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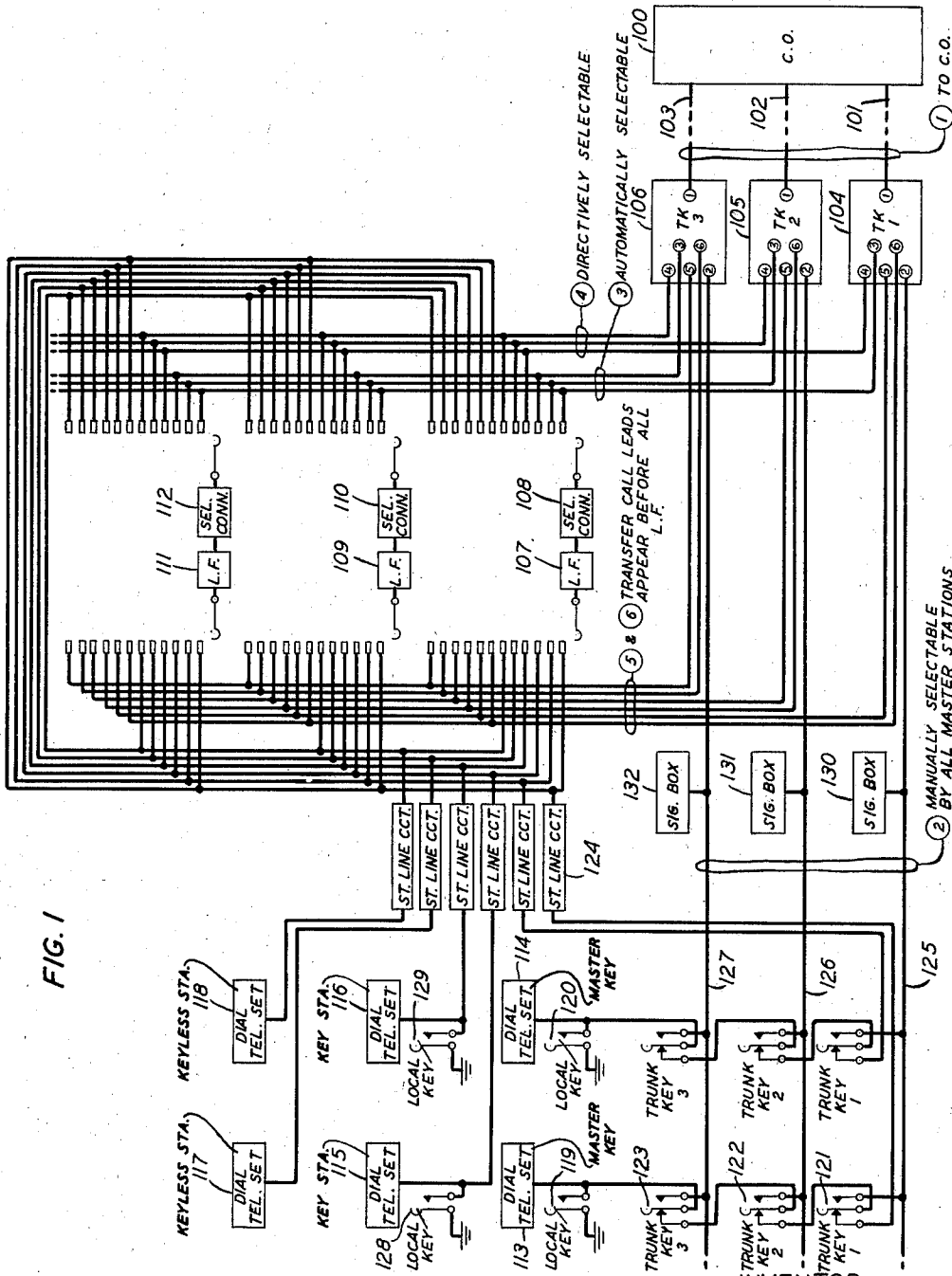
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2,289,895

TELEPHONE SYSTEM

Filed March 29, 1941

5 Sheets-Sheet 1



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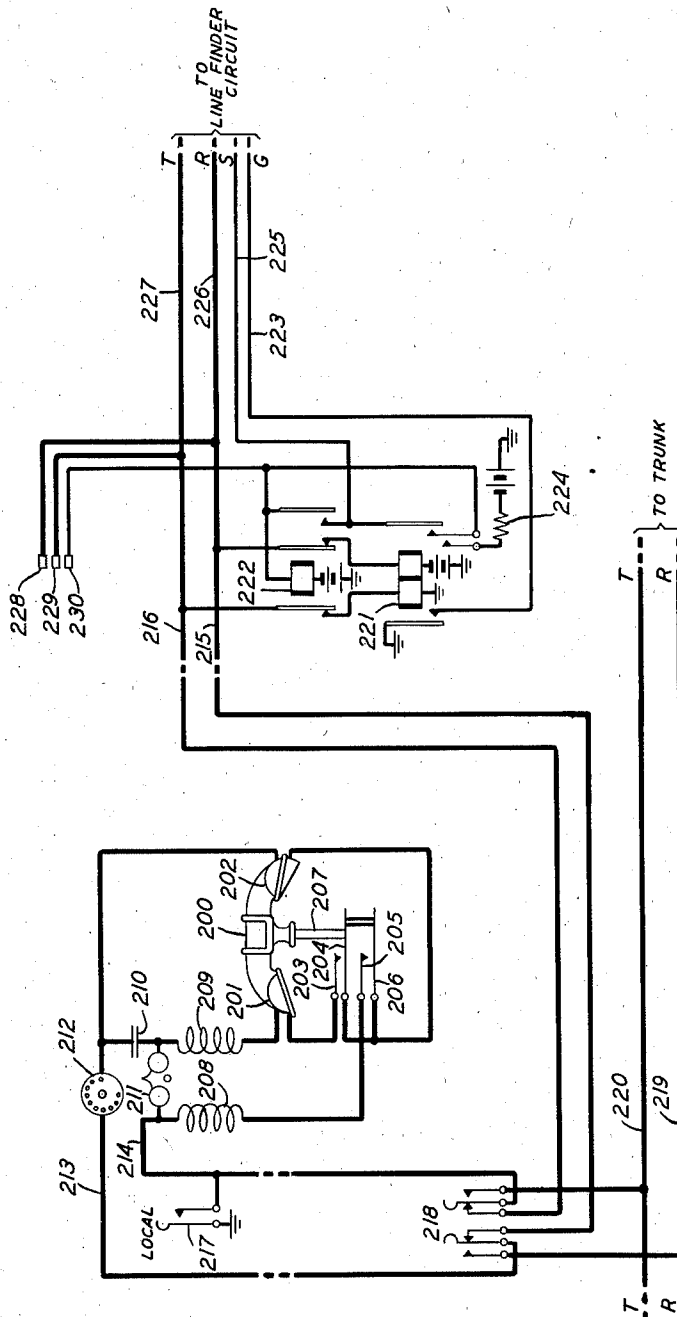
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FIG. 2



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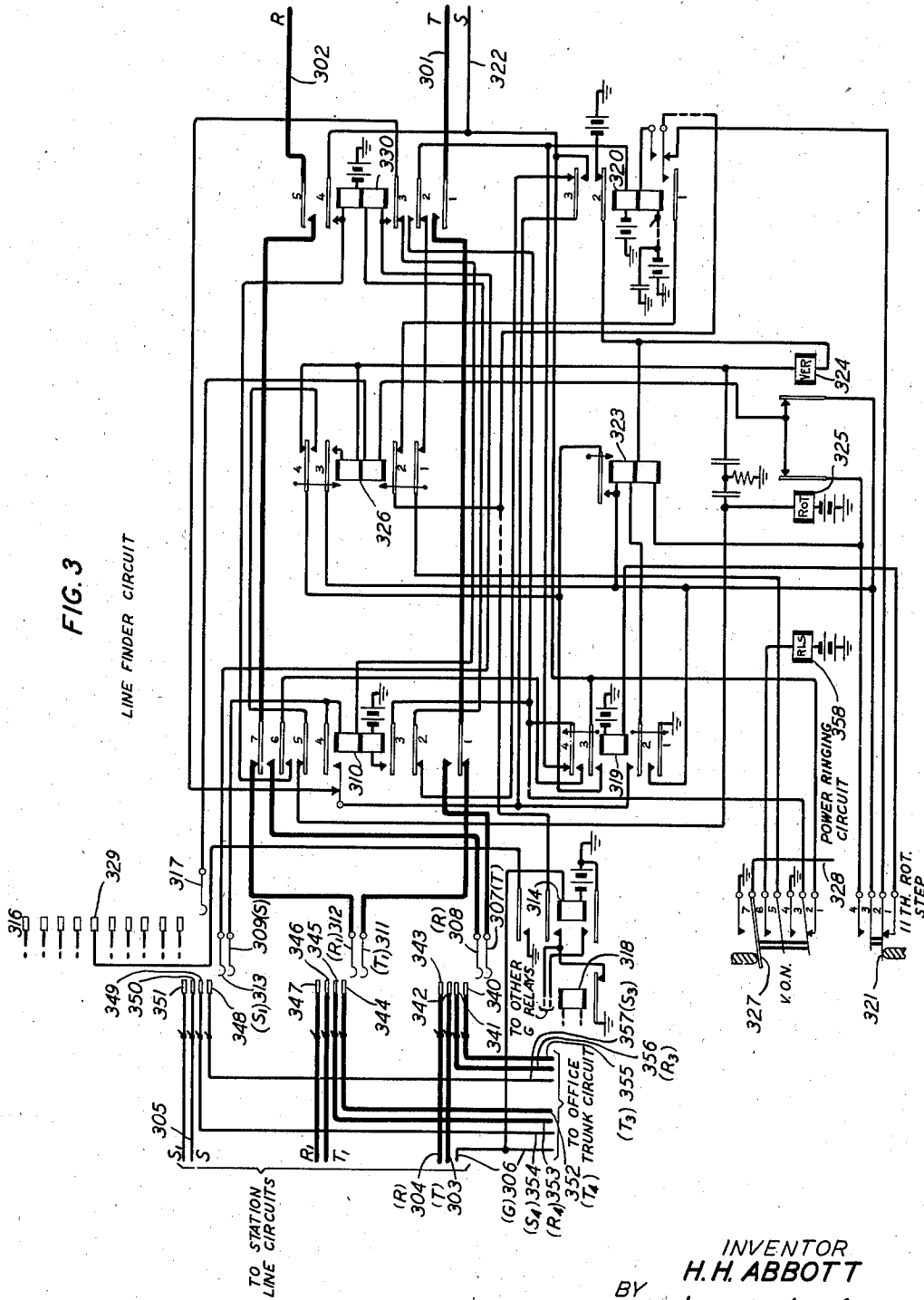
TELEPHONE SYSTEM

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FIG. 3

LINE FINDER CIRCUIT



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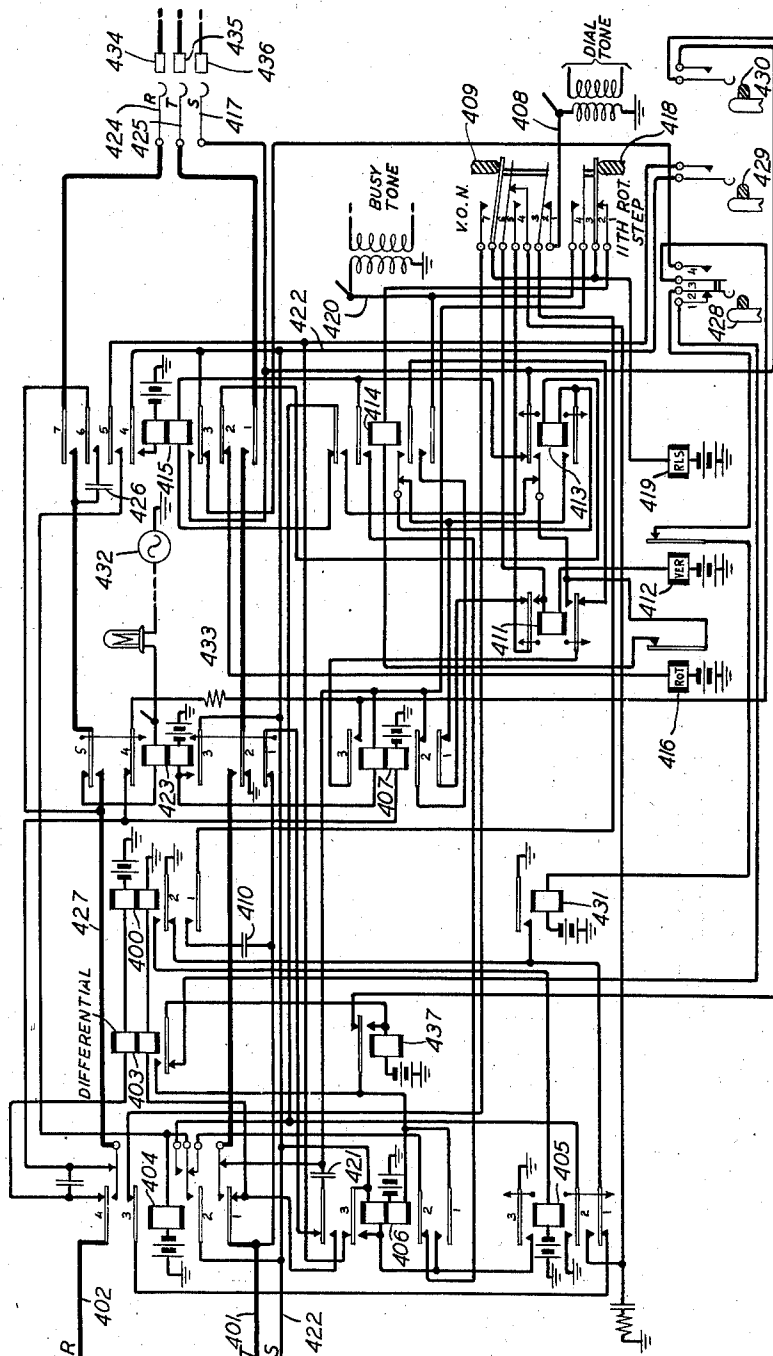
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FIG. 4

