April 17, 1945. W. M. BEAUMONT 2,374,072

TELEPHONE SYSTEM

Filed Jan. 12, 1943 6 Sheets-Sheet 1

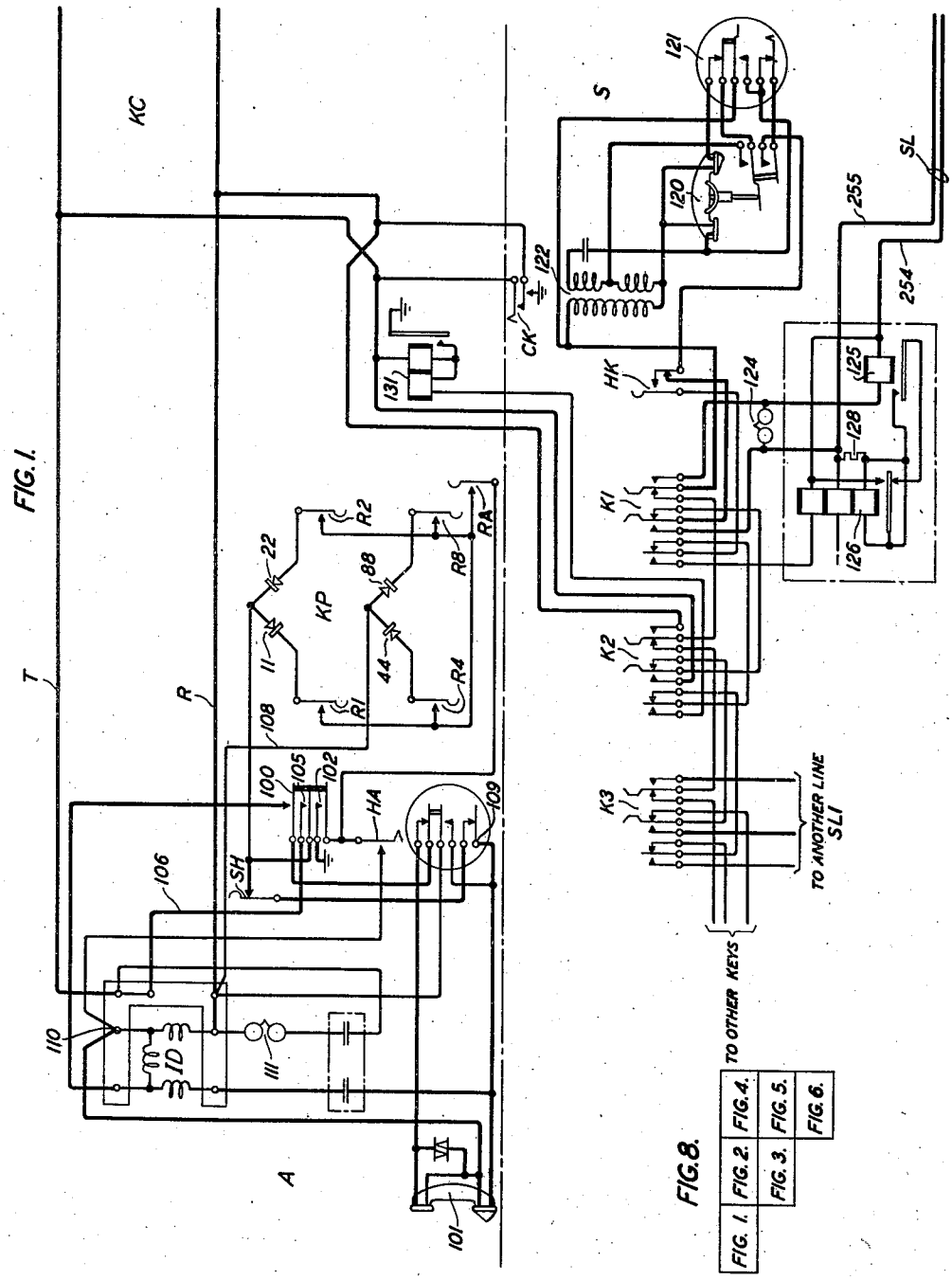

FIG. 1.

FIG. 8.

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

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TELEPHONE SYSTEM

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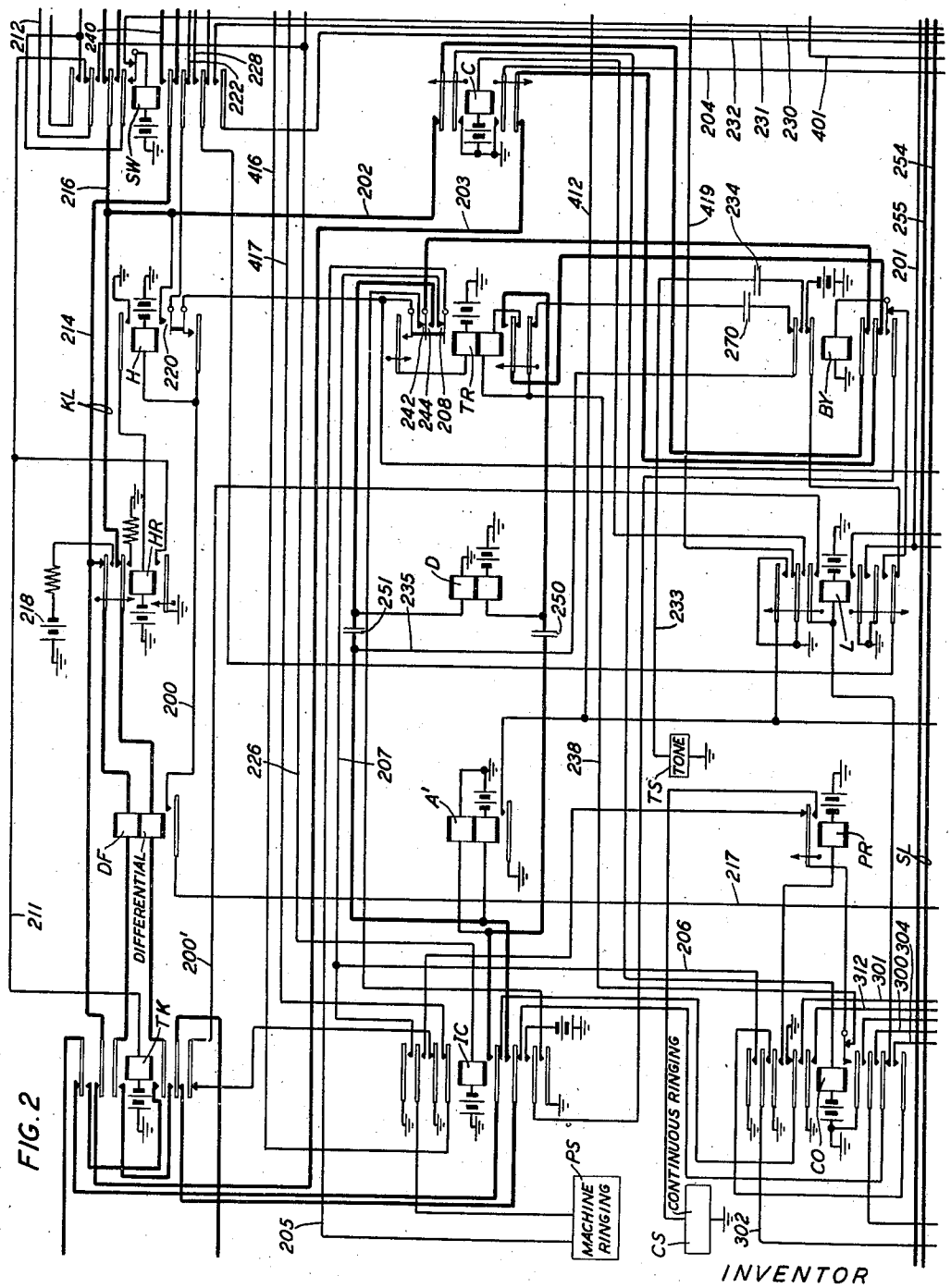

