming trunk and outgoing trunk switches over certain frames after the location of these switches is indicated by a multifrequency signaling circuit to the marker. The incoming trunk primary cross bar switch is associated with the marker through the calling incoming trunk, a link switch, and a trunk assignment connector which, with the exception of the incoming trunk bear no designated or numerical relation to the incoming primary switch or the frame on which this cross bar switch is mounted. These units of equipment may be used for calls from many different incoming trunks connected to variously located incoming primary switches. This is also true of the outgoing trunk secondary cross bar switch which is associated with the marker through the outgoing trunk equipment, patching jacks which are used for flexibilities in arranging trunk groups, trunk group relays and connectors.

Since no connection exists between the incoming primary or outgoing secondary switches and the marker except through units of selectable equipment which are common to different frames of switches, the multifrequency signaling system is included in this mechanical switching system to transmit signals to the marker giving the location of the switches connected to the incoming and outgoing trunks selected for a telephone connection. This signaling system is associated with the marker through the incoming primary cross bar switch, the apparatus of the calling incoming trunks and thence over circuits established through the units of equipment selected for connecting this trunk to the marker. The signaling system is also connected through the outgoing secondary cross bar switch, associated with the selected idle outgoing trunk, to the marker over circuits established through units of equipment selected for connecting this outgoing trunk to the marker.

In this signaling system electrical currents of different frequencies are variously combined to obtain a large plurality of different signals equivalent to the large plurality of switch frames in the machine switching office. The signaling system is also used for indications to the marker that the trunks of the group tested are all busy and that a group of trunks has been added to this regular group of trunks and that the added group may be found on a different frame from the one on which the regular trunks are located. In this case the signaling system causes an adjustment of the apparatus in the marker for associating the marker with the added group of trunks. If an idle trunk is selected from the latter group, a multifrequency signal is automatically transmitted to the marker giving the location of the switch connected with the selected idle trunk.

The organization of the signal transmitting apparatus is in general as shown in Fig. 8 of Patent 2,236,246 to G. V. King et al. and as shown in Fig. 1 of the accompanying drawings. The patent shows one signal transmitting set and the accompanying drawings show two such signal transmitting sets **100** and **110**, each set comprises a plurality of current sources which are shown as generators or oscillators, each having an amplifying system and each having associated therewith a plurality of resistances for distributing the load and to facilitate the connection of frequency combinations with transformers associated with each cross bar switch frame. Eight generators are shown in each set, each generator supplying current of a different frequency, each set is the same and, therefore, the current sources of each set are of the same eight frequencies. The output of three amplifiers is combined for each multifrequency signal and thus currents of three frequencies are simultaneously transmitted

from the current source set to the receiving circuits of the marker as later explained. For example, the output current from three transformers such as transformer 156, and two similar transformers and amplifiers supply currents of three different frequencies over leads 180 and 181. These leads are connected to the equipment of a particular cross bar switch frame which comprises transformers and the select magnets associated with the horizontal contacts of the cross bar switches on this frame. A large number of combinations of three frequencies each, may be connected to the equipment of the various cross bar switch frames or equipment of the office to supply different signaling current combinations to each one of the frames of the equipment throughout the office. As will be apparent from the circuit drawing the current of three different frequencies connected to lead 181 extends through the contact of the frame relay 202, primary winding of transformer 221, returning to the amplifiers over lead 180 to ground in each amplifier. The currents of different frequencies are transmitted to the secondary coil of transformer 221, thence through windings of select magnets such as 212 or 213 on this frame of switches, to the input winding of transformer 403 where a connection is established by the selected trunk and marker equipment. The secondary of transformer 403 is connected to the receiving circuits of the marker. The combination of three frequencies is thus transmitted to the receiving circuit of the marker that is completing a telephone connection and this signal, as later described, supplies the marker with the location of the switches associated with the trunks which have been taken for use. Successive signals are transmitted for the location of switches connected to the incoming trunk and the outgoing trunk. The same character of signal applies to switches connected to all trunks and consequently for this description only one trunk has been shown connected with the marker. Each location signal, however, comprises a different combination of current frequencies.

The receiving system of each marker comprises a plurality of receivers each having a filter which passes a particular frequency and an amplifier with a tuned transformer which is actuated by the current source of a given frequency. As herein stated, three frequencies are simultaneously transmitted by transmitting set 100 or transmitting set 110 and in consequence of this, three receiving circuits of the marker are actuated. The frequencies transmitted energize the tubes in each of the three receiving circuits which create a plate current for operating three relays, such as relays 421, 422 and 423. A group of relays 420 is selectively operated by the relays associated with each receiving circuit which make a combination for associating a signal path with a particular lead resulting from the three frequencies connected to the receiving circuits. This signal is transmitted to cut-in relays depending upon whether the indication to be transmitted applies to an incoming trunk or an outgoing trunk. If the signal applies to an incoming trunk, the incoming trunk switch cut-in relay 435 is energized by the marker which then operates the incoming trunk switch location relay 430 to associate the marker equipment with switches connected to the trunk. Likewise, a similar signal is transmitted from three other frequency sources to again operate the receiving circuits which in this case will operate three different receiving circuits so that a different combination of relays 420 is energized. The marker at this time energizes the outgoing trunk cut-in relay 436 which energizes the outgoing trunk switch location relay, such as 431, to give the marker the location of the switches connected to the selected outgoing trunk.

The calling incoming trunk may be any trunk located in any group of frames and a path through the cross bar switches must be found to a selected outgoing trunk switch on any of the outgoing frames. Combinations of incoming secondary and outgoing primary cross bar switches must, therefore, be operated for connecting the talking and signaling leads between any of the incoming primary cross bar switches and any of the outgoing secondary switches. The marker is thus guided by the multifrequency signaling combinations to associate itself with particular frame connectors such as shown in the aforementioned patent to King et al. to reach frames having switches to be used for establishing connections responsive to the registrations recorded in the marker. Connectors of this character are associated with all frames of the office associated with both the incoming and outgoing trunks. In this manner, the switches of the automatic switching telephone office are energized for connecting an incoming calling line with an outgoing trunk or outgoing line.

As herein stated, two multifrequency current transmitting sets 100 and 110 are used in the automatic switching telephone office in order that a failure in one will not affect the completion of telephone connections and the control circuit of the invention is organized to control the transfer from one transmitting set to the other under varied conditions which may be encountered to guard the switching equipment against failures of any character. The control circuit of the invention has relays A shown in Fig. 2 associated with three frames of trunk switches, one relay per frame, for connecting the multifrequency current supply set 100 to the telephone switching system and relays B associated with three frames of trunk switches, one relay per frame, for connecting the multifrequency current supply set 110 to the telephone switching system. The relays A and B are operated by the control circuit automatically responsive to failures in any of various parts of the multifrequency system as later described in detail. Normally, in order that one multifrequency current supply set be used as often as the other, the supply sets 100 and 110 are alternately connected with the telephone switching system periodically by the alternate operations of relays A and B under the regulation of switches shown in Figs. 7 and 8. The periodic transformer controlling mechanism of Figs. 7 and 8 is, however, automatically made ineffective whenever a failure in the multifrequency signaling system occurs. Failures may occur from a fault in an individual marker, multifrequency circuit, in the equipment associated with a trunk frame, or in the multifrequency current supply sets 100 or 110 any of which bring about the automatic transfer to the alternate current supply set. Should a failure occur in the multifrequency current supply set which is not at the time in use, the operation of the control circuit is automatically altered to prevent switching to this current supply set under any condition until the fault has been repaired.