SELECTOR CONNECTOR CIRCUIT



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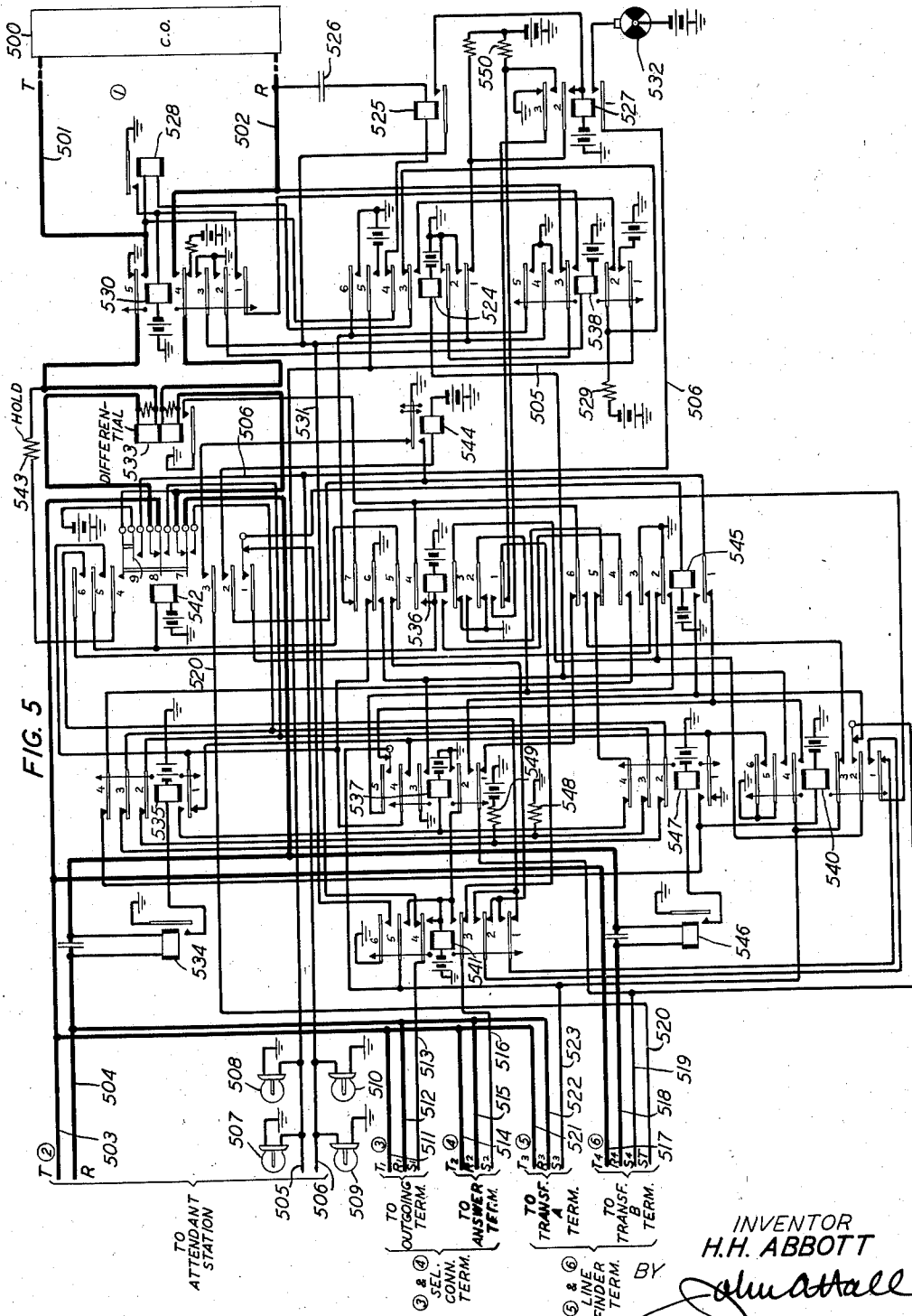
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Filed March 29, 1941

5 Sheets-Sheet 5



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2,289,895

TELEPHONE SYSTEM

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Application March 29, 1941, Serial No. 385,834

33 Claims. (Cl. 179—27)

This invention relates to telephone systems and particularly to automatic switching systems for use on subscriber premises, generally known as private branch exchange systems.

The object of the invention is to place at the subscriber's disposal simple means for rendering the service flexible without making the operation complicated. Accordingly, a central office trunk circuit is provided which may be reached by certain subscribers but not by others except under permissive conditions, which may be transferred from one called party to another, which may be held while such transfers are being made, and which may be reached automatically, directly or by directive action.

A feature of the invention is a trunk circuit having a plurality of terminals. One terminal extends to the central office where it enters circuits of ordinary and well-known arrangement. A second terminal extends to certain stations within the private branch exchange where direct access to the trunk may be had by such stations. Incidentally, signaling arrangements individual to the trunk appear at each of such stations and in addition also to other stations within the private branch exchange where a given character of service is to be rendered. A third terminal of the said trunk circuit known as the outgoing terminal thereof appears in the automatic switches of the private branch exchange and there is grouped with other similar terminals of other trunks in a hunting group. Those subscribers who have access to such trunks by manipulating their "local" key in making a call are automatically connected with the first idle trunk at its said outgoing terminal. A fourth terminal of the said trunk circuit known as the incoming terminal thereof appears in the automatic switches of the private branch exchange and may be reached by any of the subscribers only when the trunk has been properly conditioned. This incoming terminal normally tests busy but when the trunk is in the condition set up by an unanswered incoming call or being "held" on either an incoming or outgoing call will have this busy condition removed so that connection may be made by directive action. A fifth and a sixth terminal of the trunk circuit are provided for transfer service. Any subscriber having connection to the trunk over its second, third or fourth terminal may, by operating his "local" key, cause the fifth terminal thereof to extend the trunk to an automatic switch which may thereafter connect to another subscriber. Thereafter such other subscriber may, by manipulating his local

key, cause the sixth terminal to extend the trunk to an automatic switch which may thereafter connect to still another subscriber. The said fifth and sixth terminals may be used alternately and indefinitely. When the said local key is manipulated in the manner above set forth by a subscriber having connection to the said second, third or fourth terminals or to the fifth or sixth terminals as set forth, the talking connection to the central office will be severed and a holding condition established so that connection to the trunk at the distant end will not be disturbed. Thereafter, when the newly called subscriber answers, the talking connection to the central office is reestablished and a three-way circuit involving the talker at the central office end, the subscriber at the private branch exchange who has just caused this operation and the newly called subscriber is set up. The subscriber who has caused the transfer or the newly called subscriber may disconnect leaving the connection under control of the other who may thereafter transfer the call to another; or the subscriber who makes the transfer may disconnect after dialing, whereupon the newly called subscriber will entirely take over control of the trunk circuit.

Other features of the invention are involved in the various types of substations provided. Certain stations known as attendant stations will be provided with a local key to perform the functions above set forth as well as a key per trunk for gaining access to each trunk over its second terminal. By means of the local key these stations may also gain access to the trunk over their third or outgoing terminals and by means of their dials may gain access to the trunks over their fourth or incoming terminals.

Other stations, which will constitute the majority of the private branch exchange stations will be provided only with a local key and, therefore, cannot gain access to a trunk over its second terminal but in other respects will be like the attendant stations.

Still other stations will not be provided with even a local key and these stations can only gain access to a trunk by dialing and then only when the trunk has been put in condition by having the normal busy condition removed by some previous operation.

Any one of the three kinds of stations may receive a transferred call over the trunk but the last or keyless station cannot further transfer a call.

Another feature of the invention is a control

arrangement for the connecting facilities whereby when a master station or a key station is operated to automatically select the first idle trunk such an operation will take place in response to the operation of the local key at such a station. Any attempt by a subscriber at any of the stations to gain access to a trunk by dialing to the automatic trunk hunting position will be balked. By way of example, access to the trunks in response to the operation of a local key is gained by the automatic movement of a selector-connector to a given level followed by an automatic trunk hunting movement. Should a subscriber knowing the identity of such given level attempt to reach it by dialing, thinking to circumvent the restricted service provision, he would be prevented from fulfilling such a design by a control circuit provided for this purpose. Such given level can only be entered by automatic approach thereto. Directive approach automatically bars entrance to such level. Accordingly a feature of the invention is an automatic switch serving a group of outgoing lines which may only be selected automatically.

Another feature of the invention is a transfer circuit which one party may use to repeatedly set up connections to various third parties. In accordance with this feature, the party having gained access to a trunk circuit may by operating his local key to cause the operation of the differential relay in the trunk circuit causes a transferring terminal of the trunk circuit to be extended to a selector-connector. By then dialing the party may further extend the connection to a wanted party. After this either the calling or the called party may disconnect and the one still holding the connection may again transfer the call providing he has the facility in the shape of the local key.

Another feature resides in the provision of means to prevent the automatic selection of a central office line on a transferred connection. The line finder selector-connector combination differentiates between calls extended from a calling line and calls extended from a calling trunk. Where the connection has been extended from a calling line, the differential relay in the selector-connection circuit will effectively respond to the operation of the local key at the substation. Where, on the other hand, the finder has responded to a calling condition coming from a trunk, then the differential relay in the selector-connector will be ineffective to cause the usual automatic trunk hunting action of such selector-connector.

Another feature is a means for preventing an unduly long operation of a local key from causing an unintended operation. Where a subscriber at a key station initiates a call by removing his telephone from its cradle whereupon his line is extended by a line finder to a selector-connector, and then by operating his local key causes the selector-connector to further extend his line to an idle trunk it is possible by then again operating his local key to place the seized trunk in a holding condition and to have the fifth terminal thereof extended to another selector-connector. Since the action of these automatic switches is swift there is danger that the operation of the local key by the subscriber may extend in time beyond the seizure of the trunk and thereby cause an unwanted operation. The differential relay in the selector-connector therefore responds to the operation of the local key at the calling substation but does not become

effective until this key is released. Therefore, the differential relay in the trunk will not be operated immediately upon seizure of the trunk unless there is another operation of the local key by the subscriber after the trunk is seized.

Another feature is a means for dismissing a line finder when it is not wanted. In this system where a subscriber at a key station has control of a trunk he may operate the differential relay in the trunk. This results in placing a hold condition on the trunk toward the central office and at the same time causes a line finder to extend one of the transfer terminals of the trunk to a selector-connector. In the great majority of cases this operation is what is wanted. However, where the subscriber does not intend to transfer the trunk he may dismiss the line finder by disconnecting after placing the trunk in a holding condition. By way of example a subscriber at a key station may wish to permit a subscriber at a keyless station to have a trunk connection. One way of doing this is to select a trunk by a local trunk key over the second terminal of an idle trunk notifying the subscriber at the keyless station of the number of the trunk he will place in condition. He may then operate his local key to operate the differential relay in the trunk and this will result in firstly placing a holding condition on the trunk toward the central office and secondly causing a line finder to extend the fifth terminal of the trunk to a selector-connector. The transfer facilities are not wanted at this time, however, so the subscriber who has caused this operation may now disconnect and by so doing will dismiss the line finder leaving the trunk still in a holding condition. In this condition the trunk is accessible over its fourth terminal and since the subscriber at the keyless station has been notified that this condition will be established he may dial the number of the trunk and successfully establish a connection thereto. When the keyless station thus seizes the trunk the hold condition will be removed and the subscriber put in direct communication with the central office.

The drawings consist of five sheets of circuit diagram illustrating the present invention.

Fig. 1 is a schematic circuit diagram showing the complete operation of the system;

Fig. 2 is a circuit diagram showing the station circuit and the station line circuit of the telephones used in this system;

Fig. 3 is a circuit diagram showing the line-finder circuit;

Fig. 4 is a circuit diagram showing the selector-connector circuit; and

Fig. 5 is a circuit diagram showing the trunk circuit.

The various circuit diagrams are not connected together in a complete system as the use of these various circuits will be apparent from consideration of the schematic of Fig. 1.

The telephone system herein disclosed is a system for use on subscriber premises and is in the nature of a private branch exchange. A central office 100 will be reached over a number of trunk lines here illustrated by the lines 101, 102 and 103. Each line terminates at the subscriber's premises in a trunk circuit 104, 105 and 106, respectively. Each of these trunk circuits is similar to that circuit shown in detail in Fig. 5, and each has six terminals therein indicated by the numerals 1-6, inclusive. Terminal 1 of each trunk circuit extends to the central office. Terminal 2 of each trunk circuit extends to a cer-

tain master station where a connection to the trunk may be made manually. Terminal 3 of each trunk appears in the bank terminals of the selector-connector switch where it may be approached automatically. Terminal 4 of each trunk appears in the bank terminals of the selector-connector switch where it may be approached directly. Terminals 5 and 6 appear in the terminals of the line-finder switch and may be alternately used to extend the trunk to various lines within the private branch exchange.

The switching arrangement within this telephone system consists of a plurality of line finder and selector-connector combinations. The numerals 107 and 108 respectively designate the first line finder and selector-connector combination. The numerals 109 and 110 respectively designate a second line finder and selector-connector combination and the numerals 111 and 112 respectively designate the third line finder selector-connector combination. It will be noted that the bank terminals of the various line finders are multiplied. In the same manner it will be noted that the bank terminals of the various selector-connectors are similarly multiplied.

Various types of lines terminate in the banks of the line-finder switches so that these line-finders will respond to a calling condition set up by these various types of lines and after having found the calling line will extend the connection to the companion selector-connector which may then be set upon the terminals of various types of outgoing lines.