FIG. 2

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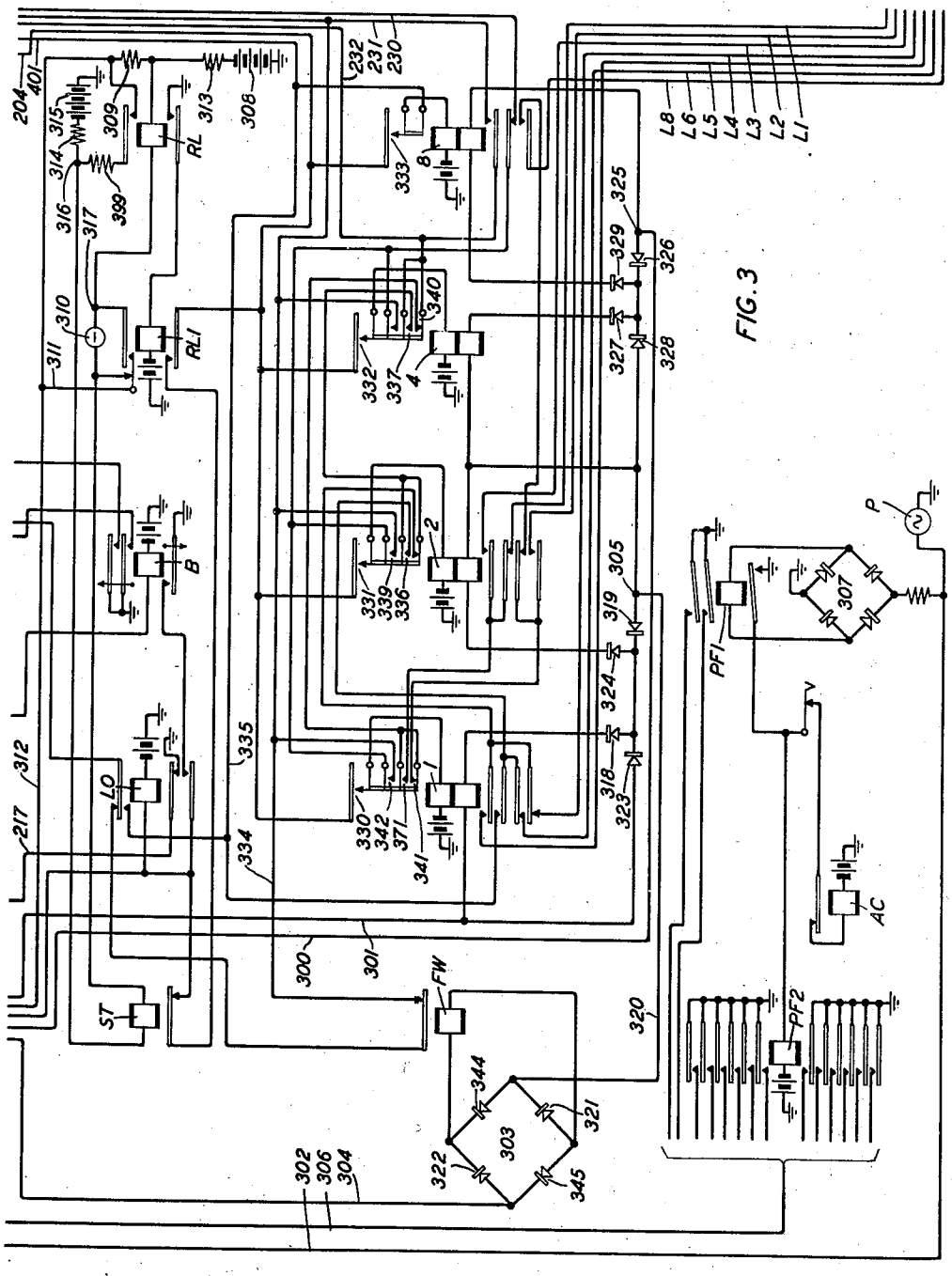