Detail description

The relays A and B, **202** to **207**, inclusive, have been shown for three frames of cross bar switches, frame **0**, frame **5** and frame **9** which may be considered as three of the first ten frames in the automatic switching telephone office. The office may have a large number of frames for both incoming and outgoing trunks. Switching equipment has been shown diagrammatically for two frames, frame **0** and frame **9**. The multicontact relays **200** and **201** each have a number of contacts thereon equivalent to the number of relays A or B and therefore equivalent to the number of frames in the automatic switching telephone office. Relays **200** and **201** are operated and released by the control mechanism under varying conditions as hereinafter described for operating either the A relays for connecting the multifrequency current supply set **100** to the frame switching equipment or the B relays for connecting the multifrequency current supply set **110** to the frame switching equipment.

Each frame location signal consists of current of three different frequencies from generators or oscillators associated with amplifiers, the output of each amplifier being connected to as many load distributing or mixer resistances, such as **130**, **138**, as are required for signal circuits. For convenience these resistances will be known herein as mixer resistances, one from each of three different amplifiers being connected together to form a combination of currents of three different frequencies for a multifrequency signal. An example of the frequencies of the current output of eight amplifiers, such as may be used in each multifrequency current supply sets may be given as 425 cycles, 595 cycles, 765 cycles, 935 cycles, 1105 cycles, 1275 cycles, 1445 cycles and 1615 cycles. The oscillators, amplifiers and mixer resistances are furnished in duplicate as shown for sets **100** and **110**, Fig. 1, which are both constantly energized unless a fault occurs in one of the oscillators or amplifiers. The output of the amplifier transformers, such as transformer **156**, is constantly impressed upon the mixer resistances and thus a current flow is established whenever any current frequency combination is connected to the mechanism of a marker, such as diagrammatically shown in Fig. 4 by the selection of a trunk circuit. As shown in the drawings, Figs. 2 and 4, when an outgoing trunk circuit is selected by the marker over lead **232** a relay in trunk **230** responds for connecting ground to lead **231** which operates relay **402** in the marker for connecting the combination of curents of three different frequencies with the receiving circuits connected with transformer **403** to establish the location of this trunk for the marker and the frame location of the switches connected to this trunk. The receiving circuits in each marker are tuned to respond to the aforementioned frequencies, one receiving circuit for current of each frequency. Since three frequencies are transmitted simultaneously over a single lead, there are three receiving circuits which respond to operate three corresponding relays in the marker. The combination of relays which is operated for establishing the switch location is fully described in the aforementioned Patent 2,236,246 to G. V. King et al. and need not be repeated herein. An example is however diagrammatically shown in which the energization of receivers **411**, **416** and **417** energizes a relay combination for operating the incoming trunk switch location relay **430** when the cut-in relay **435** is operated and the energization of receivers **410**, **411** and **416** energizes a relay combination for operating the outgoing trunk switch location relay **431** when cut-in relay **436** is operated.

Relay **200** is shown energized which energizes the relays A to connect output current from all amplifiers in the multifrequency current supply set **100** with the telephone switching system, to be connected in varying combinations to the receiving circuits when an idle trunk is selected by the marker. A failure in some part of the system or the automatic advance of the periodic transfer control equipment will disconnect the multifrequency current source supply set **100** from the switching system and connect the multifrequency current source supply set **110** to the switching system.

The periodic transfer from one multifrequency current source supply set to the other will first be described. The switches shown in Figs. 7 and 8 are arranged to take forty-four steps from the normal position and return thereto for one cycle of operation. By reference to Fig. 7 it will be apparent that when switch brush **720** has traveled step by step over the terminals of switch arc **701** from terminal **1** to terminal **22** the switch brush **723** will be in position to advance to terminal **23** of switch arc **704** upon the next step forward of the switch brushes. Brush **723** then makes twenty-two forward steps to again arrive in the position shown which also brings brush **720** into the position shown associated with terminal **1**. Switches **700**, **800** and **820** are arranged to operate in this manner. Switches **800** and **820** are continuously operated under the control of interrupters **805** and **825** which, however, may be disconnected by the operation of key **835**. Switch **700** is under the control of switch **800**.

Each operation of the control circuit is check tested so as to remove the probability of failure in the control circuit and thus remove the probability of failure in supplying the multifrequency currents to the marker. A general idea of the periodic transfer equipment will precede the detailed description of this equipment. It will be noted that relays **312**, **311**, **313**, **314** and **315** are shown energized in order that one of the multifrequency current supply sets may be shown actively serving the telephone switching system. A circuit is thus established for relay **200** from ground through its winding contact **3** of relay **312**, resistance **307** to battery. This position of these relays is checked by the control circuit as later described. Circuits are established for relays **311** and **313** by the current supply sets. Each amplifier of the current supply sets has a rectifier connected to the output coil of its transformer for creating a direct current circuit to operate relays **120**, **121** to **127** in current supply set **100** and relays **190**, **191** to **192** in current supply set **110**. Since all amplifiers are normally energized by their associated oscillators these relays are all normally operated and a chain circuit is thus established through their contacts, one of which may be traced from battery, through resistance **128**, contacts of relay **127** to relay **120**, thence over lead **184**, winding of relay **313** to ground. A second circuit may be traced from battery, through resistance **198** of supply set **110**, through the contacts of relay **197** to relay **190**, thence over conductor **185**, winding of relay **311** to ground. Relays **311** and **313** are therefore normally operated and the release of either of these relays establishes circuits for actuating the control

mechanism as later described. The release of any of the relays, such as 120, associated with each amplifier lights a lamp, such as 139, so that an amplifier which is not supplying current may be easily detected. Various combinations are established with relays 314 and 315, the purpose of which will be clearly apparent from the description. In position one of the control switches, a circuit is established for relay 314 from battery, through its winding, conductor 742, brush 722 of switch arc 703, contact 4 of relay 501, key 520 to ground. A circuit is established for relay 315 from battery, through its winding, conductor 741, brush 720 of switch arc 701, contact 4 of relay 514 to ground.

The control circuit is shown arranged to disconnect one multifrequency supply set from the switching system and connect the other one thereto every eighty-eight steps of switch 800 which comprises two complete cycles of this switch. Switches 800 and 820 are advanced in unison when interrupters 805 and 825 connect ground through their individual segments, one through switch magnet 800 to battery and the other through switch magnet 820 to battery. The switches therefore are started forward for counting a period of time when the multifrequency current supply set 100 is connected to the telephone switching equipment. When brush 808 reaches terminal 6 of arc 801 a circuit is established for relay 830 from battery, through the winding of this relay, switch terminal and brush 808 over conductor 840 to ground on key 519. Relay 830 in operating establishes a locking circuit for itself through its contact 2, contact of relay 831 to ground over conductor 840. When switch brush 836 reaches terminal 9 of arc 821 a circuit is established for relay 832 from battery, through its winding, contact and brush, as recited, to ground, over conductor 840. It will be noted that this relay operates when brush 836 reaches terminal 4 but for the first operation as now being described the relay will release without producing any action, terminal 4 is used upon the next cycle of this switch. This relay remains operated during the time that brush 836 is resting on terminal 9 which shunts the winding of relay 831 so that the latter relay does not operate until brush 836 moves off of terminal 9. At this time a circuit is established for relay 831 from battery in series with relay 832, contact of relay 832, contact 1 of relay 830 to ground, over conductor 840. The operation of relay 831 opens the locking circuit for relay 830 which releases, thus releasing both relays 832 and 831. If switch brush 808 arrives at terminal 15 and relay 830 has not been properly released by the action of switch 820, a circuit is established for relay 613 which may be traced from battery, through the winding of this relay, contact 3 of relay 830, terminal 15 of arc 801, brush 808, to ground, over conductor 840. This indicates that the switches 800 and 820 are not stepping in unison and consequently lamp 614 is lighted from battery through its filament, contact 2 of relay 613 to ground. An audible alarm is also given. This alarm circuit may be traced from ground, through contact 1 of relay 613, conductor 537, contact 1 of relay 504, contact 1 of relay 503 to battery through the audible alarm mechanism. This check of the movement of two switches continues every few terminals as is apparent from the switch terminal strapping as the switch rotates from terminal 1 to terminal 44.