For actual subscriber use there are provided therein, by way of example, telephone stations 113 to 118, inclusive. Stations 113 and 114 are known as master stations and each is provided with a local key such as 119 and 120, respectively, and a plurality of trunk keys such as those designated 121 to 123 associated with station 113. It will be apparent that if a subscriber at station 113 operates key 121 such station will be transferred from a connection to the station line circuit 124 to line 125 extending to terminal 2 of trunk circuit 104 so that the subscriber at this station may obtain direct access to the trunk manually. Likewise, through the operation of keys 122 and 123 connections to lines 126 and 127 leading to terminals 2 of trunk circuits 105 and 106, respectively, may be made.

The subscriber at station 113 by removing his receiver from its switchhook may operate the station line circuit 124 which will put a calling condition on the associated line-finder terminal and cause one of the line finders to make connection thereto. Assuming that line finder 107 makes connection to this terminal then the subscriber at station 113 through the operation of his dial may set the selector-connector 108 directly on one of the terminals of that switch which will lead either to one of the terminals 4 of the trunk circuits or one of the lines 114 to 118 inclusive.

It will also be apparent hereinafter that if the subscriber at station 113 removes his receiver from the switchhook and causes the connection of line-finder 107 to his line terminals and then operates his local key 119 before operating the dial that responsive action in the selector-connector will cause this switch to automatically hunt over the terminals leading to the No. 3 terminals of the trunk circuits to select the first idle one of these trunks.

Stations 115 and 116 are provided with local

keys 128 and 129, respectively. These local keys perform exactly the same functions as the local keys associated with stations 113 and 114. Therefore it will be noted that the difference between stations 115 and 116 and stations 113 and 114 is that stations 115 and 116 have no direct manual access to the trunks and therefore must make connection to a trunk through the line-finder selector-connector facilities.

Stations 117 and 118 have no local key and are known as keyless stations. Therefore neither of these stations is able to make connection to the third terminals of the trunk circuits through the automatic selection of the first idle one. Such stations are therefore restricted to making a connection to the terminals 4 of these trunks in the manner to be hereinafter more fully described. It will be noted that under ordinary conditions a bar is established on the terminals of each fourth terminal of these trunks so that a directly established connection to one of these terminals will not give a station access to the trunk except under a particular circumstance. It will hereinafter appear that this bar is removed under two conditions, first when the trunk is in that condition established by an incoming call from the central office and second when the trunk is being held on a connection established over one of its other terminals. Thus, if a subscriber, for instance at the station 117, wishes to make a trunk call, he may first establish a connection by dialing a call to either a master station such as 113 or a key station such as 115 and request permission to make such a trunk call. If permission is given the subscriber at station 113 or 115 will establish a connection to a trunk and after having so established this connection will put it in a holding condition by operation of the local key thereat. After a connection is established from station 113 or 115 to a trunk 104, by way of example, and the local key 119 or 128 is depressed an operation of the trunk circuit will put a holding condition on the trunk toward the central office and at the same time remove the bar from the fourth terminal thereof so that the station 117 may then successfully establish a connection through a line-finder selector-connector combination to the fourth terminal of the trunk 104.

It will be noted hereinafter that if station 113 establishes a connection to trunk 104, by way of example, to either the second, third or fourth terminal thereof, or if a station 115 establishes a similar connection to the trunk through its third or fourth terminal and then the local key is operated, such trunk will be put in a holding condition and at the same time fifth terminal thereof will become active and a line-finder will be connected thereto. Thereupon the subscriber at station 113 or 115 may dial the number of any other station in the system, 118, by way of example, and connection will be established thereto. If the station 113 or 115 in making such a connection maintains such a connection active by holding the receiver off the hook a three-way connection will be established upon the answer of station 118 including station 113 or 115, the line to the central office 101 and station 118. If station 113 or 115 then hangs up, its line will be entirely cleared from the now established connection between station 118 over the fifth terminal of trunk 104 and the central office.

The subscriber at station 118 not having at his disposal a local key, is impotent to further transfer the trunk call. If, however, the call had first been transferred to a station having a local

key, say station 116, by way of example, the call could have been further transferred. The subscriber at station 116 finding it desirable to make such a transfer would operate his local key 129 whereupon the sixth terminal of trunk circuit 104 would become active and a line-finder would be connected thereto so that the subscriber at station 116 would directly operate the associated selector-connector to another subscriber within this system. If in this case the call is transferred to a station provided with a local key this last station may again transfer the connection by operating the local key whereupon the fifth terminal of the trunk circuit 104 would again become active. In this manner the trunk call may be indefinitely transferred back and forth between subscribers until finally it is transferred to a substation which has no local key, whereupon this operation would come to an end since such last subscriber is impotent to operate the transfer circuits of the trunk.

On a call incoming from the central office, a signal will appear some place on the premises of the subscriber in a signal box 130, 131 or 132. This signal box has in it a pair of signals, one for indicating that the trunk is busy and the other for indicating either an incoming call or the fact that the trunk is in a holding condition. And when either of these two latter indications are being given a connection may be directly established to the fourth terminal of the associated trunk. The signal boxes are not associated with any particular substation necessarily but may be placed at strategic points about the subscriber's premises where they may be observed by several subscribers. When the calling condition is being signaled any station which observes this signal may make connection to the fourth terminal of such trunk by the directive operation of a selector-connector. If the signal is observed by a master station such as station 113 or 114 a direct manual connection may be made thereto through the operation of the associated trunk key.

It will be noted that each of the station line circuits such as 124 has a terminal both in the line finder bank and selector-connector bank whereby any station within this system may directly set up a connection to any other station therein. The line-finder bank also has in its terminals the transfer terminals of the trunk circuits leading to the terminals 5 and 6 thereof and the selector-connector bank has therein terminals leading to the third and fourth terminals of each of the trunk circuits.

To recapitulate the master stations may at various times be connected to the trunk circuits over terminals 2, 3, 4, 5 and 6 thereof and may transfer the trunk to any other station. The busy lamps are within sight of all master stations to facilitate the selection of an idle trunk over its second terminal. The key stations 115 and 116 may at various times be connected to a trunk over terminals 3, 4, 5 and 6 thereof and may transfer the trunk circuit to other stations. The keyless stations 117 and 118 may at various times be connected to the trunks over terminals 4, 5 and 6 thereof but may not further transfer the connection. Put in another way all stations provided with a local key may automatically gain access to the first idle one of the trunk circuits. No station may directly gain access to the fourth terminals of the trunks unless either the calling or holding signal in the signal box is being displayed. Through the terminals 5 and 6 of the

trunk the trunk may be directly extended to any station in the system, but only those stations provided with local keys may further extend the trunk to another station. The fifth terminal of the trunk is always first to be used and thereafter the sixth and fifth terminals are alternately used so long as the trunk is being transferred from station to station.

Fig. 2 shows in detail the station circuit and a station line circuit. The station circuit comprises the handset 200 having a receiver 201 and a transmitter 202 and a set of contacts 203 to 206, inclusive, held in position shown when the handset is on its cradle by means represented by the rod 207. There is also provided an induction coil having windings 208 and 209, a condenser 210, ringer 211 and dial 212. A keyless station such as 117 would have the conductors 213 and 214 connected directly to the line station circuit conductors 215 and 216 respectively. A key station, such as 115, and a master station, such as 113, would also have a local key 217 connected so as to ground the tip conductor 214. A master station, such as 113, would be provided with a number of keys such as 218 which would transfer the conductors 213 and 214 from conductors 215 and 216, respectively, to conductors 219 and 220, respectively, leading to the second terminal of a trunk circuit. It will be understood that as many keys 218 as there are trunks may be provided.

The station line circuit comprises a line relay 221 and cut-off relay 222. When the line is idle both of these relays are in their normal unoperated position as shown. When the handset 200 is removed from its cradle then the relay 221 will be energized in the usual manner and will place a ground on the starting conductor 223 leading to the line-finder circuit. At the same time a battery connection through the resistance 224 will be connected to the sleeve conductor 225 so that the line finder may select this calling line by differentiating between the battery connection as a calling condition, the direct ground connection as a busy condition, and the open circuit connection as an idle condition. The conductors 226 and 227 lead to the line terminals of the line finder. Terminals 228, 229 and 230 represent the appearance of the line in the connector banks. It will be noted that when the line is seized over a connector terminal that the cut-off relay is operated. Likewise, when the line finder connects to this line in response to a calling condition thereon, a ground will first be connected over conductor 225 through the contacts of the line relay through the winding of the cut-off relay and then permanently through the front contact of the outer right-hand armature of relay 222 to the winding of this cut-off relay. Upon the operation of relay 222, the relay 221 if operated on a calling condition is restored and if not operated, then is thereafter prevented from operating. Upon the restoration of relay 221 on a calling condition ground on the starting lead 223 is removed. It is believed that this short description of the line circuit is sufficient since this operation is well-known.

Fig. 3 is a circuit diagram of the line-finder circuit. At the extreme left there is a circuit arrangement including terminals of the line-finder switch and connections running horizontally to station line circuits and vertically downward to the office trunk circuits. This line finder is of that type having two sets of brushes as it

serves two groups of calling lines of one hundred in each group. The lower set of terminals 340 to 343, inclusive, serve the tip and ring brushes 307 and 308; the group of terminals 344 to 347, serve the tip and ring brushes 311 and 312 and the group of terminals 348 to 351 serve the two alternate sleeve brushes 309 and 313. The sleeve brush 309 is associated with the tip and ring brushes 307 and 308 and the sleeve brush 313 is associated with the tip and ring brushes 311 and 312. When the brushes 307 and 308 come to rest respectively in contact with terminals 340 and 341, the brushes 311 and 312 will be resting on terminals 344 and 345 and the brushes 309 and 313 will be resting on the terminals 348 and 349. In accordance with which one of the terminals 348 or 349 the calling condition appears on will be determined which set of tip and ring brushes will be used.

In the present case let it be assumed that the conductors 227 and 226, 225 and 223 of the station line circuit shown in Fig. 2 are connected to conductors 303, 304, 305 and 306, respectively. This means that the calling condition will be found by brush 309 and that consequently the tip and ring brushes 307 and 308 will be rendered operative. The choice is made by relay 310 which will operate when brushes 307 and 308 are to be used and will fail to operate when brushes 311 and 312 are to be used.

When a calling condition appears for instance on conductor 306, a group relay 314 will be operated. This group relay known as the start relay will place a ground on conductor 315 leading to a particular terminal in the bank of terminals generally designated 316 to indicate to the line finder in which group the calling line appears, so that the first movement of the line finder will be a group hunting movement controlled by brush 317. Group relay 314 also closes a circuit which may be traced from a back contact of relay 318 to the winding of relay 319. The circuit for relay 319 may be traced from ground, armature and back contact of relay 318, front contact and inner upper armature of group relay 314, normal contacts of armature 1 of relay 320, contacts 2 and 1 of spring combination 321 which operates on the 11th rotary step of the line finder, winding of relay 319 to battery. Relay 319 prepares a circuit to ground sleeve lead 322 to the selector-connector when relay 323 operates, opens the release circuit, prepares a circuit for the upper winding of relays 323 and causes relay 323 to operate over its lower winding. This latter circuit may be traced from ground, armature 1 and front contact of relay 319, the armature and back contact of vertical magnet 324, the armature and back contact of the rotary magnet 325, lower winding of relay 323, armature 2 and back contact of relay 320 to battery. Relay 323 operates the vertical magnet and steps the shaft of the line finder. This circuit may be traced from ground, armature 1 and front contact of relay 319, front contact and armature of relay 323, armature 4 and back contact of relay 326, winding of vertical magnet 324, armature 2 and back contact of relay 320 to battery. Upon its energization the vertical magnet opens the circuit for the lower winding of relay 323 and this in turn opens the circuit of the vertical magnet 324. Through this interdependent circuit the vertical magnet 324 automatically steps the shaft of the line finder until the proper group has been found through the engagement of brush 317 with terminal 329.

On the first vertical step the vertical off-normal springs 327 prepare operating and locking circuits for relays 320 and 310. On the upward movement of the shaft the commutator brush 317 reaches the segment which is grounded by the operation of the group start relay 314. When the segment 329 is thus reached relay 326 operates in series with the lower winding of relay 323 and locks in the operated position. This circuit may be traced from ground, front contact and upper armature of relay 314, group contact 329, brush 317, lower winding of relay 326, armature and back contact of rotary magnet 325, lower winding of relay 323, armature 2 and back contact of relay 320 to battery. A locking circuit for relay 326 may be traced from ground, armature 1 and front contact of relay 319, armature 3 and front contact of relay 326, upper winding of relay 326, winding of vertical magnet 324, armature 2 and back contact of relay 320 to battery. This holds relay 323 in its operated position to prevent further stepping. Relay 326 is made slow in operating to give a short time between the last vertical step and the first rotary step to prevent snagging of the brushes due to vibration set up in them during vertical stepping. Relay 323 is slow in operating to prevent it from reoperating the vertical magnet after its contact closes but before it is fully released. Relay 323 is also slow in releasing to insure its holding when the line finder finds the line.

The release circuit is opened on the operation of relay 326 to preclude the possibility of the release or partial release of the shaft and reoperation of relay 319 before the release of relay 326 in which case the rotary magnet would energize without the shaft being centered on any bank level and probably cause jamming of the stationary dog or snagging of the brushes on the bank terminals. The operation of relay 326 also transfers the stepping circuit from the vertical to the rotary magnet through the movement of its armature 4. The rotary magnet then steps the shaft around until the sleeve brushes reach the terminal which is connected to battery. The circuit for rotary magnet 325 may be traced from ground, armature 1 and front contact of relay 319, front contact and armature of relay 323, armature 4 and front contact of relay 326, armature 5 and back contact of relay 310, the rotary magnet 325 to battery. Here the same interaction between relay 323 and the rotary magnet takes place as before described in connection with the action of the vertical magnet so that the rotary magnet automatically rotates the shaft of the line finder until either brush 309 or 313 encounters a calling condition heretofore described in connection with the line circuit of Fig. 2.