FIG. 3

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TELEPHONE SYSTEM

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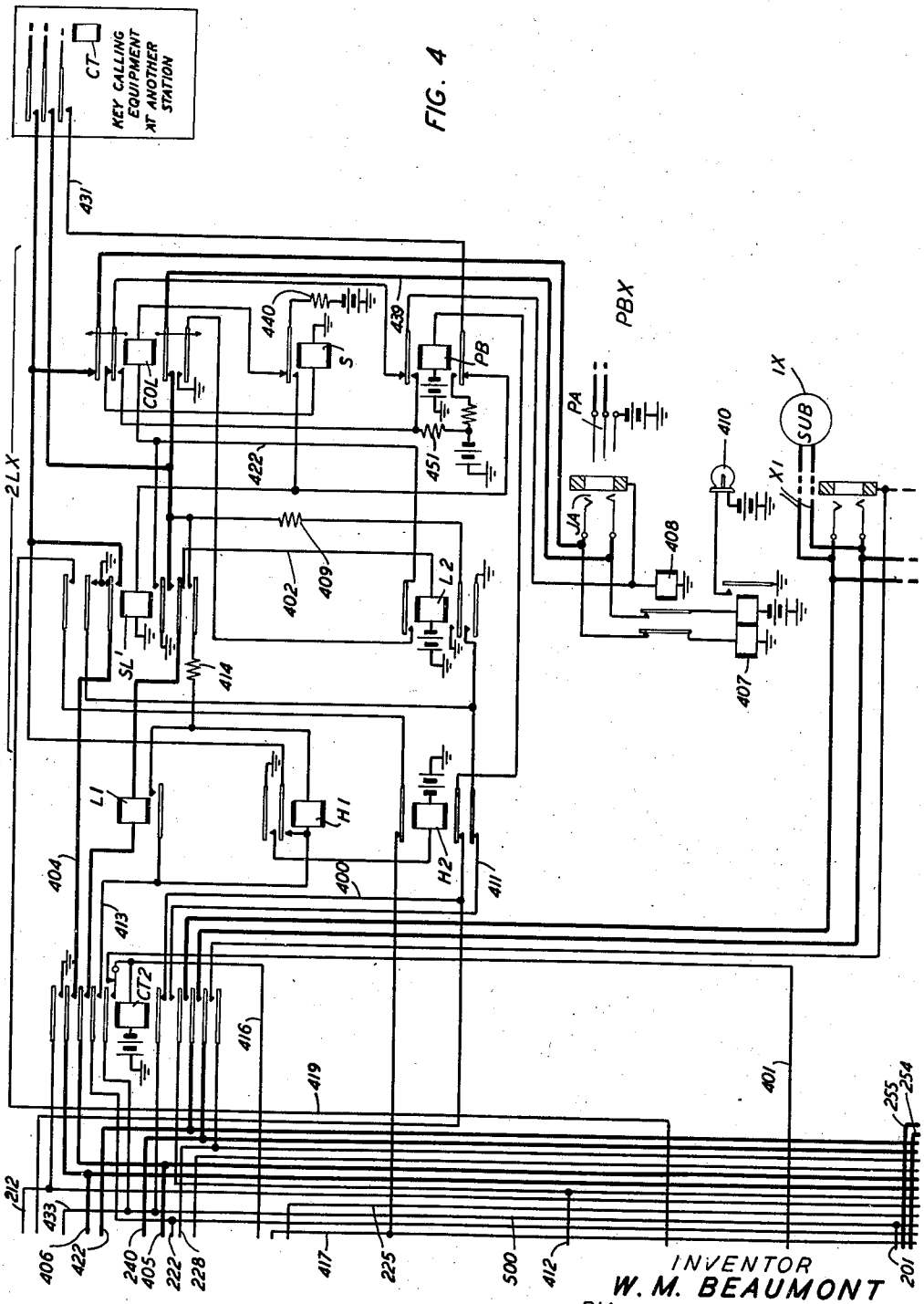
FIG. 4



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TELEPHONE SYSTEM

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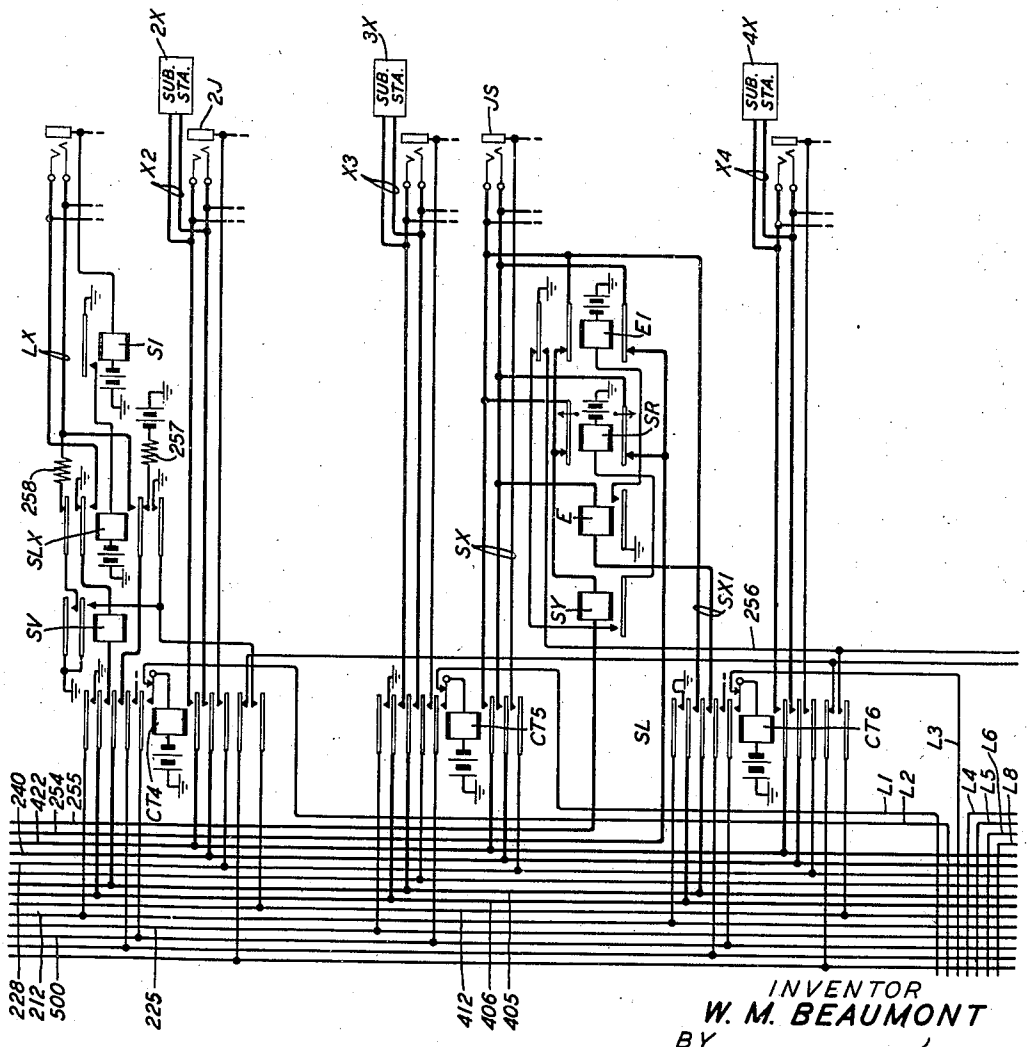
FIG.5