In position 44 of switch 800 a circuit is established for relay 518 which may be traced from battery through its winding, conductor 843, terminal 44 of arc 804, brush 811 to ground. Relay 518 establishes a circuit for relay 515 from ground on its contact 2, winding of relay 515, resistance 516 to battery. A circuit is thus established for switch magnet 700 from battery through its winding, brush 721, terminal 1 of switch arc 702, conductor 726, contact 5 of relay 314, conductor 342, to ground on contact 2 of relay 515. Upon the next step of switch 800 from position 44 to position 1 under control of interrupter 805 the circuit for relay 518 is opened. The latter relay is slow to release so that in position 1 of switch arc 802 a circuit is established for relays 517 and 511 in multiple which are also slow to release. The latter two relays in operating open circuits which prevent interference with the circuit action taking place in the periodic transfer mechanism if an automatic transfer from a failure should be simultaneously attempted by other devices of the control circuit. The release of relay 518 opens the circuit for relays 517 and 511 and at the same time opens the circuit for relay 515. Relay 515 immediately releases while relays 517 and 511 momentarily remain in their operated positions. The release of relay 515 opens the energizing circuit for magnet 700 causing brushes 720 to 725 inclusive, to move forward one step from terminal 1 to terminal 2. The movement of brushes 720 and 722 opens the circuits extending through the windings of relays 314 and 315 which release. This is the first step in a different formation of relays 314 and 315 but the release of these relays on the forty-fourth step of switches 800 and 820 does not affect a transfer from current supply set 100 to current supply set 110 since relay 312 remains operated and relay 310 remains normal. The circuit for relay 312 with both relays 314 and 315 released, may be traced from battery through resistance 316, contact 1 of relay 315, contact 1 of relay 314, contact 5 of relay 313, winding of relay 312, contact 1 of relay 313, contact 2 of relay 314, contact 2 of relay 315 to ground.

Relays 314 and 315 now remain released during the second rotation of switches 800 and 820. The following table gives the different positions taken by relays 314 and 315 and the consequent operated and normal positions of relays 312 or 310, during the rotation of switches 800 and 700. The utility of these combinations will be recognized under different control measures taken by the control circuit.

Relay 315	Relay 314	Relay 312	Relay 310	Switch 800	Switch 700	Set connected
OP	OP	OP	NOR	44	1	100
NOR	NOR	OP	NOR	88	2	100
OP	NOR	NOR	OP	44	3	110
NOR	OP	NOR	OP	88	4	110

Returning now to the action of the switches in Fig. 8, switch 800 continues to step in synchronism with switch 820, the action of which is checked in every few steps by relays 830, 831 and 832 as previously described. When the brushes of switch 800 again reaches terminal 44, brush 811 again connects ground with conductor 843 to operate relay 518 thus establishing a circuit to operate relay 515 as previously explained. Relay 515 establishes a circuit for magnet 700 which may be traced from ground through its contact 2, conductor 342, armature and outer contact 5 of relay 314 which is now released, thence over conductor 727, terminal 2 of switch arc 702, brush 721, winding of magnet 700 to battery. The brushes of

switch 800 are advanced by interrupter 805 and when brush 811 moves away from the terminal 44, the circuit for relay 518 is open but as previously stated this relay is slow to release and remains operated while brush 809 connects ground through terminal 1 of arc 802, contact 1 of relay 518, winding of relay 517 and winding of relay 511 in multiple, which operate the latter two relays to prevent interference from other mechanism of the control circuit as previously described. Relay 518 releases which immediately releases relay 515, opening the circuit through the switch magnet 700, causing this switch to advance from terminal 2 to terminal 3. This occurs after the eighty-eighth step of switch 800.

Switch to multifrequency current supply set 110

By reference to the foregoing table it will be seen that relay 314 remains normal and relay 315 is operated and that at this time the multifrequency current supply set 100 is disconnected from the switching system and multifrequency current supply set 110 is connected thereto. The circuit for relay 315 may be traced from battery through its winding, conductor 741, brush 720, terminal 3 of arc 701, to ground on contact 4 of relay 514. Since the circuit for relay 314 extends over lead 742 through brush 722 and terminal 3 of arc 703, contact 2 of relay 501 to the outer contact of key 520 which is open, it may be seen that no circuit is established for relay 314 at this time. With relay 315 operated and relay 314 normal, the circuit for relay 312 is opened and a circuit is established for relay 310. The circuit for relay 310 may be traced from battery through resistance 317, contact 3 of relay 315 operated, contact 3 of relay 314 normal, contact 5 of relay 311, winding of relay 310, contact 1 of relay 311, contact 4 of relay 314 normal, contact 4 of relay 315 operated to ground. It may be seen that the circuit for relay 312 is open by the operation of relay 315 when relay 314 remains normal since the circuit for this relay is open through contacts 1 and 2 of relay 314 or contacts 1 and 2 of relay 315 whichever viewpoint is taken.

The release of relay 312 opens the energizing circuit for relay 200 and, therefore, the A relays on all of the switch frames throughout the automatic switching system are released which disconnect the frequency current supply set 100 from the switching equipment of the office. The operation of relay 310 establishes an energizing circuit for relay 201 from battery through resistance 306, contact 3 of relay 310, winding of relay 201 to ground. Relay 201 establishes obvious circuits for the B relays on each frame of the automatic switching office, three of which are indicated 203, 205 and 207. The amplifiers of supply set 110 thereof which are shown, furnish current of the same frequencies and in the same order as the amplifiers shown for set 100 and, therefore, the leads shown connected to the switch system furnish current of the same frequencies as those which were disconnected. There may be six to ten amplifiers in each multiple frequency current supply set, all of which are connected through the contacts of the A or B relays to the switching equipment of the office which are all transferred at the same time. In the present disclosure, conductors 180 and 181 from current supply set 100 are disconnected by the release of the A relay 202 and conductors 182 and 183 from current supply set 110 are now connected through the contacts of the B relay 203 to transformer 221. The leads shown connected to transformer 223, frame 9, extend through the contacts of B relay 207 to a different combination of amplifiers from those connected to leads 182 and 183 and, therefore, different combinations of currents of three different frequencies are connected through transformer 223 from those connected to transformer 221.

When switch 800 has completed another cycle of forty-four steps, relay 518 is again energized which again energizes relay 515 causing the energization of switch magnet 700. The switch 800 then steps from position 44 to position 1 as previously described, causing the release of relays 518 and 515, and the deenergization of magnet 700 which causes the switch brushes 720 to 725 inclusive, to step from terminal 3 to terminal 4 which now brings about the operation of relay 314 and the release of relay 315. Relay 314 is energized from battery through its winding over conductor 742, brush 722, terminal 4 of arc 703, contact 4 of relay 501, to ground on key 520. In position 4 of switch 700, the circuit for relay 315 is opened since by tracing this circuit over leads 741 to brush 720, and terminal 4 of arc 701, it will be found that this circuit extends to contact 4 of relay 514 which is normal and at this time open. With relay 314 energized and relay 315 normal, the circuit for relay 310 remains energized so that at this time no change is made in multiple frequency current supply sets.