For the sake of completeness in description it will first be assumed that brush 313 detects a calling condition. Thereupon relay 330 will be operated in series with the upper winding of relay 323 in a circuit which may be traced from battery which is characteristic of the calling condition, brush 313, lower winding of relay 330, armature 2 and back contact of relay 310, back contact and armature 3 of relay 320, front contact and armature 2 of relay 319, upper winding of relay 323, front contact and armature 1 of relay 319 to ground. Relay 330 operates and closes a circuit from battery through its upper winding, its front contact and armature 4, armature 3 and front contact of relay 319, armature and front contact of relay 323, front contact and armature

1 of relay 319 to ground. The operation of relay 330 closes the tip and ring leads through from the calling line to the selector-connector, opens the release circuit and operates relay 320. The circuit for operating relay 320 may be traced from ground, contacts 3 and 2 of the vertical off-normal contacts 327, front contact and armature 2 of relay 330, the upper winding of relay 320 to ground. The operation of relay 320 closes the sleeve lead 322 through from the first selector to the line circuit, opens the test circuit to brush 313, transfers the start lead from relay 319 to the lower winding of relay 320 and removes battery from the relays 323 and 326 and the vertical magnet. This allows relay 326 to release. Battery is removed from the lower winding of relay 323 for the purpose of preventing its operation on the release of the finder switch. Battery is removed from the vertical magnet 324 to prevent the false operation if relay 326 released before relay 323 due to the difference in the releasing time of these two relays.

As soon as relay 330 is operated, and as will appear hereinafter, the relay in the selector-connector is operated which will return a ground over the conductor 322 and this ground will find its way from conductor 322 over the front contact and armature 3 of relay 320, the normal contacts of armature 4 of relay 310, armature 3 and front contact of relay 330 to brush 313 for the purpose of operating the cut-off relay in the line circuit.

If it may be assumed that brush 309 instead of brush 313 finds the calling condition, then relay 310 will operate in series with the upper winding of relay 323. The circuit for relay 310 may be traced from battery which designates the calling condition on the line brush 309, the upper winding of relay 310, back contact and armature 3 of relay 330, normal contacts of the armature 4 of relay 310, front contact and armature 2 of relay 319, upper winding of relay 323, front contact and armature 1 of relay 319. The locking circuit for relay 310 may be traced from battery, the lower winding of relay 310, front contact and armature 3 of relay 310, contacts 2 and 3 of vertical off-normal springs 327 to ground. The operation of relay 310 transfers the tip and ring leads from brushes 311 and 312 to brushes 307 and 308, respectively, closes the circuit for operating the relay 330, opens the circuit of the rotary magnet 325 and finally opens the connection from the lower winding of relay 330 at armature 2 and front contact of relay 310. The circuit of the rotary magnet 325 is opened to prevent the finder taking an additional step should the locking springs of the cut-off relay in the station line circuit fail to make contact. Through the operation of relay 310, relay 330 becomes energized in a circuit from ground, springs 3 and 2 of the vertical off-normal springs 327, armature 4 and front contact of relay 319, armature 6 and front contact of relay 310, upper winding of relay 330 to battery. Relay 330 then locks in a circuit from its front contact and armature 4, armature 3 and front contact of relay 319, armature and front contact of relay 323, front contact and armature 1 of relay 319 to ground. Upon the operation of relay 330, the circuit functions are hereinbefore described when battery was found by brush 309 instead of brush 313.

In this manner the line finder operates when a calling condition appears on any one of the terminals in its bank and connects the calling

line to the selector-connector circuit shown in detail in Fig. 4.

When the subscriber hangs up the receiver before the line is found the relay 314 releases allowing the relay 319 to release. This closes a circuit for energizing the release magnet, which may be traced from the winding of release magnet 358 through springs 5 and 4 of the vertical off-normal springs 327, armature 1 and back contact of relay 326, back contact and armature 2 of relay 330, back contact and armature 4 of relay 319, springs 2 and 3 of vertical off-normal springs 327 to ground. If this call is abandoned before the brushes have reached the line terminal the finder continues to step during the releasing time of slow release relay 319 in which case it may go to the limit of its rotary motion or, if for any other reason, such as an open sleeve circuit, the finder fails to cut through it will continue stepping until it reaches the 10th contact when the rotary shaft or cam springs 321 will operate on the 11th step and open the circuit to relay 319. The rotary shaft springs 321 also short circuit the rotary interrupter springs holding the relay 323 operated which prevents the rotary magnet from deenergizing until relay 319 releases. After an interval relay 319 releases causing relay 320 to operate and relay 326 to release. Relay 326 completes the closure of the release magnet circuit and the shaft returns to normal. If there is a line waiting on the 10th contact relay 330 will operate before relay 319 releases and relay 319 will then be held operated in series with the pulse relay of the selector until ground is returned on the sleeve to hold the finder operated. When the subscriber hangs up after the line is found ground is removed from the sleeve lead from the selector-connector allowing relay 330 to release. Release of relay 330 closes a circuit to energize the release magnet which may be traced from the winding of release magnet 358, springs 5 and 4 of vertical off-normal springs 327, armature 1 and back contact of relay 326, back contact and armature 2 of relay 330, back contact and armature 4 of relay 319, springs 2 and 3 of vertical off-normal springs 327 to ground. Relays 320 and 310, if operated, are held until the finder returns to normal. The purpose of the lower winding of relay 320 is to hold the relay operated if the finder is returned to normal at a time when the start lead is advanced through this finder circuit and has started a succeeding finder until the finder started has found the calling line.

When the line finder of Fig. 3 operates its relay 330 to connect a calling line to the selector-connector, then relay 400 operates by supplying battery and ground connection to the calling line. The connection may be traced from battery, the upper winding of relay 400, the upper winding of relay 403, back contact and armature 4 of relay 404, conductor 402 and thence through the loop of the calling line to tip conductor 401, armature 1 and back contact of relay 404, lower winding of relay 403, lower winding of relay 400 to ground. Since the calling line at this time maintains a bridge which is effectively a connection between conductors 401 and 402, current will flow through the windings of relays 400 and 403 in such manner that relay 400 will be operated, but relay 403 being differentially wound, will not operate. The operation of relay 400 results in the operation of slow-release relay 405. Relay 405 connects ground through its armature 3 and

front contact through the upper winding of relay 406 to sleeve conductor 422. If the calling condition has come from a line circuit there will be no source of ground in the line circuit. Consequently, after relay 320 operates and while relay 319 releases as hereinbefore described, upon the release of relay 319 the holding ground for relay 330 is supplied over a circuit which may be traced from ground, armature 3 and front contact of relay 405, the upper winding of relay 406, sleeve conductor 422, sleeve conductor 322, armature 4, and front contact of relay 330 through the winding of relay 330 to battery. If relay 310 has been operated then a parallel circuit will be established from sleeve conductor 322 through the front contact and armature 3 of relay 320, front contact and armature 4 of relay 310 to brush 309 and thence to the battery connection from the line circuit. If relay 310 has not been operated then a parallel circuit may be traced through the front contact and armature 3 of relay 320, normal contacts of relay 4 of relay 310, armature 3 and front contact of relay 330, brush 313 to the battery condition from the calling line. Relay 406 will operate in this circuit. The upper winding of relay 406 is of comparatively low resistance so that after the release of relay 319 in the finder circuit and before relay 406 has become operated the ground through its upper winding will effectively hold relay 330 operated and hold the cut-off relay of the line circuit operated. Relay 406 in operating locks through its lower winding, its armature 1 and front contact to the ground supplied over the front contact and armature 3 of slow releasing relay 405. At the same time relay 406 short-circuits its upper winding by its armature 3 so that the ground supplied by relay 405 will be directly connected to the sleeve conductor 422.

It should be noted that when a trunk connection is made through the line finder, as for instance when a trunk connected to conductors 352, 353, 354 and 306 sets up a calling condition and the brushes 311, 312 and 313 are driven respectively into contact with terminals 344, 345 and 349 that a ground connection is extended from the trunk circuit over the sleeve 354 and hence relay 406 in the selector-connector will not be operated because each side of its upper winding will be connected to ground. The ground from the trunk will extend back over conductor 422 and the ground from armature 3 of relay 405 will extend to the other side of the upper winding of this relay. Hence relay 406 discriminates between a connection from a calling line and a connection from a calling trunk, as for instance when trunk 104 is placed in such a condition that a calling condition appears on its fifth terminal and the line finder 107 is employed to extend such connection. It will also be noted that the operation of relay 406 will prevent the operation of relay 404 except on calls to levels on which the springs 429 are operated. Relay 404, as will appear hereinafter, is a cut-through relay and will differentiate between local and trunk calls. On a local call when relay 406 is operated relay 404 is prevented from operating and therefore talking battery will be supplied in one direction from the windings of relay 400 and in the other direction from the windings of relay 407. When a trunk has set up a call to the line finder, then relay 406 is prevented from operating and relay 404 is allowed at the proper time to operate so that now the local sup-

ply of talking battery through the windings of relays 400 and 407 will be cut off and the battery from the central office will be used.

Let it be assumed that this selector-connector is now to be used for setting up a local connection, as for instance between station 115 and station 118.

As soon as the connection between the calling subscriber and the selector-connector has been made a source of dial tone will be connected from conductor 408 through springs 1 and 2 of the vertical off-normal springs 409, armature 1 and front contact of relay 400, condenser 410 to the tip line conductor 401 and thence to the calling substation. The subscriber thereat recognizing the dial tone will proceed to dial in the usual manner. At each interruption of the line circuit by the dial, relay 400 releases and operates the vertical magnet in series with relay 411, relay 411 operating on the first impulse from relay 400. The circuit for the vertical magnet may be traced from ground, armature 2 and back contact of relay 400, armature 1 and front contact of relay 405, springs 3 and 5 of the vertical off-normal springs 409, winding of relay 411, winding of vertical magnet 412 to battery. Relay 411 operates so that upon the first step of the switch and upon the operation of vertical off-normal springs 409, the circuit may be traced through springs 3 and 4 of vertical off-normal springs 409, upper armature and front contact of relay 411, winding of relay 411 and thence through the vertical magnet. The vertical magnet steps the shaft and brushes to the desired level.

Relays 405 and 411 are not designed to be slow in releasing and do not release on dial interruptions. When the impulses from relay 400 cease relay 411 releases and transfers the pulse circuit from the vertical magnet to the rotary magnet. On the next series of impulses from the dial relay 400 on releasing operates the rotary magnet in series with relay 413, relay 413 operating on the first impulse of relay 400. This circuit may be traced from the upper armature of relay 411 and its back contact, armature 1 and back contact of relay 407, normal contacts of armature 2 of relay 414, winding of relay 413, armature 2 and back contact of relay 415, winding of rotary magnet 416 to battery. Relay 413 is designed to be slow in releasing and does not release on dial impulses. The rotary magnet 416 steps the shaft and brushes around to the terminals of the called line. Relay 413 prepares the busy test circuit and short-circuits the normal contacts of armature 2 of relay 414 through which the rotary magnet circuit is taken so that operation of relay 414, while the sleeve brush passes over the busy terminals, will not open the rotary magnet circuit.

On the completion of the dial interruptions of the last digit, relay 413 being slow in releasing, remains operated a short time after the brushes make contact with the terminals of the called line during which a busy test is made. The test circuit may be traced from the sleeve of the called line, brush 417 over the upper armature and front contact of relay 413, the armature and back contact of the rotary magnet 416, winding of relay 414, springs 1 and 2 of the 11th rotary step device 418 through the winding of release magnet 419 to battery. If the line is busy, ground will be connected to the brush 417 and relay 414 will operate. Since the relay 414 is of considerably higher resistance than the release

magnet 419, relay 414 alone will operate in this circuit.

Assuming for the time being that the line is idle then relay 414 will not be operated. At the release of relay 413, relay 415 will operate through its lower winding in a circuit which may be traced from battery through the cut-off relay 222 and the sleeve terminal 230 through the sleeve brush of the selector-connector 417, upper armature and back contact of relay 413, lower winding of relay 415, back contact and armature 4 of relay 414, armature 2 and front contact of relay 405 to ground. Relay 415 locks in the circuit from battery, the upper winding of relay 415, front contact and armature 4 of relay 415 to ground on the sleeve lead 422. Relay 415 places a direct ground on the sleeve terminal 417 through its armature 3 and front contact to operate the cut-off relay in the line circuit of the called line. The same ground also places a busy condition on the sleeve terminal in the multiple bank. Relay 415, operated, also opens the rotary magnet circuit so as to prevent further stepping of the brushes if the calling party should again operate the dial. If the called line is busy, relay 414 operates as hereinbefore described and connects the source of busy tone supplied to conductor 420 through armature 1 and front contact of relay 414 through armature 2 and back contact of relay 407 through condenser 421 through armature 4 and front contact of relay 406 back contact and armature 1 of relay 404 to tip conductor 401 whence it extends to the calling subscriber's station and notifies the subscriber thereat that the line is busy. The circuit remains in this condition until the receiver at the calling station is replaced on the switchhook.

Assuming the called line to be idle and that it has been seized and its cut-off relay operated as hereinabove described, then upon the operation of relay 415 the ringing circuit is connected to the called line from a source of ringing current 432, the upper winding of relay 423, back contact and armature 5 of relay 423, front contact and armature 7 of relay 415, ring brush 424 of the selector-connector and thence to the called line, the return path being traced through the tip brush 425, armature 1 and front contact of relay 415, armature 2 and back contact of relay 423 to ground. Ringing tone is supplied to the calling line by diverting a small portion of the ringing current through condenser 426, front contact and armature 6 of relay 415 to the ring conductor 427 so that the calling subscriber will know that the called subscriber is being rung. The ringing current passing through the upper winding of relay 423 also induces a tone in the lower winding of this relay which finds a path through the upper winding of relay 407 and thence out over the calling line so that the ringing tone supplied through condenser 426 is increased thereby. Relay 423 is designed so as to not operate on ringing current. When the receiver is removed from the switchhook at the called station, the direct current which is superimposed on the ringing current operates relay 423 which thereupon locks through its lower winding, its front contact and armature 3 to the ground on the sleeve conductor 422. Relay 423 in operating cuts off the ringing current, closes the talking circuit and short-circuits condenser 426.