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TELEPHONE SYSTEM

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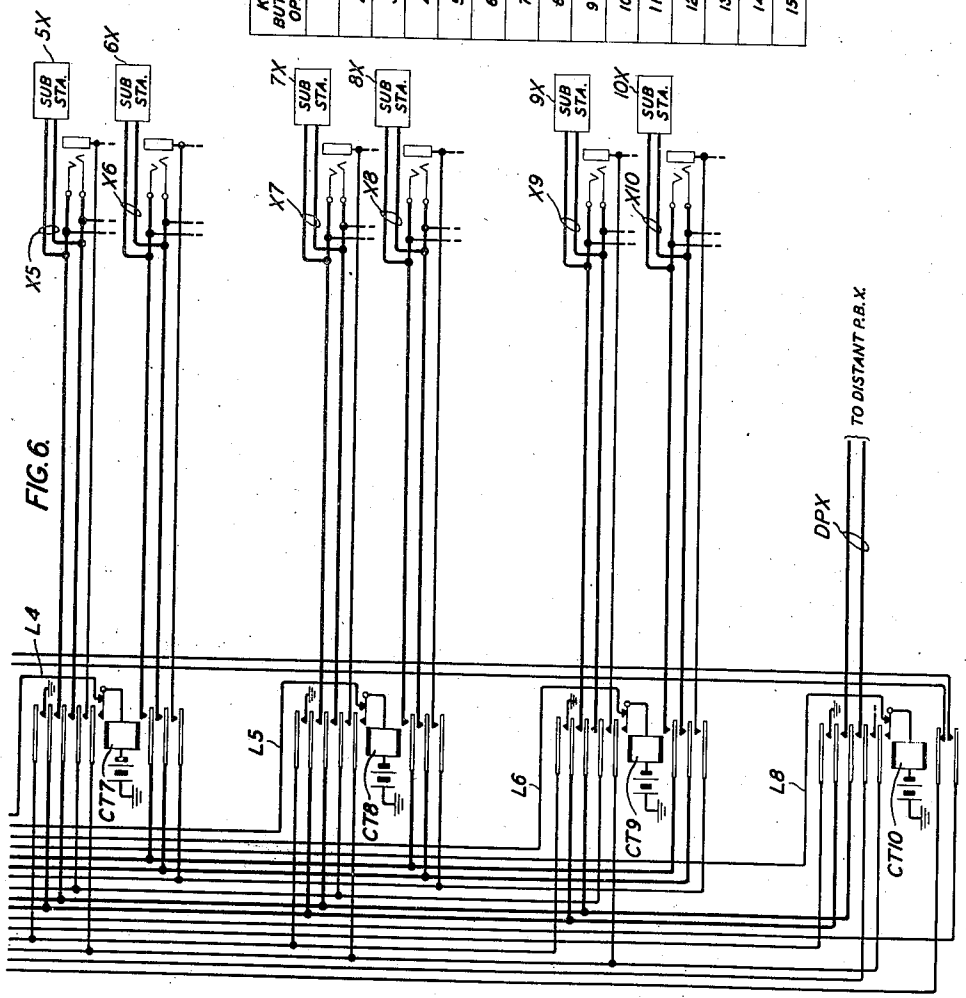
FIG. 7.

KEY BUTTON OPR-D	RECT. SWITCH CLOSED	REG. RELAY OPR-D	CONN. RELAY OPR-D	SEIZED LINE
1	R1	1	CT5	SX-SL
2	R2	2	CT4	X2
3	R1,R2	1,2	CT6	X4
4	R4	4	CT7	X6
5	R1,R4	1,4	CT8	X8
6	R2,R4	2,4	CT9	X10
7	R1,R2,R4	1,2,4	CT2	X1
8	R8	8	CT10	DPX
9	R1,R8	1,8	CT5	X3
10	R2,R8	2,8	CT4	LX
11	R1,R2,R8	1,2,8	CT6	SX1
12	R4,R8	4,8	CT7	X5
13	R1,R4,R8	1,4,8	CT8	X7
14	R2,R4,R8	2,4,8	CT9	X9
15	R1,R2,R4,R8	1,2,4,8	CT2	2LX

FIG. 6.



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Patented Apr. 17, 1945 2,374,072

UNITED STATES PATENT OFFICE

2,374,072

TELEPHONE SYSTEM

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Application January 12, 1943, Serial No. 472,107

20 Claims. (Cl. 179—27)

This invention relates to telephone systems and particularly to central office and private branch exchange telephone systems of the type in which an extension station of the executive type is provided with facilities whereby connections to frequently called subordinate stations may be established by the party at the executive station expeditiously and with a minimum of effort.

Telephone systems have been designed heretofore in which subscribers having regular private branch exchange service are enabled to initiate and complete calls to other private branch extension stations by the actuation of keys individually assigned to such extension stations. Such systems have been designed particularly for the purpose of enabling an executive, or a high official to communicate with certain frequently called subordinates in such a manner as to obviate the necessity of the executive using the regular telephone dial, or requiring the assistance of the private branch exchange attendant in completing connections between his line and the lines of the frequently called subordinates. Systems of this type, which reduce to a minimum the requirements imposed on an executive subscriber in establishing connections to the lines of a particular group of subordinates, and which render such connections to be completed in an expeditious manner, necessitate the use of auxiliary equipment at the executive station in the nature of a group of line selecting keys, and also of auxiliary switching apparatus which responds selectively to the actuation of the line selecting keys to extend the executive's line to the subordinate line corresponding to the particular line selecting key actuated.

It is the object of this invention to provide an improved telephone system of the key calling type briefly defined above and to further extend the facilities afforded by such a system.

This object is attained in accordance with a feature of the invention by providing the subscriber at a key calling station with secretarial service. More particularly, the object of the invention is attained by correlating the equipment at a key calling station with that at a secretary's station in such a manner that telephone calls originated at or incoming to the key calling station may be handled by a secretary when conditions warrant such procedure. In accordance with this particular feature of the invention a call on the line individual to the key calling station may be picked up by the secretary by the simple act of operating a key at the secretary's station which places the secretary's telephone in multiple with the key calling station line. An ancillary feature of the invention contemplates the provision of means at the secretary's station for picking up a call on the key calling line extended thereto through the private branch exchange and which was "held" by the party at the key calling station.

Another feature of the invention renders it possible for the secretary to initiate outgoing exchange calls over the line of the key calling station. When the party at the key calling station wishes to extend a call through the private branch exchange at which his line terminates, a particular key assigned for this purpose is actuated after the handset has been removed from its mounting. The actuation of this key causes a certain combination of positive and negative direct current pulses to be transmitted over a control circuit to selectively operate a corresponding combination of register relays which, in turn, function to effect the connection of the key calling station line to the line extending to the private branch exchange. In accordance with the feature of the invention under instant discussion, the connection of the key calling station line with the private branch exchange line may be effected by the actuation of means at the secretary's position, which means when utilized, simulates the operation of the particular key at the key calling station and causes the operation of the same combination of register relays and the consequent connection of the private branch exchange line with the line conductors of the key calling station. Thus the secretary has access to the private branch exchange not only by way of the secretary's own line but also by way of the key calling station line, and may originate calls thereover when conditions warrant it.

A further feature of the invention provides means whereby the party at the key calling station may establish a key-initiated call to the line extending to the secretary's station. Such a connection is established in the same manner as direct connections to any other frequently called private branch extension, that is, by the actuation of a key at the key calling station individually assigned to the secretary's line.

A still further feature of the invention permits calls incoming over the secretary's line to be "held" by the secretary and to be picked up at the key calling station. In accordance with this particular feature, when a call on the secretary's line is to be transferred to the key calling station the secretary places a hold condition on the line and disconnects her telephone therefrom. The party at the key calling station after removing the

telephone thereat from its mounting actuates a key assigned especially for the purpose of picking up a call which is "held" on the secretary's line. The actuation of such key automatically places the key calling line in multiple with the secretary's line to thus effectively connect the key calling station to the line over which the call was extended to the secretary's line and maintains such connection in the cut through condition while momentarily opening the connection towards the secretary's station to automatically remove the hold condition placed on the connection by the secretary. Such a connection may be again picked up by the secretary, in which case the connection of the secretary's telephone with her line and the disconnection of the key calling station result in the automatic release of the equipment utilized in extending the key calling line to the secretary's line.