Switch to multifrequency current supply set 100

At the end of the next cycle of switch 800 when brush 811 reaches terminal 44, relays 518 and 515 are again energized to energize magnet 700 which is deenergized when brush 811 moves away from terminal 44 causing the brushes of switch 700 to move from terminal 4 to terminal 5. At this time both relays 314 and 315 are again energized, relay 315 from battery through its winding over conductor 741, brush 720, terminal 5 of arc 701, to ground on contact 4 to relay 514 and relay 314 from battery through its winding, conductor 742, brush 722 and terminal 5 of arc 703, contact 4 of relay 501 to ground on key 520. The operation of both relays 314 and 315 after the second eighty-eight steps of switch 800, deenergizes relay 310 and energizes relay 312 for transferring from current frequency supply set 110 back to current frequency supply set 100. The circuit which is opened for relay 310 and the circuit which is established for relay 312 are believed clear and need not be repeated. The release of relay 310 opens the circuit of relay 201 which releases the B relays on all frames of the office to disconnect the amplifiers of the multiple frequency current supply set 110. The operation of relay 200 through contact 3 of relay 312 operates the A relays on all of the frames throughout the switching system to connect the amplifiers of multiple frequency current supply set 100 to the switching equipment of the office.

In the foregoing manner the continued forward stepping of switch 700 under the control of switch 800 automatically causes the connection of alternate multifrequency current supply sets to the mechanism of the automatic telephone switching system every eighty-eight steps of switch 800.

Multifrequency current supply set failure

Let it now be assumed that a failure occurs in one of the amplifiers or one of the oscillators in multifrequency current supply set 100 which at this time is connected to the automatic switch-

ing telephone system. This would mean that relay 314 and relay 315 are either both operated or both released, that relay 312 is operated, relay 200 is operated and, consequently, relays A are operated for connecting the multifrequency current set sources from amplifiers 101 to 108 in combination to the transformers such as 221 and 223 for operating the receiving circuits in the marker when a trunk is selected by the marker and the proper cut-in relays of the marker are operated. Let it also be assumed that the periodic switching arrangement controlled by the switches of Figs. 7 and 8 is in operation which has at this time connected the multifrequency current supply set 100 to the switching system.

For this description, it will be assumed that there is a fault in the oscillator 170 or that tube 160 or 161 has burned out, either of which would prevent the transmission of current of the frequency generated by oscillator 170 from reaching the output transformer 156 and the current of this frequency would not be transmitted to the switching system. It would also prevent current from reaching the rectifier 151 and, therefore, no current would flow through the winding of relay 120 and this relay would be released. The release of relay 120 lights lamp 139 and opens the circuit for relay 313, since relay 313 depends for its operating circuit upon all relays being operated which are associated with all of the amplifiers in the multifrequency current supply set 100. The release of relay 313 opens the energizing circuit for relay 312 and the release of relay 312 opens the energizing circuit for relay 200 which releases the A relays on all frames in the office, three of which are shown, 202, 204 and 206. The release of the latter relays opens the multifrequency current supply to the frame transformers such as 221 and 223 and, consequently, opens the multifrequency current supply set to the receiving circuits of the marker. The release of relay 313 establishes a circuit for relay 611 which may be traced from battery through the winding of the latter relay, contact 3 of relay 313, conductor 340 which extends to ground on release key 519. Relay 602 is operated from battery through its left winding, contact 1 of relay 511, contact 2 of relay 313, contact 2 of relay 314, contact 2 of relay 315 to ground. It will be remembered that at this time relays 314 and 315 may either be both operated or both released. Relay 602 in operating establishes a circuit for relay 514 traced from battery through its winding, contact 2 of relay 602, contact 3 of relay 512 to ground. The operation of relay 514 either operates or releases relay 315 depending upon the position of the latter relay at this time. The circuit for relay 315 may be traced from battery through its winding, thence over conductor 741, brush 720 or 723 through a terminal of arc 701 or 704 which may be open or connected to ground on relay 514 depending upon the position of brush 720 or brush 723 at this time. It is apparent that if brush 720 or brush 723 is resting on an odd numbered terminal, a circuit to ground is established with relay 514 released. Under this circumstance, relay 315 at this time will be operated and the operation of relay 514 would release relay 315. If brush 720 or brush 723 at this time is connected with an even numbered terminal of arc 701 or 704 with relay 514 released, no circuit would have been established for relay 315 and under this circumstance it would have been released so that the operation of relay 514 would operate relay 315.

In the foregoing it was assumed that relay 315 and relay 314 were operated at the time the failure occurred and therefore the operation of relay 514 would release relay 315 leaving the combination which, by reference to the table will be shown as relay 314, released and relay 315 operated to establish a circuit for relay 310. The circuit for relay 310 may be traced from ground on armature 4 of relay 315 released, inner contact and armature 4 of relay 314 energized, contact 1 of relay 311, winding of relay 310, contact 5 of relay 311, inner contact and armature 3 of relay 314 energized, contact 3 of relay 315 released, resistance 317 to battery. A circuit is now established for multicontact relay 201 from battery through resistance 306, contact 3 of relay 310, winding of relay 201 to ground. All of the B frame relays throughout the switching system such as relays 203, 205 and 207 are now energized for connecting the leads from all of the amplifiers in multifrequency current supply set 110 to the transformers such as 221 and 223 associated with the switches of the telephone office.

Referring back to the operation of relay 611 which was operated by the release of relay 313, this relay in operating establishes a locking circuit for itself through its contact 4 to ground on key 519. Lamp 616 is lighted to give a visual signal indicating a failure and a circuit is established for relay 612 from battery through its light winding, contact 2 of relay 611 to ground. An audible alarm is sounded by the operation of relay 612 which completes a circuit for alarm 535 extending from battery through this alarm equipment, contact 1 of relay 503, contact 1 of relay 504, conductor 537 to ground on contact 2 of relay 612. The operation of relay 612 holds relay 515 operated if it was already operated by relay 518 and prevents it from operating if it was not operated. This is done to prevent an automatic transfer from one multifrequency current supply set to the other by the switches of Figs. 7 and 8 at the time that the transfer is being made because of a failure. The circuit for holding relay 515 extends from ground on contact 4 of relay 612 over conductor 638 to armature 3 of relay 515. If the relay is already operated, this circuit extends through the armature and the inside contact, winding of relay 515, resistance 516 to battery. If the relay is released, this ground extends through the armature and outer contact to a point between the relay winding and resistance 516 which holds relay 515 shunted so that this relay cannot be operated by a ground through contact 2 of relay 518 if relay 518 is operated by switch 800 after the shunt connection is made. If relay 518 should at this time be operated by the switching equipment of Figs. 7 and 8, the switch 700 is not moved and the automatic transfer will not again be in possession of the control circuit until the fault has been corrected in the amplifier circuit. Key 521 may be operated which energizes relay 512 over an obvious circuit. Relay 512 holds the ground shunt on relay 515 or the operating ground on relay 515 through its contact 3. Relay 512 also establishes a locking circuit for relay 514 which, as will be remembered, was operated by relay 602.