Talking battery is now supplied to the calling station through the windings of relay 400 and to the calling station through the windings of

relay 407. The connection is controlled by the calling station. When the receiver at that station is replaced on the switchhook relay 400 releases in turn releasing relay 405. Upon the release of relays 400 and 405 the release magnet 419 is energized and the switch is returned to normal. When the switch finally reaches its normal position the circuit of the release magnet is opened at contacts 6 and 7 of the vertical off-normal contacts 409.

The selector-connector switch shown in Fig. 4 will also operate in another manner when the subscriber at the calling station operates his local key thus grounding the tip conductor 401. At this time the lower winding of differential relay 403 is short-circuited and the current through the upper winding is slightly increased so that the differential relay 403 operates.

Upon its operation relay 403 causes the operation of relay 437 in a circuit from battery, the winding of relay 437, armature and front contact of relay 403, armature 1 and front contact of relay 406, front contact and armature 3 of relay 405 to ground. Relay 437 locks through its armature and front contact and supplies ground to the armature of relay 403, so it will not be until the subscriber releases his local key to release relay 403 that the effect of the operation of relay 403 is manifested. This feature is provided so that the selector-connector will not extend the line to a trunk while the local key is still operated and thus cause an unintended operation in the trunk. Now upon the release of relay 403 the ground on its armature is extended through the contacts 428 the back contact and armature of the vertical magnet 412 to the winding of relay 431. In response to this action the selector-connector will automatically step to a particular group and thereafter automatically select the first idle line in that group. This provision is made so that one of the subscribers having a local key, such as one of the subscribers' stations 113 to 116 may automatically select the first idle trunk line to the central office over its No. 3 terminal. For this purpose and as shown in the present case the No. 3 terminals of the central office trunks will all be placed on the 9th level of the switch. For the purpose of controlling this automatic action a number of spring combinations operating on certain vertical movements of the shaft of the switch are provided.

Spring combination 428 known as the "hunt" springs are arranged to be operated when the switch is on its 9th and 10th levels. These springs are provided to change the circuit when the selector-connector reaches the 9th level on its vertical automatic movement under the control of the differential relay 403. Spring combination 429 known as the "cut-through" springs allow the transmission circuit of the selector-connector to be changed from local supply of talking battery on connections involving two local stations to the central office battery supply. These springs are arranged to be operated when the switch is in the 8th, 9th and 10th levels. The cut-through operation is carried out on the 8th level since the No. 4 terminals of the trunks are connected in its 8th level. Spring combination 430 known as the "restricted service" springs are arranged to be closed on the 9th level only. These springs are provided so that if a subscriber having knowledge that the terminals of the trunks to the central office are situated on the 9th level attempts to circumvent the restricted service provision (character-

ized by the absence of a local key) by dialing to the 9th level, he will find a bar so that no connection can be made.

Assuming that a call has been made from either a master station or a key station and that it is desired to extend a call to the central office, then upon the seizure of a selector-connector circuit the local key at such station will be operated resulting as hereinbefore described in the operation of the differential relay 403. Upon the release of relay 403, ground will be extended from armature 3 and front contacts of relay 405, front contact and armature 1 of relay 406, armature and front contact of relay 437, armature and back contact of relay 403 through springs 1 and 2 of the spring combination 428, back contact and armature of the vertical magnet 412 through the winding of relay 431 to battery. Relay 431 operates and connects ground through its armature and front contact through the armature 1 and front contact of relay 405, springs 3 and 5 of the vertical off-normal combination 409 through the winding of relay 411 and thence through the winding of the vertical magnet 412. Relay 411 and magnet 412 are operated in this circuit. The operation of the vertical magnet opens the circuit of relay 431. This relay in turn opens the circuit of magnet 412 and thus through the interdependent circuits controlled by the relay 431 and the magnet 412 the magnet steps the switch in its vertical direction. This stepping will be continued until the 9th level is reached and the circuit through the hunting spring combination 428 is opened. As the 9th level is reached a circuit will be established through springs 3 and 4 of the hunting springs 428 which may be traced from ground on sleeve conductor 422 through armature 3 and back contact of relay 415, springs 4 and 3 of the spring combination 428, resistance 433, armature 4 and back contact of relay 423, lower winding of relay 407 to battery. Relay 407 is energized in this circuit and extends the ground from spring 3 of the hunting combination 428 through the front contact and armature 3 of relay 407, lower armature and front contact of relay 411, armature and back contact of rotary magnet 416, winding of relay 414, springs 1 and 2 of spring combination 418, winding of release magnet 419 to battery and ground. Relay 414 is operated in this circuit. Through the operation of relay 414 another circuit independent of relay 411 is established through ground, front contact and armature 2 of relay 405, armature 4 and front contact of relay 414, normal contacts of the upper armature of relay 413, armature and back contact of rotary magnet 416, winding of relay 414, contacts 1 and 2 of the spring combination 418, winding of release magnet 419 to battery. Shortly thereafter the relay 411 will release its armatures whereupon ground on its lower armature is transferred from the circuit in the original energization of relay 414 to a circuit which may now be traced through armature 2 and front contact of relay 414, winding of relay 413, armature 2 and back contact of relay 415, winding and rotary magnet 416 to battery. Thus rotary magnet 416 is placed in a self-interrupting circuit and will step the brushes around until an idle trunk is found. Upon the operation of relay 413 it will extend ground from the sleeves of busy trunks through brush 417, upper armature and front contact of relay 413 to the armature and back contact of rotary magnet 416 to maintain relay 414 energized. When an idle trunk is

encountered relay 414 releases and by opening the circuit of the rotary magnet at its armature 2 stops the brushes on the terminals of the idle trunk. Upon the deenergization of relay 214 ground from the front contact and armature 2 of relay 405 is connected to the armature 4 and back contact of relay 414, lower winding of relay 415 and upon the deenergization of relay 413 through the back contact and upper armature thereof to brush 417 where battery connection from the trunk will cause the energization of relay 415. As soon as relay 415 thus becomes energized ground from sleeve 422 is connected through armature 3 and front contact of relay 415 to brush 417 to render this terminal of the selected trunk busy and to cause circuit changes therein which will be described hereinafter. Relay 415 locks through its upper winding, its front contact and armature 4 to ground on sleeve conductor 422.

Further through the energization of relay 415 the circuit for the lower winding of relay 407 is opened and this relay returns to normal. It will also be noted hereinafter that upon the selection of an idle trunk a tripping circuit for relay 423 is rendered effective upon the operation of relay 415 so that relay 423 immediately becomes energized and locks through its lower winding to the sleeve lead 422.

Relay 404 is now operated in a circuit from its winding through the front contact and armature 5 of relay 415, cut-through contacts 429 to the ground on sleeve lead 422 so that the tip and ring conductors are now disconnected from the windings of the battery supply relay 400 for the calling line and the battery supply relay 437 for the called line so that the central office battery over the trunk of Fig. 5 may be used. Relay 404 locks through its front contact and armature 2 to the sleeve lead 422.

At the end of the conversation removal of ground from the sleeve conductor 422 will result in the release of the selector-connector circuit. When the relay 404 has returned to normal and the relays 400 and 405 have released a circuit for the release magnet 419 is established through springs 6 and 7 of the vertical off-normal combination 409 through the back contact and armature 3 of relay 404, back contact and armature 1 of relay 405, back contact and armature 2 of relay 403 to ground.

Should one of the parties at any one of the stations in this system attempt to reach one of the No. 3 terminals of the central office trunks by dialing to the 9th level the following condition will be established. The selector-connector of Fig. 4 of course will respond to the nine pulses which will operate the vertical magnet 412 and lift the brushes of the selector-connector to the 9th level. However, a circuit will now be established from ground, armature 3 and front contact of relay 405, front contact and armature 1 of relay 406, armature and back contact of differential relay 403 through the restricted service contact 430 now closed as the switch has been driven to its 9th level to brush 417, thus placing a ground on the sleeve brush and thereby preventing the selection of any trunk. Ground from the sleeve 422 is connected as before described through armature 3 and back contact of relay 415, contacts 4 and 3 of the hunting combination 428 through resistance 433, armature 4, and back contact of relay 423, lower winding of relay 407 to battery, thus operating relay 407. The ground for relay 407 is therefore connected

through the front contact and armature 3 of relay 407 to the lower armature of relay 411. This takes place, of course, as soon as the 9th level has been reached and before relay 411 has been released. Therefore the ground is connected through the front contact of the lower armature of relay 411 through the armature and back contact of the rotary magnet 416 to the winding of relay 414 causing this relay to operate. The brushes will be automatically stepped around, but due to the ground which is permanently placed on the brush 417, the brushes will not stop on an idle trunk and thus the attempt of the subscriber to gain access to a central office line will be frustrated.

The trunk circuit is shown in detail in Fig. 5. The numeral 500 designated the central office and the tip and ring conductors 501 and 502 constitute the first terminal of this trunk circuit and correspond to the line designated 101 in the schematic of Fig. 1.

The conductors 503 and 504, respectively, constitute the second terminal of this trunk that is schematically represented in Fig. 1 as 125. A pair of conductors 505 and 506 to which lamps, such as 507 and 508, connected to conductor 505 and 509 and 510 connected to conductor 506, represent the signal boxes such as that labeled 130 in Fig. 1. The lamps 509 and 510 connected to conductor 506 represent the line lamps and these will flash on an incoming call and remain steadily lighted while the trunk is being held. The lamps 507 and 508 connected to conductor 505 indicate that the trunk is busy.

Conductors 511, 512 and 513 constitute the third terminal of the trunk and it may be connected to terminals 435, 434 and 436, respectively, in the ninth level reached by the selector-conductor of Fig. 4.

The conductors 514, 515 and 516 constitute the fourth terminal of this trunk and may be connected to terminals such as 435, 434 and 436, respectively, in the eighth level of the selector-conductor of Fig. 4.

The conductors 517, 518, 519 and 520 constitute the fifth terminal of the trunk and may be connected to conductors 352, 353, 354 and 306, respectively, in the line finder of Fig. 3. Conductor 520 is the starting conductor and is used with both the fifth and sixth terminals of the trunk. Conductors 521, 522 and 523 constitute the sixth terminal of this trunk and might, for instance, be connected to conductors 355, 356, and 357, respectively, leading to the line finder terminals.

The operation of this circuit is as follows: The trunk conductor 501 is normally open at the central office. When the trunk is seized, however, ground is connected to conductor 501 and this will complete a circuit through the winding of relay 528, armature 3 and back contact of relay 524, resistance 529 to battery, whereupon relay 528 causes the operation of cut-through relay 530, which, through its armature 3 places a ground on the sleeve conductor 531. Relay 538 responds to the operation of relay 530 and through its operation connects battery to conductor 505 to light the busy lamps 507 and 508. When ringing current is applied to the line at the central office a path may be traced from conductor 501 through armature 4 and back contact of relay 524, winding of ringing relay 525, condenser 526 to ring conductor 502. Relay 525 responds to this current and causes the operation of relay 527 from ground on sleeve

conductor 531 to the winding of relay 527. Relay 527 locks through its front contact and armature 2, the back contact and armature 1 of relay 524 to the ground on sleeve conductor 531. Relay 527 establishes a connection from a source of battery through the interrupter 532, front contact and armature 1 of relay 527 to conductor 506 whereby the line lamps 509 and 510 are caused to flash intermittently, thus notifying any one of the subscribers within the premises that a call is incoming on the corresponding trunk.

This call may be answered over terminal 2 or 4 of the trunk. Any one of the subscribers such as those at stations 113 and 114 may manually gain access to the trunk through the operation of their corresponding trunk keys. Any station may dial the number of the trunk and reach it through its terminal 4. In this connection it should be noted that the sleeve conductor 516 is normally grounded by a circuit which may be traced from the back contact and armature 3 of relay 527, thence through the back contact and armature 1 of relay 536, the back contact and armature 3 of relay 541 to conductor 516. When an incoming call is received and relay 527 is operated, this ground is removed so that access to the trunk may be gained over its fourth terminal.

It will further be noted in the ensuing description that when the trunk is put in a "held" condition that the relay 536 will operate and that this too will disconnect ground from conductor 516 and instead connect battery thereto through the resistance 550. It may be also incidentally mentioned this time that when the trunk is being "held" battery, through armature 9 and front contact of relay 542, will be connected to conductor 506 to cause the lamps 509 and 510 to operate steadily so that whenever lamps 509 and 510 are operating either steadily or intermittently, the ground normally connected to the sleeve conductor 516 is removed so that a subscriber within the exchange may gain access to the trunk over its fourth terminal by directly dialing to that terminal.

It should be noted that relay 528 is provided so that if the call at the central office should be abandoned the release of this relay will release cut-through relay 530, thus removing ground from the sleeve 531 and returning the trunk to its normal position.

Let it be assumed that the subscriber at station 113 answers this incoming call over the second terminal of the trunk by operation of a key such as 121. The telephone station circuit 113 will then be bridged across the conductors 503 and 504, which, through the operation of relay 530, are connected to conductors 501 and 502, respectively. This will operate as the usual response of a subscriber to an incoming call and be noted accordingly by the apparatus at the central office. The windings of the differential relay 533 and the winding of relay 534 are included in this circuit. Relay 534 alone operates, the windings of the differential relay being so poled that they oppose each other in this connection. The operation of relay 534 causes the operation of relay 535 and this relay extends ground from armature 6 and back contact of relay 536 over armature 1 and front contact of relay 535 to the winding of relay 537 which now becomes operated. Relay 537 causes the operation of relay 524 so that the tip side of the line 501 connected through the winding of relay 528

is now transferred to the back contact of armature 2 of relay 538 but this relay being operated through the operation of relay 530 removes the winding of relay 528 effectively from the connection. Relay 537 causes the operation of relay 541 and this relay now connects ground from the front contact and armature 2 of relay 537 through the front contact and armature 3 of relay 541 to sleeve conductor 516 and also through the front contact and armature 4 of relay 541 to the sleeve conductor 513, thereby rendering this trunk inaccessible over its third or fourth terminals. In other words, upon the response of the subscriber over the second terminal of the trunk, both the third and fourth terminals are rendered artificially busy. Relay 545 is operated over a circuit from armature 6 of relay 541, normal contacts of armature 1 of relay 542 to relay 545.