In accordance with another feature of the invention the apparatus and circuits are so arranged that calls may be extended to the key calling station when originated at other key calling stations. Such calls are extended to the key calling station by way of the private branch exchange line over which all calls directed to the key calling station arrive. When such a call is extended to the key calling station the tip and ring conductors of the said line are physically separated from their normal terminations at the exchange thereby isolating the line from the exchange. This feature provides secrecy on connections involving two key calling stations and precludes the possibility of an attendant at the exchange effectively associating her telephone set with the connection for the purpose of eavesdropping, or for any other purpose.

A further feature of the invention contemplates the assignment of a key at the key calling station to each of a one-way line circuit to the local exchange and a line circuit extending to a distant exchange. Thus the key calling subscriber has access to the local exchange over a plurality of lines and may also complete calls to extension lines which terminate at an exchange other than the local exchange.

These and other features of the invention will be readily understood from the following description made with reference to the accompanying drawings, which when assembled in the manner indicated in Fig. 8 constitute a circuit diagram of a telephone system embodying the present invention.

Before entering into a detailed description of the method of operation of the system disclosed in the drawings, a brief reference to the equipment furnished the executive station A and the secretary's station S, and also to the apparatus controlled thereby will be made. The upper portion of Fig. 1 illustrates schematically the apparatus located at the key calling station A associated with the line KC. This apparatus consists of a telephone set comprising the handset 101, dial 109, ringer 111, induction coil ID and the telephone hook switch 100. These elements perform well-known functions. In practice the telephone set may assume the general appearance of a standard set and differs therefrom in that it has mounted on the base thereof fifteen key-buttons and a designation strip which bears a designation for each key corresponding to the line to which it is individually assigned. These key-buttons are manually operable and control the operation of four rectifier control switches R1, R2, R4 and R8 and also switches SH and RA. The switches identified and the fifteen key-buttons constitute a key-set which is so mechanically designed that whenever any one of the fifteen key buttons is actuated the switch SH is operated to disassociate the telephone at station A from the line and the switch RA is operated to connect the ground associated with contact 102 of the hook switch 100 to the contacts of the rectifier control switches R1, R2, R4 and R8, it being understood that when the handset 101 is removed from its mounting the switch 100 is actuated to close its several contacts. The switches R1, R2, R4 and R8 are disposed relative to the fifteen key-buttons so as to be operated singly or in combinations when the key-buttons are actuated. When the switches R1, R2, R4 and R8 are actuated they function to effectively connect the corresponding dry rectifiers 11, 22, 44 and 88 to the line conductors of the line KC. Switch R1 serves to complete the ground circuit to the tip conductor T of line KC through rectifier 11; switch R2 serves the same purpose with respect to rectifier 22; switch R4 serves to complete the ground circuit to the ring conductor R of line KC through rectifier 44; and switch R8 serves the same purpose relative to rectifier 88. At P in Fig. 3 there is shown a source of alternating current which, as will appear more fully in a later description, furnishes current to the rectifiers 11, 22, 44 and 88. The table illustrated in Fig. 7 indicates the manner in which the rectifier control switches are operated in response to the actuation of each of the fifteen key buttons.

A separate manually operable key HA is mounted on the telephone set at station A and acts as a hold key. When actuated, it connects ground to the point 110 of induction coil ID to cause differential relay DF, Fig. 2, to operate for a purpose to be described in detail hereinafter.

The lower portion of Fig. 1 represents a secretary's station S which is equipped with a telephone set comprising the handset 120, dial 121, ringer 124 and induction coil 122. This telephone set is also equipped with a series of keys mounted on the base thereof such as keys K1, K2, K3 and HK, the last constituting a hold key which functions, when actuated, to place a hold condition on the secretary's private branch exchange line SL. The key K1 serves to connect the secretary's telephone set with the line SL; the key K2 serves to connect the secretary's telephone set in multiple with the line conductors of the key calling station line KC; and the key K3 serves to associate the secretary's telephone with the line SL1 to which the secretary may have access. An auxiliary key CK, known as a "call" key, is located at the secretary's station S and functions, when operated, to extend the key calling station line KC to the two-way private branch exchange line 2LX (Fig. 4). This key serves the same general purpose with respect to the secretary's station S as does the No. 15 key-button at station A which serves to extend the key calling station line KC to the exchange PBX.

Fig. 2, and the relays ST, LO, B, RL1 and RL of Fig. 3 constitute a supervisory circuit which functions to provide all the supervisory, signaling and other features embodied in the key calling system disclosed. The lower portion of Fig. 3 includes relays 1, 2, 4 and 8 which constitute a register circuit, the said relays operating singly or in combinations under the control of the rectifier control switches R1, R2, R4 and R8 as indicated by the table shown in Fig. 7. These register relays function to selectively control the op-

eration of the connector relays CT2, CT4, CT5, CT6, CT7, CT8, CT9 and CT10, shown at the left of Figs. 4, 5 and 6. Each connector relay, with the exception of relay CT10, is equipped with upper and lower sets of armatures, only one of which sets is effective at a time. Which set is effective is determined by whether or not the switching relay SW shown at the upper right of Fig. 2 is operated. Each armature set of the connector relays serves a particular line so that each connector relay other than relay CT10 serves two lines. The lines served by each connector relay are indicated by the table shown in Fig. 7.

Connector relay CT2 serves the two-way private branch exchange line 2LX and the private branch extension line X1 with which the station 1X is associated; relay CT4 serves the one-way private branch exchange line LX and the extension line X2 with which the station 2X is associated; relay CT5 serves the extension line X3 with which the station 3X is associated, and also the multiple extension SX associated with the secretary's line SL; relay CT6 serves the line multiple SX1 of the secretary's line SL and the extension line X4 with which is associated the station 4X; relays CT7, CT8 and CT9 serve the extension lines X5, X6, X7, X8, X9 and X10 with which the stations 5X, 6X, 7X, 8X, 9X and 10X respectively, are associated; and relay CT10 serves the line DPX which terminates at a distant private branch exchange. The various private branch exchange lines and extension stations are illustrated terminating in jacks at the local manual exchange PBX. It is to be understood that such lines may well terminate in switch terminals at a dial exchange, the manual exchange terminations being shown for the sake of simplicity of disclosure only.

At the upper right corner of Fig. 4 there is diagrammatically indicated the equipment of another key calling station. This showing contains a single connector relay CT which, in practice, would correspond to one of the connector relays of the key calling equipment associated with station A. This relay functions to extend a call from another key calling station to station A by way of the two-way private branch exchange line 2LX.

Having described, in a general way, the circuits and apparatus illustrated, the method of operation of the disclosed system will now be described in detail.