When the correction in the amplifier has been made, restoring the current output to the trans-

former 156 of the amplifier, relay 120 is again operated which reestablishes the circuit for relay 313. With the control circuit equipment in the positions as herein described, the operation of relay 313 will not at this time function to change the position of any of the equipment. The operation of relay 120 extinguishes lamp 139. The attendant who has repaired the amplifier equipment now operates the release key 519. The operation of this key releases relays 602, 612 and 611. Key 521 is now restored which releases relays 512 and 514 which removes the ground from the armature 3 of relay 515. The function of the switches shown on Figs. 7 and 8 for the periodic transfer is now restored. Normally, at this time if relay 315 has been operated because of the failure, it would be released and if released because of the failure it would be reoperated. Consequently, the multifrequency supply set in use at the time that the failure occurred would be restored to use. This, however, might be automatically changed a short period thereafter by the periodic transfer equipment controlled by the switches of Figs. 7 and 8.

In the foregoing description a failure in multifrequency current supply set 100 was described and the same description may apply to a failure in the multifrequency current supply set 110, with the exception that this would cause the release of relay 311 instead of the release of relay 313. The release of relay 311 causes the operation of relay 610 instead of relay 611 previously described when relay 313 was released. If at this time the multifrequency current supply set 110 was connected to the office switching system, relays 314 and 315 are formed into a different combination than would be the formation if multifrequency current supply circuit 100 had been connected to the office switching system. By reference to the chart herein given it will be noted that when the multifrequency current supply set 110 is connected to the office switching system, relay 310 is operated and relay 312 is released which circuit is established by the combination formed of relays 314 and 315. In one case relay 315 is operated and relay 314 is released and in the other case relay 314 is operated and relay 315 is released. Consequently, relay 610 establishes slightly different circuits than relay 611 through the contacts of relays 314 and 315. The remaining operations of the control circuit are the same for transferring from multifrequency current supply set 110 to multifrequency current supply set 100.

Failure in multifrequency current supply set not serving the office

Since the oscillators for both multifrequency current supply sets are in continuous operation and consequently the current is constantly transmitted from all of the output transformers of the amplifiers whether these amplifiers are connected to the switching mechanism office or not, a failure may occur in an amplifier of the multifrequency current supply set which is not at the time connected to the switching system of the office. The life of an amplifier tube having been exhausted would automatically cause a release of a relay such as 120 or 190 and consequently open the circuit for relay 311 or relay 313 depending upon the current supply set not in use. The amplifier relay which was released establishes a circuit for its associated lamp to indicate the amplifier which had a fault therein. The release of relay 313 establishes a circuit for relay 611 from battery through its winding, contact 3 of relay 313, conductor 340 to ground on a contact of key 519. The release of relay 311 would establish a circuit for relay 610 from battery through its winding, contact 3 of relay 311, conductor 340 to ground on a contact of relay 519. The operation of relay 611 lights lamp 616 as a visual indication that multifrequency current supply set 100 has a fault therein and the operation of relay 610 lights lamp 615 as a visual indication that multifrequency current supply set 110 has a fault therein. The operation of either of these relays establishes a circuit from ground over conductor 537, contact of relay 504, contact of relay 503, audible alarm circuit 535 to battery giving an audible alarm so that the fault in the multifrequency supply set which is not serving an office will be immediately repaired.

Since the multifrequency current supply set in which the failure occurred was not connected to the switching system, no interruption results from the failure and, consequently, the mechanism for transferring the switching system to the other supply set is not operated under this condition. In this case, no circuit is established for the operation of relay 602 which as previously outlined is the first relay to be operated in the mechanism for making a transfer from one multifrequency current supply set to the other. The circuit for relay 602, as previously explained, was established through its left winding, contact of relay 511, contact of the released relay depending upon whether it was 311 or 313, thence through the contacts of relays 314 and 315 to ground. However, by reference to the chart, it will be apparent that if multifrequency current supply set 100 is connected to the office, relays 313 and 312 are energized and the circuit for relay 312 can only be established with relays 314 and 315 both operated or both released. Under this circumstance, if relay 311 should release, a circuit could not be established for relay 602 since the circuit for this relay is not established to ground through contacts 4 of relays 314 and 315 since one of the contacts for establishing this circuit is open.

The foregoing would also be true if the multifrequency current supply set 110 is connected to the office and a failure occurred in current supply set 100. This would be the case when relay 311 and relay 310 are both operated. The circuit for relay 310 is only established when one of relays 314 and 315 is released and the other one operated. If relay 313 were released at this time because of a failure in the multifrequency current supply set 100 not connected to the switching system, no circuit will be established for relay 602 because the circuit for this relay would extend through contact 2 of relay 313 released but since one of relays 314 and 315 is operated and the other released, no circuit to ground would be established through contacts 2 of the latter relays. During the time that a repair is being made in the multifrequency current supply set which is not in use, key 521 is operated which operates relay 512 to connect ground with the winding of relay 515 to either maintain this relay operated if it is at this time operated or to place a shunt around its winding to prevent its operation by relay 518, as previously explained. This prevents the switches of Figs. 7 and 8 from automatically transferring the switching system to the multifrequency current supply set under repair.

Failure in marker

Relay 442 is included in each marker and is operated if the marker fails to obtain a satisfactory multifrequency switch location signal. Conductor 441 extends to all mechanism in the marker which could cause such a failure and in case of failure associates a ground with conductor 441 for operating relay 442. Relay 442 connects ground with conductor 443 which extends through contact 2 of relay 551, winding of relay 603 to battery. Relay 603 in operating establishes a locking circuit for itself over lead 340 to ground on release key 519. A circuit for lighting lamp 607 is established through contact 3 of relay 603 to indicate to an attendant that trouble has occurred in an individual marker which has not received a satisfactory multifrequency current signal. A circuit for relay 514 is established by relay 603 which may be traced from battery through the winding of relay 514, contact 1 of relay 612, contact 4 of relay 512, contact 1 of relay 603 to a ground on the contact of relay 600 or 601 whichever relay is operated depending upon the multifrequency current supply set in use at the time. The circuit for either relay 600 or 601 is also established through the contacts of relay 603, the circuit for relay 600 may be traced from battery through its winding, contact 1 of relay 601, contact 2 of relay 310, if 310 is operated, contact 5 of relay 603, contact 1 of relay 602, contact 3 of relay 511 to ground on the release key 519. A circuit traced for relay 600 is only established when relay 310 is energized and therefore is only established when the multifrequency current supply set 110 is connected with the switching system. If multifrequency current supply set 100 is associated with the switching system when this character of failure occurs, a circuit is established for relay 601 from battery through its winding, contact 1 of relay 600 which would then be normal, contact 2 of relay 312 operated, contact 5 of relay 603, contact 1 of relay 602, contact 3 of relay 511 and thence to ground on key 519. Relay 603 also establishes a circuit for an audible alarm by connecting ground through its contact 2 to conductor 537, contact 1 of relay 504, contact 1 of relay 503 through the audible alarm equipment 535 to battery.