Let it be assumed that the incoming call is actually for a party at, say, station 116. The party at station 113 will therefore operate his local key such as 119 which, by unbalancing the line, will result in the operation of the differential relay 533. This relay establishes a circuit from ground through its armature and front contact, armature 1 and back contact of relay 540, armature 1 and front contact of relay 541, back contact and armature 5 of relay 536, winding of relay 542 to battery. Relay 542 operates and locks through its armature 5 and front contact to the ground supplied over the back contact and armature 6 of relay 536. It will also be noted that due to the operation of relay 537 and through the front contact and armature 4 of this relay the ground from armature 6 is supplemented by a ground at the back contact of armature 1 of relay 547 when this relay is not operated and by a ground over the front first contact and armature 6 of relay 540 when this relay is operated.

Relay 542 opens the line between the subscriber at station 113 and the central office but through its armature 4 and front contact it connects a holding coil 543 across the central office line. It will be noted that the holding coil 543 connects to the tip of the line 531 ahead of the upper winding of relay 533 but that the front contact of armature 4 of relay 542 is connected to the ring of the line behind the lower winding of relay 533 so that the lower winding only of this differential relay is now included in the holding circuit. Relay 533 therefore remains operated while this holding condition is maintained. At the same time relay 542 connects ground from the armature and back contact of relay 544 through the front contact and armature 3 of relay 542 to the start conductor 523 so that a line finder will hunt for a calling line. The calling condition will appear on terminal 5 of the trunk through the connection of battery through the winding of relay 544, front contact and armature 2 of relay 542, armature 1 and front contact of relay 545, normal contacts of armature 2 of relay 540 to sleeve conductor 519. It will be noted at this time that sleeve conductor 523 is grounded through the front contact and armature 5 of relay 541. It will also be noted that the transfer relay 545 upon the operation of relay 542 became locked in a locking circuit from ground, armature 3 and front contact of relay 545, armature 1 and front contact of relay 542 to the winding of relay 545. When a line finder finds the calling terminal 5 of this trunk, relay 544 will be operated and this will remove ground

from the start conductor 520 and thereupon extend ground through armature 2 and front contact of relay 545 to the sleeve conductor 519 so that immediately the calling terminal is found ground is connected from the trunk into the line finder sleeve in the manner hereinbefore noted. Relay 544 is slow in operating to allow time for the operation of relay 310 or 330.

As soon as the line finder has found the calling terminal which, in this instance, connects to conductors 517, 518 and 519, the source of talking battery supply through the windings of relay 400 in the selector-connector will be connected to the tip and ring conductors so that the calling subscriber at the station 113 will now be supplied with talking battery over this path. Relay 546 as well as relay 534 is now included in the circuit and relay 546 will respond with result that relay 547 is operated and due to the ground supplied by armature 6 of relay 536, relay 540 will follow. Through the operation of relays 535 and 547 the talking battery supply through the resistance coils 548 and 549 and over the front contacts of armatures 7 and 8 of relay 542 will be disconnected from the talking circuit so that the operation of relays 534 and 546 depends now entirely upon the talking battery supply from the selector-connector. Relay 536 now responds in a circuit which may be traced from ground, the armature 1 and front contact of the differential relay 533, armature 1 and front contact of relay 540, armature 2 and front contact of relay 541, front contact and armature 6 of relay 542, winding of relay 536 to battery and ground. Relay 536 immediately locks through its front contact and armature 4 to the ground supplied by the armature of the relay 533.

It should be noted at this point that after the subscriber on the second terminal of this trunk has operated his local key and the differential relay 533 has responded thereto that a holding condition has been put on the trunk toward the central office and that the line finder has connected to the fifth terminal of the trunk. The subscriber may now disconnect or he may dial another subscriber. Assuming for the time being that he disconnects and thereby dismisses the line finder, then relay 534 will release followed at proper intervals through the slow-releasing characteristics of relay 535, 537, and 541 in the release of these relays. Relay 546 also releases and this is followed at proper intervals by the release of relays 547 and 540. Relay 535 releases before relay 540 releases because of the slow releasing characteristics of the relays. Then a holding circuit for relay 540 is momentarily established during the releasing time of relay 537 over a path from battery through the winding of relay 540, back contact and armature 4 of relay 535, front contact and armature 4 of relay 545, front contact and armature 3 of relay 536, armature 2 and front contact of relay 540, armature 1 and front contact of relay 537, front contact and armature 1 of relay 545, front contact and armature of relay 544 to ground. When relay 537 releases, this holding circuit is opened but another holding circuit for relay 540 remains until the line finder releases, this holding circuit being over conductors 519, 322, 422, top winding of relay 406 and armature 3 of relay 405. When both relay 405 and relay 537 have released, the line finder releases and then relay 540 releases.

The trunk is now being held and this condition is noted first by the steady illumination of the line lamps 509 and 510 through the connec-

tion of battery to the conductor 506 by the front contact and armature 3 of relay 542. Secondly, the normal ground on sleeve conductor 516 has been removed and this conductor may now be traced through the armature 3 and back contact of relay 541, armature 1 and front contact of relay 536 through resistance 550 to battery which marks this terminal as available. Therefore, the trunk may be seized over its terminal 4 by any one of the subscribers within the exchange dialing to this terminal.

If, after the trunk has been put in a "held" condition, and the subscriber within the exchange has disconnected so that relay 534 is released, the connection is abandoned at the central office, then the differential relay being held through its lower winding will release. This allows relay 536 to release and this in turn opens the holding circuit for relay 524 which in turn allows the cut-through relay 520 to release so that the whole trunk circuit returns to normal.

We have assumed, however, that the call on the trunk circuit is to be transferred to another station within the exchange, by way of example, station 116. The subscriber at station 113 may now dial the number of wanted station and the connector will respond in the manner hereinbefore described. The relays 535, 537, 547 and 540 are slow to release and will remain operated during the time that the relays 524 and 546 respond to the impulses.

After the second digit of the number of the wanted station has been dialed, relay 404 in the selector-connector operates as hereinbefore described. This disconnects battery and ground from the talking circuit. Thereupon relays 546 and 534 release followed by relay 547. Relay 535 may also release. However, when relay 547 releases, battery and ground are reconnected to the talking circuit through resistances 548 and 549. Then relay 534 reoperates and holds or reoperates relay 535. After relay 547 releases, relay 540 releases.

The subscriber at station 113 may now hang up or he may await the response of the called subscriber. If he hangs up then relays 534, 535, 537 and 541 will all release. Relay 535 will release a short interval after relay 534. Relay 537 will release a short interval after relay 535. A short interval after the release of relay 537 relay 541 releases and this now removes ground from the sleeve terminals 513 and 516. Sleeve terminal 513 is immediately grounded again over armature 4 and back contact of relay 541 to the ground supplied to the sleeve conductor 531. Sleeve conductor 516, however, is left connected through the armature 1 and front contact of relay 536 through the resistance 550 to battery at this time so that this fourth terminal is rendered available within the exchange. This is for the purpose of allowing the trunk to be picked up again by anyone within the exchange if the called party now being rung by the selector-connector reached over the fifth terminal does not answer.

Let it be assumed that in time the subscriber at station 116 responds to the summons of his call bell. It will be noted that since this connection through the line finder and selector-connector came from a trunk whereby ground was supplied over the sleeve 519 so that the relay 496 had no opportunity to operate and therefore the cut-through relay 404 became operated upon the finding of the called line through the operation of relay 415. The answering called party's tele-

phone will now be included in a circuit from battery feed coils 548 and 549 through the back contacts of armatures 2 and 3 of relay 535 and the back contacts of armatures 2 and 3 of relay 547 and thence through the back contacts of armatures 7 and 8 of relay 542 to the trunk conductors which include the relay 546. Relay 546 responds to the answer of the called subscriber and this will cause the operation of relay 547. The battery feed for the called subscriber is cut off by relay 547 but maintained momentarily by relay 535. Since at this time relay 536 is operated, ground through the armature 6 of relay 536 is not available for the operation of relay 540 and since when relay 547 responds the ground is disconnected at the back contact of armature 1 of relay 547, the locking circuit of relay 542 is opened. Relay 542 now returns to normal and opens the holding circuit toward the central office so that the differential relay 533 releases and this in turn causes the release of relay 535. The called subscriber is now in communication with the central office and relay 546 is maintained operated through the battery supply from the central office. Upon disconnection of relay 535 ground may be traced from armature 6 and back contact thereof through the armature 1 and back contact of relay 535, armature 1 and front contact of relay 547 to the winding of relay 540. Relays 544 and 545 are released upon the release of relay 542. Relay 524 is maintained energized from ground over armature 5 of relay 540.

The sleeve conductor 516 is now grounded at armature 3 and back contact of relay 527. Sleeve conductor 513 is grounded through armature 4 and back contact of relay 541 to ground on sleeve conductor 531. Sleeve conductor 519 is grounded from the front contact and armature 2 of relay 540 and sleeve conductor 523 is opened. Thus the third and fourth terminals of this trunk are now rendered unavailable; the line lamps 509 and 510 are dark and the busy lamps 507 and 508 are lighted through a battery connection through armature 5 of relay 524 as well as through armature 1 of relay 533.

Let it be assumed now that the subscriber at station 116 wishes to further transfer this connection. Thereupon this subscriber will operate his local key 129 which will result in the operation of the differential relay 533. Relay 533 will extend ground from its armature and front contact over armature 1 and front contact of relay 540, armature 2 and back contact of relay 541, back contact and armature 5 of relay 536 to the winding of relay 542. Relay 542 now operates and locks in a circuit through its armature 5 and front contact, armature 1 and back contact of relay 535, front contact and armature 6 of relay 540 to ground. Relay 542 as before establishes the holding circuit through the resistance 543 and the lower winding of the differential relay 533 so that this differential relay now holds from the central office battery and maintains ground on its front contact. Through the operation of relay 542 ground is placed on the start conductor 520 from the armature and back contact of relay 544. This results in the starting of another line finder. At this time a calling condition is placed on conductor 523 from battery through the winding of relay 544, front contact and armature 2 of relay 542, armature and back contact of relay 545, front contact and armature 4 of relay 540 to sleeve conductor 523. In the same manner as hereinbefore described the line finder will seek out this calling line and upon finding it will

cause the operation of relay 544. Ground will now be extended from armature and front contact of relay 544 through armature 2 and back contact of relay 545 to the sleeve conductor 523 so that when the line finder makes connection to this trunk a ground will be connected to the sleeve which will result in the failure of relay 406 in the selector-connector to operate. Let it be assumed in this case that the subscriber at station 116, connected now over the fifth terminal of this trunk through the line finder and connector, dials into the selector-connector now connected over the sixth terminal of the trunk. The battery supply will come from the relay 400 in the selector-connector now seized and both relays 534 and 546 will be operated. Dial pulses will operate both of these relays but the slow operating relays 535 and 547 will remain operated so that now all the slow-releasing relays 535, 537, 547, 540 and 541 will be maintained operated. It should be noted that upon the seizure of the sixth terminal by the line finder that relay 536 is operated when relay 541 responded to the operation of relay 534. The difference between this and the case described hereinbefore is that in the present instance the transfer relay 545 is not operated. This is due to the difference in timing between the operation of relays 534 and 546. Where relay 534 is first operated so that relay 541 becomes operated, before relay 542, then the transfer relay 545 becomes operated, but where, as in the present case, relay 546 is first operated and then relay 542 is operated before the relay 541 becomes operated, relay 545 is maintained in its unoperated condition.

It is believed that with this explanation other various operations of this trunk circuit will be apparent. The transferring of calls from station to station may proceed indefinitely, first the fifth, then the sixth and then the fifth terminals may be used alternatively and this may go on until some station to which the call has been transferred is unable to operate the differential relay 533.

Stations 117 and 118 are known as keyless stations and they have restricted service, that is, the parties at these stations are now allowed to make a trunk call without permission from some one of the parties at some one of the other stations. In case a party at station 117 wants to make a call, he will first have to set up a regular connection to one of the other stations, let us say, by way of example, station 113. There he states his wants and if permission is given he is told to disconnect. Thereupon the party at the master station 113 may manually connect to a trunk circuit or by the use of his local key may automatically connect to a third terminal of the first idle trunk circuit and when he has thus gained access to a central office line he will operate his local key again and cause the operation of differential relay 533, thus putting the trunk in a "held" condition. If the party at station 117 knows which trunk has been selected as by observation of the line lamp 509 or 510, the party at 117 may now dial the number of this trunk and gain access thereto over its fourth terminal. If the keyless station 117 is at such a point that observation of the line lamps 509 and 510 is impossible, then the party at master station 113, after gaining access to the trunk either over its second or third terminal, may operate his local key so as to operate the differential relay 533 and put the trunk in a "held" condition and at the same time cause a line finder to pick up the fifth

terminal thereof. The party at station 113 may now dial the number of the station 117 and when this party answers he will be connected to the trunk.

It should be noted that in this or any other of the cases heretofore described, if the party transferring the connection does not hang up, then a conference connection will be established including both the party at the central office, the party who has dialed the called party, and the called party. After this either the calling or called party may hang up and the other will maintain the connection. So long as either relay 534 or 546 is maintained energized the central office connection will be held and either party may therefore further transfer the connection.