Call to private branch exchange line

In making a call to a station to which the party at the key calling station A does not have direct access, that is, to a station which is not represented by any of the key-buttons of the telephone set at the key calling station, it is necessary that such a call be extended automatically by way of the regular automatic switches at the private branch exchange, or through the medium of the operator at the exchange in the case of a manual exchange. To initiate such a call, the party at the executive or key calling station removes the telephone handset at station A from its mounting and actuates key-button No. 15 which in the drawings is assigned to the private branch exchange line 2LX.

When the handset 101 is removed from its mounting at station A, the switch 100 is actuated. This switch effectively connects the telephone transmitter and receiver of the handset 101 across the tip and ring conductors T and R of the line KC, and at contact 102 it connects ground potential to the switch RA which switch, as hereinbefore mentioned, operates whenever any of the fifteen key-buttons of the telephone set at the key calling station is actuated for the purpose of supplying ground to the rectifier key pulsing equipment indicated at KP. With the telephone set bridged across the line KC, relay L (Fig. 2) of the supervisory circuit operates in a circuit extending from grounded battery, winding of relay L, back contact and third lower armature of relay CO, back contact and second lower armature of relay IC, back contact and middle lower armature of relay TK, ring conductor R of the line KC, through the closed subscriber's loop at station A, tip conductor T of the line KC, outermost upper armature and back contact of relay TK, first lower armature and back contact of relay IC, to ground by way of the second upper armature and back contact of relay CO. Relay L locks under control of relays TK and IC in a circuit from grounded battery, winding and first upper armature and front contact of relay L, conductor 200, third lower armature and back contact of relay TK, to ground by way of the back contact and second upper armature of relay IC.

With relay L operated, relay C (Fig. 2), relay B (Fig. 3) and relay PB (Fig. 4) operate. Relay B operates in an obvious circuit which includes the third outer armature and front contact of relay L. Relay C operates in an obvious circuit which includes the middle upper armature and front contact of relay L. Relay PB operates in a circuit extending from grounded battery, winding of relay PB, first lower armature and back contact of relay H2, conductor 400, back contact and first lower armature of relay CT2, conductors 500 and 201, front contact and second lower armature of relay L to ground. This circuit also now finds ground at the first upper armature and front contact of relay B.

At its second upper and lower armatures relay C, operated, opens the tip and ring conductors to the tripping circuit which includes the lower winding of tripping relay TR. At its first lower armature and front contact, relay C connects ground to conductor 204 which serves as a holding ground for the register relays 1, 2, 4 and 8, and at its first upper armature and front contact it completes an obvious operating circuit for relay CO.

Relay PB (Fig. 4) operated, connects battery to the sleeve contact of jack JA which terminates the two-way line circuit 2LX at the private branch exchange PBX thereby rendering the line busy to the private branch exchange equipment. This battery connection is made by way of the upper armature and front contact of relay PB and resistance 451. It is to be understood that the jack terminations of the various lines at the exchange have been illustrated for reasons of simplicity only, and that should such lines terminate in a dial exchange the busy condition produced by relay PB would be reflected in the automatic switch thereat to render the key calling, or executive's line busy to this equipment. At its lower armature and front contact relay PB places a similar busy condition on the lead 431 which extends to the equipment at another key calling station.

Relay CO, the register connector relay, operated, extends the tip and ring leads T and R of the station A to the conductors 301 and 300,

respectively, which connect with the register circuit comprising relays 1, 2, 4 and 8. The ring the middle lower armature and back contact of relay TK, the second lower armature and back contact of relay IC, and the third lower armature and front contact of relay CO, whereas the lead R is connected to the lead 300 by way of tip lead T is connected to the lead 301 by way of the third upper armature and back contact of relay TK, the first lower armature and back contact of relay IC, and the second upper armature and front contact of relay CO. Thus the register circuit is effectively connected to the calling line when the handset at station A is removed from its mounting.

At its fifth upper armature and front contact relay CO connects ground to lead 206 and thence by way of conductor 207, normal contacts 208 of tripping relay TR to the motor start lead 205 which results in the operation of the ringing machine included in the equipment shown schematically at PS in Fig. 2. At its middle upper armature, relay CO completes an obvious operating circuit for relay PR. At its fourth upper armature and front contact and its fourth lower armature and front contact, relay CO completes a circuit from the alternating current source P (Fig. 3), by way of conductors 302 and 304 and full-wave rectifier 303 to the point 305 of the register circuit. This power source P furnishes current to the register relays 1, 2, 4, and 8, which operate selectively under the control of the key-buttons at the calling station A.

At its second lower armature and front contact relay CO prepares an operating circuit for relay LO by connecting one terminal of the relay winding to the lead 306 which terminates in one of the front contacts of power failure relay PF2. It will be observed that the power source P normally furnishes operating current to the winding of relay PF1 by way of the full-wave rectifier 307 so that this relay PF1 is held operated so long as there is no power failure. This relay controls the operating circuits to relays PF2 and AC so that as long as relay PF1 is operated the relays PF2 and AC are deenergized. In the event of a power failure, relay PF1 releases its armatures thereby causing relays PF2 and AC to operate, the latter functioning as a buzzer signal to audibly indicate the power failure. Relay PF2 in operating, connects ground potential to a plurality of leads, such as 306, each of which extends to a different relay LO associated with the supervisory equipment serving different key calling stations. Thus should there be a power failure at the time a key calling station initiates a call, the relay LO corresponding to the calling station would operate over the lead 306 and the corresponding contacts of the relay CO.

Relay LO under the condition of power failure functions to automatically extend the calling line KC to the exchange PBX by way of the two-way private branch exchange line circuit 2LX. More particularly, with relay LO operated due to the power failure, relay CT2 (Fig. 4) operates in a circuit extending from grounded battery, winding and normal make-before-break contacts of relay CT2, conductor 401, conductor 335, front contact and upper armature of relay LO, front contact and first lower armature of relay L to ground. At its fifth upper armature relay CT2 causes relay TK to operate which disconnects the register circuit from the calling line KC and extends the latter to the link KL which, with relay CT2 operated, is extended to the exchange line circuit 2LX. Relay TK, operated, also opens the locking circuit for relay L which relay restores its armatures. Relay B, however, does not release since it is now held operated under control of relay L2 in the exchange line circuit 2LX as will now be described.