The operation of relay 514 connects ground through its contact 1 to the armature 3 of relay 515 which holds relay 515 operated if it was already operated or prevents it from being operated by placing a shunt around resistance 516 and the winding of this relay. As herein stated this action prevents automatic switching of the multifrequency supply sets by the switches in Figs. 7 and 8 if at the time the switches have arrived in position to operate relay 518 or do so shortly after a failure occurs. In either case switch 700 is prevented from advancing to the next terminal. The positions of relays 314 and 315 is now altered for switching from one multifrequency supply set to another. Let it be assumed that relay 315 is released and that relay 314 is energized before relay 514 is operated. By operating relay 514 a circuit is established for energizing relay 315 from battery through its winding, conductor 741, brush 720 or 723, any even numbered terminal of switch arc 701 or 723 to ground on contact 4 of relay 514. It will be seen that if brush 720 or 723 were resting on an odd numbered terminal relay 315 would already have been operated to ground on contact 4 of relay 514 before the latter relay was operated and therefore the operation of relay 514 would cause the release of relay 315 instead of the operation of this relay. The result in either case is to change the formation of relays 315 and 314 so that the alternate multifrequency current supply set is taken for use. As for this example, relay 315 is operated in response to the operation of relay 514 and consequently if relay 314 should have been in an operated or released condition the formation would be changed so that under one condition a switch would be made from supply set 100 to supply set 110 and under the other condition a switch would be made from supply set 110 to supply set 100. Let it now be assumed that relay 314 was normal and relay 315 normal before the operation of relay 514. Under this condition relay 312 is energized for connecting multifrequency supply set 100 to the switching system. By operating relay 315 responsive to the operation of relay 514 and leaving relay 314 normal, relay 312 is automatically released and a circuit is established for relay 310 through contacts 4 of relays 314 and 315 so that the transfer is made from multifrequency current supply set 100 to multifrequency current supply set 110. Under this condition relays 311 and 313 are not involved in the transfer as was the case when a failure occurred in an amplifier or oscillator in one of the multifrequency current supply sets.

Failure of frame relay

An alarm is sounded, indicating lamps are lighted and a transfer of multifrequency current supply sets is effected when a frame relay such as relay 204 failed to operate. This would also take effect if all A relays or all B relays fail to operate when a transfer of multifrequency current supply sets is attempted but not completed because of a fault in a control circuit relay such as relays 310, 312, 314 or 315. First, let it be assumed that relay 204 failed to operate in response to the operation of relay 200 for connecting the multifrequency supply set 100 to the transformer associated with each frame. It will be noted that relay 300 is a normally operated relay with relays A operated and relays B released or with relays B operated and relays A released. The circuit for this relay extends from ground through its winding, contact 1 of relay 207 which at this time is released, contact 1 of relay 206 operated, contact 1 of relay 205 released, contact 1 of relay 204 operated, of relay 203 released, contact 1 of relay 202 operated through resistance 209 to battery. If relay 204, as assumed, failed to operate, the circuit for relay 300 is opened causing it to release which causes a series of rapid operations in the control circuit. The frame relays 202 to 207 are wired in groups of ten frames and a relay such as 300 is provided for each ten frames of switching equipment. The circuit for relay 300 extends through the frame relays of ten frames, three frames being shown. One relay such as 301 is also provided for each ten frames. Ten relays, such as 321, 322 and 323, are provided for all of the frames of the office. The probability is assumed that failure would occur in only one frame relay at one time so that the ten relays and ten lamps shown in the lower portion of Fig. 3 will be sufficient for the entire office to designate one of the relays which failed to operate in any of the frame groups.

The release of relay 300 establishes an energizing circuit for relay 301 from battery through

its winding, contact 2 of relay 300, contact 1 of relay 515, contact 1 of relay 602, contact 3 of relay 511 to ground on key 519. Relay 300 also establishes a circuit from ground through its contact 1, resistance 519 and the non-linear resistance 510 winding of relay 504 to battery. This ground must be associated with thermistor 510 for a period of time in order to cause a current of sufficient strength to flow through it to operate relay 504. At this time relay 504 is energized to light lamp 507 and sound a major alarm by associating ground through its contact 4 with alarm equipment 542. Relay 301 in operating connects ground through its contact 1 filament of lamp 302 to battery lighting lamp 302 and ground through its contact 6 filament of lamp 303 to battery lighting lamp 303. There are a plurality of lamps of this character connected with a plurality of relays such as 301 and the lamps are arranged in order on a signal indicating board. When lamp 302 is lighted it indicates the particular ten frames in which a failure occurred and the lighting of lamp 303 indicates the type of switching frames, that is, whether the frame is an incoming trunk switching frame, an outgoing trunk switching frame or another type of frame associated with toll equipment.

By the lighting of lamps 302 and 303 it is therefore known that the failure of the frame relay occurred in a particular group of ten frames which are in a particular line-up of frames. The lighting of a lamp 324, 325 or 326 will now indicate that the failure occurred in frame 0, frame 5 or frame 10 in this particular block of ten frames represented by lamp 302. Relay 320 connects the ten relays which are herein represented by only three relays 321, 322 and 323 with the frame relays, one of which has failed to operate. Assuming that the relay which failed to operate is frame relay 204, a circuit is established for relay 322 from ground through contact 4 of relay 204 released, contact 4 of relay 205 released, contact 2 of relay 320, winding of relay 322 to battery. The remaining relays, such as 321 and 323, would not have a circuit established because the associated A relays 202 and 206 are at this time operated. Relay 322 in operating establishes a locking circuit for itself which may be traced through its contact 1 over conductor 331, contact 1 of relay 512 to ground on contact 3 of relay 501 when this relay is operated as will be explained in the following paragraph. Relay 322 in operating also lights lamp 325 over an obvious circuit to indicate the particular frame having a relay therein which has failed to operate.

Relay 301 which operated upon the release of relay 300 establishes a circuit for relay 612 which may be traced from ground on contact 4 of relay 301 through the right winding of relay 612 to battery. Relay 612 in operating establishes a circuit from ground on its contact 3 over conductor 537 to actuate alarm 535 as previously traced. Relay 301 establishes a circuit for relay 600 or 601 depending upon whether the failure occurred in the A relays or the B relays which also depends upon which multifrequency current supply set was at the time associated with the switching system. Since we have assumed that the failure occurred in relay 204 a circuit is established for relay 601 from battery through its winding, contact 1 of relay 600, contact 2 of relay 312 operated, contact 2 of relay 301, contact 1 of relay 515, contact 1 of relay 602, contact 3 of relay 511 to ground on key 519. This is the same ground to which relay 301 is at this time locked. Relay 601 in operating establishes an obvious circuit for lamp 605 to indicate the multifrequency current supply set which is at the time serving the switching system. A circuit is established for relay 502 which may be traced from battery through its winding, contact 1 of relay 512, conductor 331, contact 1 of relay 322, contact 2 of relay 320, contact 4 of relay 205 released to ground on contact 4 of relay 204 released. Relay 501 energizes and relay 502 is locked over a circuit which may be traced from battery through the winding of relay 501, right winding of relay 502, contacts 1 and 2 of relay 502, contact 1 of relay 515, contact 1 of relay 602, contact 3 of relay 511 to ground on key 519. As previously stated, the operation of relay 501 closes a locking circuit for relay 322 to retain lamp 325 lighted. Relay 301 is also locked at this time over a circuit as previously described, thus retaining lamps 302 and 303 lighted.

The operation of relay 501 causes the switching from one multifrequency current supply set to the other. This is done by releasing relay 314 if at this time it is operated or by operating relay 314 if at this time it is released. Since relay 204 associated with multifrequency supply set 100 was assumed as the relay which failed, the transfer will be made from multifrequency current supply set 100 to multifrequency current supply set 110. For this purpose it will be assumed that both relays 315 and 314 are in an operated position and that the operation of relay 501 causes the release of relay 314. This would assume that switch brush 722 or 725 is associated at the time the terminal 1, 4, 5 or similarly strap terminal in arc 703 or 706 which establishes a circuit for operating relay 314 through contact 4 of relay 501 to ground on key 520. The operation of relay 501 will open this circuit and release relay 314. Relay 315 therefore is now operated and relay 314 released which opens the circuit for relay 312 and establishes the circuit for relay 310 as previously traced for this combination of these relays.