Thus, the party to the original connection described as being made over the second terminal of this trunk comprising conductors 503 and 504 transfers the call to another station over the fifth terminal thereof comprising conductors 517, 518 and 519. When such called party answers, a conference connection will be established. If the called party in this case hangs up and releases the connection the party over the second terminal of the trunk will maintain the communication with the central office. This party may again operate his local key and again cause the operation of the differential relay 533 so that another line finder will pick up the fifth terminal of this trunk. In this manner a subscriber, say at station 113, may repeatedly extend the trunk to a different called subscriber.

It should be noted that any station within the system having gained access to the trunk circuit of Fig. 5 over any one of the terminals controlling relay 534 may transfer a connection repeatedly as above described or may transfer the connection to a party over the fifth terminal, who may then, in turn, transfer the connection to another party over the sixth terminal. Any party having control of relay 534 may transfer the connection to the terminal including relay 546 and vice versa.

It should be noted furthermore that if a party connected to the second, third, fourth or sixth terminals has operated his local key and, therefore, caused the operation of the differential relay 533 he will seize a selector-connector. At this state it will be possible for such subscriber to again operate his local key to operate the differential relay 403 in the seized selector-connector, but since the associated line finder has responded to the calling condition coming from a trunk, relay 406 will not have been operated and, therefore, the operation of the differential relay 403 will be ineffective so that a call cannot be transferred to another outgoing trunk.

What is claimed is:

1. In a telephone system, a trunk line circuit having a plurality of terminals, a first terminal extending to a distant point, a second terminal manually accessible to a plurality of substation circuits, a third terminal automatically accessible to a plurality of substation circuits, a fourth terminal directly accessible to a plurality of substation circuits and a fifth and a sixth terminal alternatively extensible to substation circuits.

2. In a telephone system, a trunk line circuit having a plurality of terminals, a first terminal extending to a distant point, a second terminal manually accessible to a plurality of privileged substation circuits, a third terminal automatically accessible to a plurality of substation circuits, a

fourth terminal directly accessible to a plurality of substation circuits and a fifth and a sixth terminal alternatively extensible to substation circuits, said fourth terminal being normally marked as busy, and means under control of connections made to any other of said terminals for removing said normal busy condition and rendering said fourth terminal accessible.

3. In a telephone system, subscriber stations, automatic switches controlled from said subscriber stations for interconnecting said stations and central office lines, a central office line directly accessible by said switches, said line being normally busy to connections established over said switches, means responsive to an incoming call over said central office line for removing said normal busy condition, and means controlled from said stations over an established connection to said central office line for removing said normal busy condition.

4. In a telephone system, subscriber stations, automatic switches controlled from said subscriber stations for interconnecting said stations and central office lines, central office lines each having a plurality of terminals in said switches, means at said stations for causing said switches to automatically connect a calling line to the first idle one of said central office lines over one of said terminals of said central office lines, means controlled from said stations to cause said switches to directly approach another of said terminals of said central office lines, said last terminal being normally busy, means responsive to an incoming call over one of said central office lines for removing said normal busy condition, means controlled by said stations over a connection established to one of said central office lines over said one of said terminals for removing said normal busy condition whereby connection may be established over said approached terminal.

5. In a telephone system, subscriber lines, links having incoming and outgoing terminals, switches for interconnecting said lines via said links, central office lines each having a plurality of terminals accessible by the outgoing terminals of said links, means individual to each said subscriber line for causing an outgoing terminal of a link to automatically connect to one of the terminals of a central office line, an impulse dial on each said subscriber line, means responsive to dial impulses for causing an outgoing terminal of a link to connect to another terminal of a particular one of said central office lines, said last of said terminals being normally marked busy, means controlled over an established connection to one of said central office lines for removing said normal busy condition whereby a directly established connection to a central office line may be completed.

6. In a telephone system, subscriber stations, certain of said stations known as key stations being equipped with means to operate a differential relay included in circuits which may be temporarily connected to said stations, others of said stations being not so equipped, link circuits through which said stations may be interconnected, a differential relay in each said link circuit, switches for interconnecting said lines via said links under subscriber station control, central office lines each having a plurality of terminals, means in said links responsive to said differential relay for automatically selecting an idle one of said central office lines, each said central office line having therein a differential relay responsive to substation control, means

for causing said links to directly approach another of said terminals of a central office line, said last terminal being normally busy, and means responsive to said central office line differential relay for removing said normal busy condition whereby a directly established connection to a central office line may be completed.

7. In a telephone system, subscriber stations, certain of said stations known as key stations being equipped with means to operate a differential relay included in circuits which may be temporarily connected to said stations, others of said stations known as keyless stations being not so equipped, link circuits through which said stations may be interconnected, each said link having an incoming and an outgoing terminal and a differential relay controlled over the incoming terminal thereof, switches for interconnecting said lines via said links under substation control, central office lines each having a plurality of terminals accessible to the outgoing terminals of said link circuits and a plurality of terminals accessible to the incoming terminals of said link circuits, means in said lines responsive to the said differential relay therein for automatically selecting an idle one of said central office lines over an outgoing link terminal, means for causing said links to directly approach another of said terminals of a central office line by way of the outgoing terminal of said link, a differential relay in each of said central office lines, means responsive to the said central office line differential relay for connecting one of said links to said central office line over the incoming terminal of the said link circuit, and one of said terminals of the said central office line accessible thereto, means simultaneously responsive to said central office line circuit differential relay for interrupting the talking circuit to said central office, for placing a holding condition on said central office line and for rendering said directly approachable terminal of said central office line circuit accessible.

8. In a telephone system, subscriber stations certain of said stations known as key stations being equipped with means to operate a differential relay included in circuits which may be temporarily connected to said stations, others of said stations known as keyless stations being not so equipped, link circuits through which said stations may be interconnected, each said link having an incoming and an outgoing terminal and a differential relay controlled over the incoming terminal thereof, switches for interconnecting said lines via said links under substation control, central office lines each having a plurality of terminals accessible to the outgoing terminals of said link circuits and a plurality of terminals accessible to the incoming terminals of said link circuits, means in said lines responsive to the said differential relay therein for automatically selecting an idle one of said central office lines over an outgoing link terminal, means for causing said links to directly approach another of said terminals of a central office line by way of the outgoing terminal of said link, a differential relay in each of said central office lines, means responsive to the said central office line differential relay for connecting one of said links to said central office line over the incoming terminal of the said link circuit, and one of said terminals of the said central office line accessible thereto, means simultaneously responsive to said central of-

rice line circuit differential relay for interrupting the talking circuit to said central office, for placing a holding condition on said central office line and for rendering said directly approachable terminal of said central office line circuit accessible, means for thereafter extending said link circuit by its outgoing terminal to either a key station or a keyless station, means responsive to the answer of said last called station for restoring said interrupted talking circuit and for removing said holding condition, alternatively means responsive to the seizure of said central office line over its said directly approachable terminal for restoring said interrupted talking circuit and for removing said holding condition, and means thereafter responsive to said differential relay for connecting another of said links to said central office line over the incoming terminal of the said link and one of said terminals of the said central office line accessible thereto.

9. In a telephone system, subscriber lines each having a station circuit connected thereto, certain of said station circuits having manually operable means therein for operating a normally inoperative relay in a circuit which may be temporarily connected to said subscriber lines associated therewith, central office lines, cross-bar switches comprising coordinate rows of sets of permanently paired contacts for interconnecting said lines, link circuits for completing interconnections of subscriber lines and interconnections of subscriber lines and central office lines, each said link and each said central office line circuit including therein a normally inoperative relay responsive to said manually operable means in said certain of said station circuits, means operative on a calling station call when said associated subscriber line has been extended through said cross-bar switch to one of said links and responsive to the operation of said normally inoperative relay therein for automatically operating said cross-bar switches to extend said link to the first idle one of said central office lines, means operative on a calling station call when said associated subscriber line has been extended through said cross-bar switch to one of said links and responsive to directive operation of said calling station circuit for extending said link to a particular one of said central office lines, said central office lines presenting a bar to such directly established connections under normal conditions, means under control of other connections to said particular central office line for removing said bar whereby said particular central office line is rendered accessible to said directly established calls, said last means being controlled by said normally inoperative relay in said central office line circuit, means operative on an established connection from one of said subscriber line and link circuit connections established either automatically or directly and responsive to said central office line circuit normally inoperative relay for extending said central office line circuit through said cross-bar switches to another of said link circuits, and means for thereafter extending said other of said link circuits through said cross-bar switches to another of said subscriber line stations as a called line.

10. In a telephone system, subscriber lines each having a station circuit connected thereto, certain of said station circuits having manually operable means therein for operating a normally inoperative relay in a circuit which may be tem-

porarily connected to said subscriber lines associated therewith, central office lines, cross-bar switches comprising coordinate rows of sets of permanently paired contacts for interconnecting said lines, link circuits for completing interconnections of subscriber lines and interconnection of subscriber lines and central office lines, each said link and each said central office line circuit including therein a normally inoperative relay responsive to said manually operable means in said certain of said station circuits, means operative on a calling station call when said associated subscriber line has been extended through said cross-bar switch to one of said links and responsive to the operation of said normally inoperative relay therein for automatically operating said cross-bar switches to extend said link to the first idle one of said central office lines, means operative on a calling station call when said associated subscriber line has been extended through said cross-bar switch to one of said links and responsive to directive operation of said calling station circuit for extending said link to a particular one of said central office lines, said central office lines presenting a bar to such directly established connections under normal conditions, means under control of other connections to said particular central office line for removing said bar whereby said particular central office line is rendered accessible to said directly established calls, said last means being controlled by said normally inoperative relay in said central office line circuit, means operative on an established connection from one of said subscriber line and link circuit connections established either automatically or directly and responsive to said central office line circuit normally inoperative relay for extending said central office line circuit through said cross-bar switches to another of said link circuits, means for thereafter extending said other of said link circuits through said cross-bar switches to another of said subscriber line stations as a called line, means in said central office line circuit simultaneously responsive to said last-mentioned operation of said central office line circuit normally inoperative relay to disable the talking circuit over said central office line and to place a holding condition thereon, and means responsive to the answer of said called station to remove said holding condition and to reenable said talking circuit over said central office line.

11. In a telephone system, subscriber lines each having a station circuit connected thereto, certain of said station circuits having manually operable means therein for operating a normally inoperative relay in a circuit which may be temporarily connected to said subscriber lines associated therewith, central office lines, cross-bar switches comprising coordinate rows of sets of permanently paired contacts for interconnecting said lines, link circuits for completing interconnections of subscriber lines and interconnection of subscriber lines and central office lines, each said link and each said central office line circuit including therein a normally inoperative relay responsive to said manually operable means in said certain of said station circuits, means operative on a calling station call when said associated subscriber line has been extended through said cross-bar switch to one of said links and responsive to the operation of said normally inoperative relay therein for automatically operating said cross-bar switches to extend said link to the first idle one of said central office lines, means

operative on a calling station call when said associated subscriber line has been extended through said cross-bar switch to one of said links and responsive to directive operation of said calling station circuit for extending said link to a particular one of said central office lines, said central office lines presenting a bar to such directly established connections under normal conditions, means under control of other connections to said particular central office line for removing said bar whereby said particular central office line is rendered accessible to said directly established calls, said last means being controlled by said normally inoperative relay in said central office line circuit, means operative on an established connection from one of said subscriber line and link circuit connections established either automatically or directly and responsive to said central office line circuit normally inoperative relay for extending said central office line circuit through said cross-bar switches to another of said link circuits, means for thereafter extending said other of said link circuits through said cross-bar switches to another of said subscriber line stations as a called line, means in said central office line circuit simultaneously responsive to said last-mentioned operation of said central office line circuit normally inoperative relay to disable the talking circuit over said central office line and to place a holding condition thereon, and means responsive to the answer of said called station to remove said holding condition and to reenable said talking circuit over said central office line whereby a three-way connection is established between said central office line, said calling line which has gained access to said central office line either automatically or directly and said called line.

12. In a telephone system, a plurality of stations, each equipped with a key for grounding one conductor of said station circuit and each equipped with a dial, a selector-connector responsive both to said keys and said dials, a group of trunks outgoing from said selector-connector, means responsive to key control for causing said selector-connector to automatically select the first idle one of said trunks and means for barring access to said trunks when said selector-connector is under control of said dials.

13. In a telephone system, a plurality of stations, each equipped with a key for grounding one conductor of said station circuit and each equipped with a dial, a selector-connector, a group of trunks outgoing from said selector-connector, a differential relay in said selector-connector responsive to said keys and means responsive thereto for causing said selector-connector to automatically select the first idle one of said trunks, and means for barring access to said trunks when said selector-connector is operated under dial control.

14. In a telephone system, a plurality of stations, each equipped with a key for grounding one conductor of said station circuit and each equipped with a dial, a selector-connector, groups of lines outgoing therefrom, a differential relay in said selector-connector responsive to said station keys for causing said selector-connector to automatically select the first idle one of a given group of said outgoing lines and means for barring access to the lines of said given group when said selector-connector is moved under dial control to said group.

15. In a telephone system, a plurality of stations each equipped with a key for grounding

one conductor of said station circuit and each equipped with a dial, a selector-connector arranged to step in one direction to select a group and in another direction to select a line in that group, a differential relay in said selector-connector responsive to said station keys for causing said selector-connector to automatically perform both its group hunting and line selecting movements to select the first idle terminal of a particular group, and means for preventing the line selecting movement of said selector-connector when set under dial control to said particular group.

16. In a telephone system, a trunk line circuit having a plurality of terminals, a first terminal extending to a distant point, a second, a third and a fourth terminal accessible to subscribers, a fifth and a sixth terminal extensible to subscribers, means in said trunk circuit responsive to subscriber control over said second to sixth terminals inclusive for rendering first said fifth terminal active or alternatively if said fifth terminal is busy then said sixth terminal active.