When the relay CT2 operated to extend the link KL to the line circuit 2LX, relay L2 operated in a circuit which may be traced from grounded battery, winding of relay L2, back contact and second lower armature of relay SL', winding of relay L1, front contact and third upper armature of relay CT2, conductor 405, back contact and first lower armature of relay SW, conductor 214 of link KL, front contact and second upper armature of relay HR, upper winding of relay DF, first upper armature and front contact of relay TK, front contact and second lower armature of relay TK, ring conductor R of line KC, closed subscriber's loop at station A, tip conductor T of line KC, third upper armature and front contact of relay TK, front contact and first lower armature of relay TK, lower winding of relay DF, first upper armature and back contact of relay HR, conductor 216 of link KL, second upper armature and back contact of relay SW, conductor 406, fourth upper armature and front contact of relay CT2, conductor 404, first upper armature and back contact of relay SL' to ground. Relay B is held operated in a circuit extending from grounded battery, winding of relay B, conductor 412, second lower armature and front contact of relay CT2, conductor 411, back contact and second lower armature of relay H2, front contact and second lower armature of relay L2 to ground. Thus relay B is held operated and maintains the circuits in the cut-through condition. Relay L1 operates in the circuit traced for relay L2 and maintains the relay H1 short-circuited.

Relay L2 at its first lower armature and front contact connects ground to the ring conductor 439, extending to the exchange, by way of resistance 409, and the second lower armature and back contact of relay COL. This ground, as will appear from a later description, brings in a lamp signal at the exchange PBX, or in the case of a dial exchange causes the line switch to start operating in a well-known manner. Thus, in the event of a failure of the power source P, a call which is initiated at station A is automatically extended to the exchange over the two-way line circuit 2LX.

Time out

At its first upper armature and front contact relay CO completes an operating circuit for relay ST which relay in operating performs no useful function at the present time unless the calling party fails to actuate a line selecting key-button within a predetermined period of time following the removal of the handset 101 from its mounting. The description is continued under the assumed condition of no power failure.

Should the calling party at station A fail to operate one of the key-buttons within a given interval after starting a call by removing the handset at the calling station from its mounting, the circuit functions to release the register circuit from the calling line. More particularly, when relay CO operated as described above, an operating circuit for relay RL (Fig. 3) is completed which includes grounded battery 308, resistance 313, winding of relay RL, thermistor 310, normal

make-before-break contacts of relay RL1, conductors 311 and 312, front contact and first upper armature of relay CO and associated ground. When this circuit is closed, the resistance of the thermistor 310 is high and relay RL does not receive sufficient current to operate. After a time interval, the resistance of thermistor 310 becomes low enough to permit relay RL to operate which, in turn, operates relay RL1 in an obvious circuit. Relay RL1 operated connects the winding of relay ST in series with the thermistor 310 in a potentiometer circuit. The potentiometer circuit includes battery 315, resistance 314 to the point 316 where it divides, one branch extending to ground by way of resistance 399, upper armature and front contact of relay RL and conductor 312, another branch including the winding of relay ST, thermistor 310, upper armature and front contact of relay RL1, conductors 311 and 312, front contact and first upper armature of relay CO, to ground. Thus the current in thermistor 310 is reduced and the thermistor will cool off, increasing its resistance. When this current reaches a certain value relay ST will release causing relay LO to operate in a circuit extending from grounded battery, winding of relay LO, back contact and armature of relay ST, front contact and lower armature of relay RL1, conductor 204, first lower armature and front contact of relay C to ground. With relay LO operated, relay CT2 (Fig. 5) operates in a circuit extending from grounded battery, winding of relay CT2, normal make-before-break contacts of relay CT2, conductors 401 and 335, front contact and upper armature of relay LO, to ground by way of the front contact and first lower armature of relay L. At its second lower armature and front contact relay LO locks to ground at the front contact and lower armature of relay B.

Relay CT2, operated, causes relay TK (Fig. 2) to operate in a circuit which is traced from grounded battery, winding of relay TK, conductor 211, back contact and third upper armature of relay SW, conductor 212, fifth upper armature and front contact of relay CT2 to ground. Relay TK, operated, disassociates the tip and ring conductors T and R of the line KC from the conductors 300 and 301 which extend to the register circuit thereby disconnecting the register from the calling line. Relay TK also opens the locking circuit for relay L causing this relay to restore its armatures. Relay L releases relays B and C. Relay B releases relay LO and causes relay CT2 to be deenergized. The circuit is thus restored to normal. It is assumed in the preceding description that the party at the station A replaces the handset before actuating a key-button, in which case the relay L2 would not operate to hold relay B operated. Otherwise the line KC is extended to the exchange in the manner described in connection with a power failure.

Ordinarily the party at the key calling station will operate one of the key-buttons to complete a call before the timing circuit releases relay ST. In the following description the calling party is assumed to have operated the No. 15 key-button immediately after removing the handset from its mounting at station A. Obviously then, when relay CO operated, as hereinbefore described, to complete an operating circuit for relay ST, the timing circuit including thermistor 310 will not have sufficient time to cause the release of relay ST so that this relay remains operated in a circuit extending from grounded battery 315, resistance 314, winding of relay ST, normal make-before-break contacts of relay RL1, conductors 311 and 312, front contact and first upper armature of relay CO to ground. Thus, relay LO will not operate and the call will progress in a normal manner.

When key-button No. 15 is actuated, the varistor or rectifier controlling contacts R1, R2, R4 and R8 are closed, as indicated by the table shown in Fig. 7, to effectively connect the rectifiers 11, 22, 44 and 88 to the conductors of line KC. It is understood that switch RA is closed and switch SH is opened whenever any one of the key-buttons is actuated. In accordance with the table shown in Fig. 7, register relays 1, 2, 4 and 8 operate when the rectifier controlling contacts R1, R2, R4 and R8 are closed in response to the actuation of key-button No. 15.

Due to the closure of rectifier controlling contact R1, register relay 1 operates in a circuit which may be traced from ground, switchhook contact 102 at station A, switch RA, rectifier controlling switch R1, positive poled rectifier 11, switchhook contacts 105, conductor 106, tip conductor T of line KC, third upper armature and back contact of relay TK, first lower armature and back contact of relay IC, second upper armature and front contact of relay CO, conductor 301 lower winding of register relay 1, positive poled rectifiers 318 and 319, conductor 320, rectifier 321 of full wave rectifier 303, winding of relay FW, rectifier 322, conductor 304, front contact and fourth lower armature of relay CO, front contact and fourth upper armature of relay CO, conductor 302, alternating current source P to ground. Relay 1 operates in this circuit on the positive pulses transmitted over the tip conductor T of line KC.

Register relay 2 operates in a circuit extending from ground, switchhook contact 102, switch RA, rectifier controlling switch R2, negative poled rectifier 22, switchhook contacts 105, conductor 106, tip conductor T of line KC, third upper armature and back contact of relay TK, first lower armature and back contact of relay IC, second upper armature and front contact of relay CO, conductor 301, negative poled rectifiers 323 and 324, lower winding of relay 2 to the point 305, conductor 320, and thence to ground through the source P by way of the circuit previously described in connection with the operation of relay 1, except that the rectifiers 344 and 345 of full wave rectifier 303 are substituted for rectifiers 321 and 322. Relay 2 operates in this circuit on the negative impulses transmitted over the tip conductor T of line KC.