The operation of relay 501 also opens the circuit for relay 320 which releases. This, however, does not interfere with the lamp signals giving the location of the relay since the relays lighting these lamps are locked in position. The attendant upon observing the trouble by the illumination of the aforementioned lamps operates key 521 which operates relay 512 to associate ground with the winding of relay 515 which as herein described prevents interference from the periodic transfer mechanism of Figs. 7 and 8. When the trouble has been repaired this attendant restores key 521 and operates key 519 which releases relays 502, 501, 612 and 301 and the units relay 322 and the circuit is restored to the position and condition before the fault occurred. The restoring of the control circuit as previously explained, is automatically controlled by the periodic switching equipment of Figs. 7 and 8 and the control relays associated therewith.

It was brought out in the foregoing description that one relay 300 and one relay 301 are connected to each of a plurality of groups of A and B frame relays, each group comprising ten A relays and ten B relays for each group of ten frames in the automatic switching office. Let it now be assumed that multi-frequency current supply set 110 is connected to the switching equipment of the office with all B relays operated and that circuits are established for switching from multifrequency current supply set 110 to

multifrequency current supply set 100. Let it also be assumed that a failure occurred in the control mechanism which prevented the operation of relay 312 when circuits were established for this transfer. Because of the attempted transfer of current supply sets, relay 310 would have been released and, therefore, if relay 312 did not operate circuits would not be established for either relay 200 or relay 201. Under this condition both the A relays on all frames in the office and the B relays on all frames in the office are released. Relay 300 connected with all frame groups is thus released and relay 301 associated with all frame groups is operated to light their individual lamps which indicate that the failure effects the entire switching system. Relay 320 is thus operated and the ten units relays 321 to 323 are operated to light the ten lamps connected with those relays which indicates that all A and B relays of a group are released. It is clear from the foregoing description and the drawings that the operation of the relay 301 immediately causes the multifrequency current supply set 110 to be reconnected to the switching system of this office by the reoperation of the B relays. The leads through the contacts of all relays 300 and 301 extending to the mechanism of the control circuit are strapped together so that each or all of these relays effects the same operations in the control circuit. An attendant observing the lamp signals may easily analyze this trouble. The multifrequency current supply set 110 now remains connected to the office switching system until the fault has been corrected.

What is claimed is:

1. In an automatic switching telephone office, trunks, switches mounted on a plurality of frames forming a switching system for completing telephone connections, markers for operating said switches, selectively operable switch locating devices in said markers, a multifrequency signaling system comprising duplicate multifrequency current supply sets common to the switches of said office, each set having a plurality of current sources of different frequencies, a plurality of receiving circuits in each marker tuned to the different frequencies of the current sources in said duplicate multifrequency current supply sets, selectively actuated by currents connected thereto from one of said supply sets, a control mechanism, means in said control mechanism for connecting one of said multifrequency current supply sets to said switching system, means in said marker responsive to the selection of trunks connected to switches for connecting current sources from said current supply set to the receiving circuits of said marker for operating switch locating devices to direct the marker in the operation of the switches connected with said trunks for completing a telephone connection, a periodically operating device in said control mechanism, and means automatically responsive to the operation of said device for periodically disconnecting one multifrequency current supply set from said switching system and for connecting the alternate one of said duplicate multifrequency current supply sets thereto.

2. In an automatic switching telephone office, trunks, switches mounted on a plurality of frames forming a switching system for completing telephone connections, markers for operating said switches, selectively operable switch locating devices in said markers, a multifrequency signaling system comprising duplicate multifrequency current supply sets common to the switches of said office, each set having a plurality of current sources of different frequencies, a plurality of receiving circuits in each marker tuned to the different frequencies of the current sources in said duplicate multifrequency current supply sets, selectively actuated by currents connected thereto from one of said supply sets, a control mechanism, means in said control mechanism for connecting one of said multifrequency current supply sets to said switching system, means in said marker responsive to the selection of trunks connected to switches for connecting current sources from said current supply set to the receiving circuits of said marker for operating switch locating devices to direct the marker in the operation of the switches connected with said trunks for completing a telephone connection, and means automatically operable in said control mechanism responsive to a failure in said multifrequency signaling system for disconnecting the one multifrequency current supply set from said switching system and for connecting the alternate one of said duplicate multifrequency current supply sets thereto.

3. In an automatic switching telephone office, trunks, switches mounted on a plurality of frames forming a switching system for completing telephone connections, markers for operating said switches, selectively operable switch locating devices in said markers, a multifrequency signaling system comprising duplicate multifrequency current supply sets common to the switches of said office, each set having a plurality of current sources of different frequencies, a plurality of receiving circuits in each marker tuned to the different frequencies of the current sources in said duplicate current supply sets, selectively actuated by currents connected thereto from one of said multifrequency supply sets, a control mechanism, means in said control mechanism for connecting one of said multifrequency current supply sets to said switching system, means in said marker responsive to the selection of trunks connected to switches for connecting current sources from said multifrequency current supply set to the receiving circuits of said marker for operating switch locating devices to direct the marker in the operation of switches connected with said trunks for completing a telephone connection, automatically operable periodic transfer mechanism for periodically disconnecting one multifrequency current supply set from said switching system and for connecting the alternate one of said duplicate multifrequency current supply sets thereto and means automatically operable in said control mechanism responsive to a failure in the multifrequency supply set connected to said switching system for nullifying said periodic transfer control mechanism, for disconnecting the multifrequency supply set which failed and for connecting the alternate one of said duplicate multifrequency current supply sets to said switching system.

4. In an automatic switching telephone office, trunks, switches mounted on a plurality of frames forming a switching system for completing telephone connections, markers for operating said switches, selectively operable switch locating devices in said markers, a multifrequency signaling system comprising duplicate multifrequency current supply sets common to the switches of said office, each set having a plurality of current sources of different frequencies, a plurality of receiving circuits in each marker tuned to the dif-

ferent frequencies of the current sources in said duplicate multifrequency current supply sets, selectively actuated by currents connected thereto from one of said supply sets, a control mechanism, means in said control mechanism for connecting one of said multifrequency current supply sets to said switching system, means in said marker responsive to the selection of trunks connected to switches for connecting current sources from said current supply set to the receiving circuits of said marker for operating switch locating devices to direct the marker in the operation of switches connected with said trunks for completing a telephone connection and means automatically operable in said marker responsive to the failure of said marker to receive a multifrequency switch locating signal for actuating said control mechanism to disconnect said one multifrequency current supply set from said switching system and for connecting the alternate one of said duplicate multifrequency current supply sets thereto.

5. In an automatic switching telephone office, trunks, switches mounted on a plurality of frames forming a switching system for completing telephone connections, markers for operating said switches, selectively operable switch locating devices in said markers, a multifrequency signaling system comprising duplicate multifrequency current supply sets common to the switches of said office, each set having a plurality of current sources of different frequencies, a plurality of receiving circuits in each marker tuned to the different frequencies of the current sources in said duplicate multifrequency current supply sets, selectively actuated by currents connected thereto from one of said supply sets, a control mechanism, means in said control mechanism for connecting one of said multifrequency current supply sets to said switching system, means in said marker responsive to the selection of trunks connected to switches for connecting current sources from said multifrequency current supply set to the receiving circuits of said marker for operating switch locating devices to direct the marker in the operation of switches connected with said trunks for completing a telephone connection, automatically operable periodic transfer mechanism for periodically disconnecting the one multifrequency current supply set from said switching system and for connecting the alternate one of said duplicate multifrequency current supply sets thereto, means automatically operable in said control mechanism responsive to a failure in the multifrequency supply set connected to said switching system for nullifying said periodic transfer control mechanism, for disconnecting the multifrequency supply set which failed and for connecting the alternate one of said duplicate multifrequency current supply sets to said switching system and means for resetting said control mechanism to reestablish the control of said periodic transfer mechanism.