17. In a telephone system, a plurality of subscribers' stations, a plurality of trunk line circuits each extending in one direction to a central office, each said trunk line circuit being accessible to said subscribers' stations, each said trunk line circuit having a plurality of terminals extensible to said subscribers' stations, means in each of said trunk line circuits under control of any one of said stations connected thereto for operating an idle one of said extensible terminals.

18. In a telephone system, a plurality of subscribers' stations each provided with a local key for grounding one side of the station line circuit, a plurality of trunk line circuits extending in one direction to a central office, each said trunk line circuit being accessible to said subscribers' stations and extensible to said subscribers' stations, a differential relay in each of said trunk line circuits responsive to the operation of a said local key at one of said subscribers' stations connected to said trunk line circuit, and means responsive to said differential relay for opening an established talking path between said central office extension and said connected subscriber's station, for establishing a holding connection on said central office extension and for preparing said trunk line circuit for extension to another of said subscribers' stations.

19. In a telephone system, a plurality of subscribers' stations each provided with a local key for grounding one side of the station line circuit, a plurality of trunk line circuits extending in one direction to a central office, each said trunk line circuit being accessible to said subscribers' stations and extensible to said subscribers' stations, a differential relay in each of said trunk line circuits responsive to the operation of a said local key at one of said subscribers' stations connected to said trunk line circuit, means responsive to said differential relay for opening an established talking path between said central office extension and for preparing said trunk line circuit for extension to another of said subscribers' stations, and means responsive to the completed extension of said trunk line circuit to said other one of said subscribers' stations for reestablishing said opened talking connection and for releasing said holding connection.

20. In a telephone system, a plurality of subscribers' stations each provided with a local key for grounding one side of the station line cir-

cuit, a plurality of trunk line circuits extending in one direction to a central office, each said trunk line circuit being accessible to said subscribers' stations and extensible to said subscribers' stations, a differential relay in each of said trunk line circuits responsive to the operation of a said local key at one of said subscribers' stations connected to said trunk line circuit, means responsive to said differential relay for opening an established talking path between said central office extension and for preparing said trunk line circuit for extension to another of said subscribers' stations for releasing said differential relay.

21. In a telephone system, a plurality of subscribers' stations, certain of said stations each being provided with a local key for grounding one side of the station line circuit, a plurality of trunk line circuits extending in one direction to a central office, each said trunk line circuit being accessible to said subscribers' stations and extensible to said subscribers' stations, a two-winding differential relay in each of said trunk line circuits responsive to the operation of a said local key at one of said subscribers' stations connected to said trunk line circuit, and means responsive to said differential relay for opening an established talking path between said central office extension and said connected subscriber's station, for establishing a holding connection on said central office extension including one winding of said differential relay, and for preparing said trunk line circuit for extension to another of said subscribers' stations.

22. In a telephone system, a plurality of subscribers' stations, certain of said stations each being provided with a local key for grounding one side of the station line circuit, a plurality of trunk line circuits extending in one direction to a central office, each said trunk line circuit being accessible to said subscribers' stations and extensible to said subscribers' stations, a two-winding differential relay in each of said trunk line circuits responsive to the operation of a said local key at one of said subscribers' stations connected to said trunk line circuit, means responsive to said differential relay for opening an established talking path between said central office extension and said connected subscriber's station, for establishing a holding connection on said central office extension including one winding of said differential relay, and for preparing said trunk line circuit for extension to another of said subscribers' station, and means responsive to the completed extension of said trunk line circuit to said other one of said subscribers' stations for releasing said differential relay.

23. In a telephone system, a plurality of subscribers' stations, certain of said stations each being provided with a local key for grounding one side of the station line circuit, a plurality of trunk line circuits extending in one direction to a central office, switching mechanism comprising line finder and selector-connector combinations for extending connections from line finder bank terminals to selector-connector bank terminals, each of said subscribers' stations having a line circuit terminating in said line finder bank terminals and said selector-connector bank terminals, each of said trunk line circuits having extensions terminating in said line finder bank terminals and said selector-connector bank terminals, each said trunk line circuit having a differential relay responsive to the operation of a said local key at one of said subscribers' stations

connected to said trunk line circuit, and means in said trunk line circuit responsive to said differential relay for opening an established talking path between said central office extension and said connected subscriber's station for establishing a holding connection on said central office extension and for rendering a terminal of said trunk line circuit in said line finder bank active.

24. In a telephone system, a plurality of subscribers' stations, certain of said stations each being provided with a local key for grounding one side of the station line circuit, a plurality of trunk line circuits extending in one direction to a central office, switching mechanism comprising line finder and selector-connector combinations for extending connections from line finder bank terminals to selector-connector bank terminals, each of said subscribers' stations having a line circuit terminating in said line-finder bank terminals and said selector-connector bank terminals, each of said trunk line circuits having extensions terminating in said line finder bank terminals and said selector-connector bank terminals, each said trunk line circuit having a differential relay responsive to the operation of said local key at one of said subscribers' stations connected to said trunk line circuit, means in said trunk line circuit responsive to said differential relay for opening an established talking path between said central office extension and said connected subscriber's station, for establishing a holding connection on said central office extension and for rendering a terminal of said trunk line circuit in said line finder bank active, a differential relay in each of said selector-connectors responsive to the operation of said local key at one of said subscribers' stations, means responsive to a connection established from one of said subscribers' stations by one of said line finders for rendering said last differential relay effective, and means responsive to a connection established from one of said trunk line circuits by one of said line finders for rendering said last differential relay ineffective, said last differential relay when effective operating means in said associated selector-connector for causing said selector-connector to automatically select an idle one of said trunk line circuits.

25. In a telephone system, a plurality of subscribers' stations, certain of said stations each being provided with a local key for grounding one side of the station line circuit, a plurality of trunk line circuits extending in one direction to a central office, switching mechanism comprising line finder and selector-connector combinations for extending connections from line-finder bank terminals to selector-connector bank terminals, each of said subscribers' stations having a line circuit terminating in said line-finder bank terminals and said selector-connector bank terminals, each of said trunk line circuits having extensions terminating in said line-finder bank terminals and said selector-connector bank terminals and said selector-connector having means to differentiate between a connection extended thereto by its associated line finder from one of said subscribers' stations or from one of said trunk line circuits, a differential relay in each of said selector-connectors rendered effective by said last means on a connection extended from one of said subscribers' stations, said differential relay being responsive to the operation of said local key at said station, and means responsive to said differential relay to cause said selector connector to automatically select an idle one of

said trunk line circuits terminating in said selector-connector bank terminals.

26. In a telephone system, a plurality of subscribers' stations, certain of said stations each being provided with a local key for grounding one side of the station line circuit, a plurality of trunk line circuits extending in one direction to a central office, switching mechanism comprising line finder and selector-connector combinations for extending connections from line-finder bank terminals to selector-connector bank terminals, each of said subscribers' stations having a line circuit terminating in said line-finder bank terminals and said selector-connector bank terminals, each of said trunk line circuits having extensions terminating in said line-finder bank terminals and said selector-connector bank terminals, each said selector connector having means to differentiate between a connection extended thereto by its associated line finder from one of said subscribers' stations or from one of said trunk line circuits, a differential relay in each of said selector-connectors rendered effective by said last means on a connection extended from one of said subscribers' stations, said differential relay being responsive to the operation of said local key at said station, means responsive to said differential relay to cause said selector-connector to automatically select an idle one of said trunk line circuits terminating in said selector-connector bank terminals, and means responsive to a directive operation of said selector-connector for rendering said differential relay thereafter ineffective.

27. In a telephone system, a plurality of subscribers' stations, certain of said stations each being provided with a local key for grounding one side of the station line circuit, a plurality of trunk line circuits extending in one direction to a central office, switching mechanism comprising line-finder and selector-connector combinations for extending connections from line-finder bank terminals to selector-connector bank terminals, each of said subscribers' stations having a line circuit terminating in said line-finder bank terminals and said selector-connector bank terminals, each of said trunk line circuits having extensions terminating in said line-finder bank terminals and said selector-connector bank terminals, each said selector connector having a differential relay responsive to the operation of a local key in a connection from one of said subscribers' stations, and means responsive to the operation and the subsequent release of a said differential relay for causing the associated selector connector to automatically select an idle one of said trunk line circuits.

28. In a telephone system, a plurality of subscribers' stations, certain of said stations each being provided with a local key for grounding one side of the station line circuit, a plurality of trunk line circuits extending in one direction to a central office, switching mechanism comprising line finder and selector-connector combinations for extending connections from line-finder bank terminals to selector-connector bank terminals, each of said subscribers' stations having a line circuit terminating in said line-finder bank terminals and said selector-connector bank terminals, each of said trunk line circuits having extensions terminating in said line-finder bank terminals and said selector-connector bank terminals, a differential relay in each of said selector-connector circuits responsive to the operation of a local key at a connected sub-

station for causing the said selector-connector to automatically select an idle one of said trunk line circuits, a differential relay in each of said trunk line circuits responsive to the operation of a local key at a connected substation and means to prevent the prolonged operation of one of said local keys from operating a selector connector to automatically select an idle trunk line circuit and thereupon operate the differential relay of said selected trunk line circuit.

29. In a telephone system a plurality of subscribers' stations, certain of said stations each being provided with a local key for grounding one side of the station line circuit, a plurality of trunk line circuits extending in one direction to a central office, switching mechanism comprising line-finder and selector-connector combinations for extending connections from line-finder bank terminals to selector-connector bank terminals, each of said subscribers' stations having a line circuit terminating in said line-finder bank terminals and said selector-connector bank terminals, each of said trunk line circuits having extensions terminating in said line-finder bank terminals and said selector-connector bank terminals, a differential relay in each said selector-connector circuit responsive to the operation of a local key at a connected substation for causing the said selector connector to automatically select an idle one of said trunk line circuits, a differential relay in each of said trunk line circuits responsive to the operation of a local key at a connected substation for placing a hold condition on the said central office extension of said trunk line circuit and for causing another terminal of the said trunk line circuit to be extended by one of said line finders to one of said selector connectors and means for preventing a single operation of one of said local keys from effectively operating more than one of said differential relays in a serial connection involving both a selector-connector circuit and a trunk line circuit.

30. In a telephone system, a plurality of subscribers' stations, certain of said stations each being provided with a local key for grounding one side of the station line circuit, a plurality of trunk line circuits extending in one direction to a central office, switching mechanism comprising line-finder and selector-connector combinations for extending connections from line-finder bank terminals to selector-connector bank terminals, each of said subscribers' stations having a line circuit terminating in said line-finder bank terminals and said selector-connector bank terminals, each of said trunk line circuits having extensions terminating in said line-finder bank terminals and said selector-connector bank terminals, a differential relay in each said selector-connector circuit responsive to the operation of a local key at a connected substation for causing the said selector-connector to automatically select an idle one of said trunk line circuits, a differential relay in each of said trunk line circuits responsive to the operation of a local key at a connected substation for placing a hold condition on the said central office extension of said trunk line circuit and for causing another terminal of the said trunk line circuit to be extended by one of said line finders to one of said selector connectors and an additional relay in each of said selector-connector circuits for rendering said differential relay effective upon its release, whereby the differential relay operating condition is prevented from being present on

the terminals of a selector connector upon the automatic selection of a trunk line circuit.

31. In a telephone system, a plurality of subscribers' stations, certain of said stations each being provided with a local key for grounding one side of the station line circuit, a plurality of trunk line circuits extending in one direction to a central office, switching mechanism comprising line-finder and selector-connector combinations for extending connections from line-finder bank terminals to selector-connector bank terminals, each of said subscribers' stations having a line circuit terminating in said line-finder bank terminals and said selector-connector bank terminals, each of said trunk line circuits having extensions terminating in said line-finder bank terminals and said selector-connector bank terminals, a differential relay in each said selector-connector circuit responsive to the operation of a local key at a connected substation for causing the said selector connector to automatically select an idle one of said trunk line circuits, a differential relay in each of said trunk line circuits responsive to the operation of a local key at a connected substation for placing a hold condition on the said central office extension of said trunk line circuit and for causing another terminal of said trunk line circuit to be extended by one of said line finders to one of said selector connectors and a relay in each said selector-connector circuit responsive to the operation of the associated differential relay for delaying the said automatic response of said selector connector until the subsequent release of the said differential relay.

32. In a telephone system, a plurality of subscribers' stations, certain of said stations each being provided with a local key for grounding one side of the station line circuit, a plurality of trunk line circuits extending in one direction to a central office, switching mechanism comprising line-finder and selector-connector combinations for extending connections from line-finder bank terminals to selector-connector bank terminals, each of said subscribers' stations having a line

circuit terminating in said line-finder bank terminals and said selector-connector bank terminals, each of said trunk line circuits having extensions terminating in said line-finder bank terminals and said selector-connector bank terminals, a differential relay in each of said trunk line circuits responsive to the operation of one of said local keys at a connected one of said stations for placing a hold condition on the said central office extension of said trunk line circuit and for causing another terminal of the said trunk line circuit to be extended by one of said line finders to one of said selector connectors and means for thereafter dismissing said last selector connector.

33. In a telephone system, a plurality of subscribers' stations, certain of said stations each being provided with a local key for grounding one side of the station line circuit, a plurality of trunk line circuits extending in one direction to a central office, switching mechanism comprising line-finder and selector-connector combinations for extending connections from line-finder bank terminals to selector-connector bank terminals, each of said subscribers' stations having a line circuit terminating in said line-finder bank terminals and said selector-connector bank terminals, each of said trunk line circuits having extensions terminating in said line-finder bank terminals and said selector-connector bank terminals, a differential relay in each of said trunk line circuits responsive to the operation of one of said local keys at a connected one of said substations for placing a hold condition on the said central office extension of said trunk line circuit and for causing another terminal of the said trunk line circuit to be extended by one of said line finders to one of said selector connectors and means responsive to the release of the said connected substation circuit for maintaining the said established hold condition and for releasing the said line finder and selector connector to which said other terminal of said trunk line circuit has been extended.

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