6. In an automatic switching telephone office, trunks, switches mounted on a plurality of frames forming a switching system for completing telephone connections, markers for operating said switches, selectively operable switch locating devices in said markers, a multifrequency signaling system comprising duplicate multifrequency current supply sets common to the switches of said office, each set having a plurality of current sources of different frequencies, a plurality of receiving circuits in each marker tuned to the different frequencies of the current sources in said duplicate multifrequency current supply sets, selectively actuated by currents connected thereto from one of said supply sets, a control mechanism, means in said control mechanism for connecting one of said multifrequency current supply sets to said switching system, means in said marker responsive to the selection of trunks connected to switches for connecting current sources from said multifrequency current supply set to the receiving circuits of said marker for operating switch locating devices to direct the marker in the operation of switches connected with said trunks for completing a telephone connection, automatically operable periodic transfer mechanism for periodically disconnecting one multifrequency current supply set from said switching system and for connecting the alternate one of said duplicate multifrequency current supply sets thereto and means automatically operable in said control mechanism responsive to a failure in the multifrequency supply set not connected to said switching system for nullifying said periodic transfer mechanism.

7. In an automatic switching telephone office, trunks, switches mounted on a plurality of frames forming a switching system for completing telephone connections, markers for operating said switches, selectively operable switch locating devices in said markers, a multifrequency signaling system comprising duplicate multifrequency current supply sets common to the switches of said offices each set having a plurality of current sources of different frequencies, a plurality of receiving circuits in each marker tuned to the different frequencies of the current sources in said duplicate multifrequency current supply sets selectively actuated by currents connected thereto from one of said supply sets, a control mechanism, a relay A on each frame of said office for connecting certain current sources from one of said duplicate multifrequency current supply sets through the switching mechanism of respective frames to marker receiving circuits, a relay B on each frame of said office for connecting duplicate current sources of the same frequency from the other multifrequency supply set through the same respective switching mechanism to marker receiving circuits, means in said control mechanism for operating relays A on all said frames or relays B on all said frames for connecting one of said multifrequency current supply sets to the switching system of the office, means in said marker responsive to the selection of trunks for connecting current sources from the multifrequency current supply set to the switching system and to the receiving circuits of said marker for operating switch locating devices to direct the marker in the operation of said switches and means in said control mechanism automatically operable for periodically operating alternate relays A and relays B for periodically connecting alternate multifrequency current supply sets to said switching system.

8. In an automatic switching telephone office, trunks, switches mounted on a plurality of frames forming a switching system for completing telephone connections, markers for operating said switches, selectively operable switch locating devices in said markers, a multifrequency signaling system comprising duplicate multifrequency current supply sets common to the switches of said office, each set having a plurality of current sources of different frequencies, a plurality of receiving circuits in each marker tuned to the different frequencies of the current sources in said

duplicate multifrequency current supply sets selectively actuated by currents connected thereto from one of said supply sets, a control mechanism, a relay A on each frame of said office for connecting certain current sources from one of said duplicate multifrequency current supply sets through the switching mechanism of respective frames to marker receiving circuits, a relay B on each frame of said office for connecting duplicate current sources of the same frequency from the other multifrequency supply set through the same respective switching mechanism to marker receiving circuits, means in said control mechanism for operating relays A on all said frames or relays B on all said frames for connecting one of said multifrequency current supply sets to the switching system of the office, means in said marker responsive to the selection of trunks for connecting current sources from the current supply set connected to the switching system to the receiving circuits of said marker for operating switch locating devices to direct the marker in the operation of said switches and means in said control mechanism automatically operable for periodically operating alternate relays A and B for periodically connecting alternate multifrequency current supply into said switching system, signaling means for indicating the location of an A relay or a B relay which failed to operate when the circuit for said relay was energized by the control circuit and means automatically operable in said control circuit for operating all B relays when any A relay fails to operate or for operating all A relays when any B relay fails to operate.

9. In an automatic switching telephone office, trunks, switches mounted on a plurality of frames forming a switching system for completing telephone connections, markers for operating said switches, selectively operable switch locating devices in said marker, a multifrequency signaling system comprising duplicate multifrequency current supply sets common to the switches of said office, each set having a plurality of current sources of different frequencies, a plurality of receiving circuits in each marker tuned to the different frequencies of the current sources in said duplicate multifrequency current supply sets selectively actuated by currents connected thereto from one of said supply sets, a control mechanism, a pair of relays in said control mechanism for controlling the selection of the multifrequency current supply sets for connection to the switching system arranged to have both relays in the same relative positions for selecting one multifrequency current supply set and in oppositely related positions for selecting the other multifrequency current supply set, means in said marker responsive to the selection of trunks for connecting current sources from the selected multifrequency current supply set to the receiving circuits of said marker for operating switch locating devices to direct the marker in the operation of switches and means in said control circuit automatically responsive to a failure in the selected multifrequency current supply set for releasing or operating one of said relays which ever is required to alter their related positions for selecting the other multifrequency current supply set and means automatically responsive to the alteration of the related positions of said relays for connecting the selected multifrequency current supply set with the switch system

10. In an automatic switching system, switches, switch operating mechanism, a signaling system comprising duplicate multifrequency supply sets common to said switching system, each set having a plurality of current sources of different frequencies, a plurality of receiving circuits tuned to the different frequencies of the current sources in said duplicate current supply sets, selectively actuated by currents connected thereto from one of said multifrequency supply sets for controlling the selection of certain of said switches, a control mechanism, means in said control mechanism for connecting one of said multifrequency current supply sets to said switching system, means for connecting certain of said current sources from said multifrequency current supply set to said receiving circuits for directing the operation of certain switches, automatically operable periodic transfer mechanism means responsive to the operation of said mechanism, for periodically disconnecting one multifrequency current supply set from said switching system and for connecting the alternate multifrequency current supply set thereto and means automatically operable in said control mechanism responsive to a failure in the multifrequency supply set connected to said switching system for nullifying said periodic transfer control mechanism, for disconnecting the multifrequency supply set which failed and for connecting the alternate one of said duplicate multifrequency current supply sets to said switching system.

11. In an automatic switching system, switches, switch operating mechanism, a signaling system comprising duplicate multifrequency current supply sets common to said switches, each set having a plurality of current sources of different frequencies, a plurality of receiving circuits tuned to the different frequencies of the current sources in said duplicate current supply sets selectively actuated by currents connected thereto from one of said multifrequency supply sets for controlling the selection of certain of said switches, a control mechanism, means in said control mechanism for connecting one of said multifrequency current supply sets to said switching system, means for connecting certain of said current sources from said multifrequency current supply set to said receiving circuits for directing the operation of certain switches, automatically operable periodic transfer mechanism, means responsive to the operations of said mechanism for periodically disconnecting one multifrequency current supply set from said switching system and for connecting the alternate multifrequency current supply set thereto and means automatically operable in said control mechanism responsive to a failure in the multifrequency supply set not connected to said switching system for nullifying said periodic transfer mechanism.

ALOYSIUS J. BUSCH.
ISRAEL H. HENRY.
CHARLES F. SEIBEL