The operating circuit for register relay 4 extends from ground, switchhook contact 102, switch RA, rectifier controlling switch R4, negative poled rectifier 44, conductor 108, ring conductor R of the line KC, middle lower armature and back contact of relay TK, second lower armature and back contact of relay IC, third lower armature and front contact of relay CO, conductor 300, to the point 325, thence through negative poled rectifiers 326 and 327, lower winding of register relay 4, to the point 305, conductor 320 and thence to the grounded source P by way of the circuit previously described in connection with the operation of register relay 1. Relay 4 therefore operates on the negative impulse transmitted over the ring conductor R of the line KC.

Register relay 8 operates in a circuit extending from ground, switchhook contact 102, switch RA, rectifier controlling switch R8, positive poled rectifier 88, conductor 108, ring conductor R of the

line KC, middle lower armature and back contact of relay TK, second lower armature and back contact of relay IC, third lower armature and front contact of relay CO, conductor 300, to the point 325, thence through the lower winding of relay 8, positive poled rectifiers 329 and 328 to the point 305, conductor 320, and thence to the grounded source P by way of the circuit previously traced for relay 2. Relay 8 thus operates on the positive impulse transmitted over the ring conductor R of line KC.

Register relays 1, 2, 4 and 8 in actuating their respective upper armatures to close contacts 330, 331, 332 and 333 lock to ground at the front contact and first lower armature of relay C by way of common conductor 204. It will be noted that during the period that key-button No. 15 is actuated and the operating impulses traverse the circuits traced for relays 1, 2, 4 and 8, relay FW is operated and holds its armature disengaged from its working contact. When the key-button is released and the impulses cease to flow, relay FW restores its armature to extend the ground at the front contact and first lower contact of relay L to the conductor 334, this ground constituting a functional ground which serves to operate the connector relays, such as CT2, as presently will be described.

With register relays 1, 2, 4 and 8 operated and locked, and with relay FW released, relay CT2 operates in a circuit extending from grounded battery, winding and normal make-before-break contacts of relay CT2, conductor 401, conductor 335, front contact and second lower armature of relay 1, contact 336 of relay 2, contact 337 of relay 4, first lower armature and front contact of relay 8, conductor 231, conductor 334, back contact and armature of relay FW, back contact and upper armature of relay LO, front contact and first lower armature of relay L to ground.

Relay CT2, operated, locks by way of its first upper armature and front contact, conductors 500 and 201 to ground at the front contact and first upper armature of relay B. At its fifth upper armature and front contact relay CT2 completes an operating circuit for relay TK (Fig. 2) which extends from grounded battery, winding of relay TK, conductor 211, back contact and third upper armature of relay SW, conductor 212 and the fifth upper armature and front contact of relay CT2 to ground. At its first lower armature, relay CT2 opens the operating circuit for relay PB in the private branch exchange line circuit 2LX causing this relay to restore its armatures. At its third and fourth upper armatures and front contacts relay CT2 extends the link KL (Fig. 2) of the supervisory circuit to the private branch exchange line circuit 2LX which, as shown in Fig. 4, terminates at the exchange PBX in the jack JA. This line circuit may well terminate in the terminals of a line switch at an automatic or dial exchange but as hereinbefore explained, it is shown terminated at a manual office merely to simplify the disclosure.

With relays TK (Fig. 2) and CT2 (Fig. 5) operated, a circuit may be traced from grounded battery, winding of relay L2, conductor 402, back contact and second lower armature of relay SL', winding of relay L1, front contact and third upper armature of relay CT2, talk conductor 405, back contact and first lower armature of relay SW, talk conductor 214 of link KL, back contact and second upper armature of relay HR, upper winding of differential relay DF, first upper armature and front contact of relay TK, front contact and second lower armature of relay TK, ring conductor R of line KC, through the closed subscriber loop at station A, tip conductor T of line KC, third upper armature and front contact of relay TK, front contact and first lower armature of relay TK, lower winding of differential relay DF, first upper armature and back contact of relay HR, tip conductor 216 of link KL, second upper armature and back contact of relay SW, conductor 406, fourth upper armature and front contact of relay CT2, conductor 404, first upper armature and back contact of relay SL' to ground. Relays L2 and L1 operate in this circuit but relay DF, being differential, does not operate at this time. Relay L1 short-circuits the winding of relay H1.

When relay L2 operates it completes an operating circuit for line relay 407 which extends from grounded battery, right winding of relay 407, first armature and back contact of sleeve relay 408, ring conductor 439, second lower armature and back contact of relay COL, resistance 409, first lower armature and front contact of relay L2 to ground. Relay 407 operates in this circuit and completes an obvious circuit for line lamp 410.

It is to be understood that the ground applied to the ring conductor 439 would serve in a dial exchange to start a line finder operating in the well-known manner to seize the calling line.

At its second lower armature and front contact relay L2 extends ground over a circuit which includes the second lower armature and back contact of relay H2, conductor 411, front contact and second lower armature of relay CT2, conductor 412 to battery and ground through the winding of slow-to-release relay B to maintain relay B operated.

Upon noting the lighted signal 410 the private branch exchange operator would insert plug PA into jack JA associated with the lamp signal 410 to handle the call in the usual manner.

When relay TK operated, it caused the release, directly or indirectly, of relays L, ST, RL, RL1, C, CO and the register relays 1, 2, 4 and 8. Relay B, however, as indicated above, is held operated.

It is to be understood that should the calling line terminate at a dial exchange, the party at station A would proceed to complete the initiated call by operating the dial 109 in the well-known manner. After the seizure of the calling line by the line finder in the exchange the operation of the dial would set the automatic switches at the exchange in the well-known manner to extend the calling line to the line of a called subscriber whose telephone designation is dialed by the calling party at station A.

However, when in response to the lighted lamp signal 410 at the manual exchange illustrated, the attendant thereat picks up the call in the manner indicated above, relay S operates from battery on the sleeve of the plug PA, over the sleeve terminal of jack JA, upper armature and back contact of relay PB, first upper armature and back contact of relay COL to ground through the winding of relay S. Relay S, operated, closes an obvious operating circuit for relay SL'. Relay SL' at its first upper and second lower armatures and front contacts closes the talking circuit from the exchange through to the calling station A and at its second upper armature and front contact it connects ground to the lead 411 by way of the second lower armature and back contact of relay H2, which ground

serves to hold relay B (Fig. 3) operated which, in turn, holds the equipment in the cut-through condition. Relay L2 releases when relay SL' operates.

On a manual connection the calling subscriber informs the exchange attendant of the telephone number of the desired called party and the attendant extends the connection in the usual manner.

The insertion of plug PA into jack JA of the calling line causes the lamp signal 410 to be extinguished in the well-known and obvious manner. Relay S operated, connects busy battery to the lead 431 extending to the equipment at another key calling station.

At the termination of the call between the key calling station A and the desired private branch exchange extension station the party at station A replaces the handset 101 on its mounting, the private branch exchange automatic equipment or the attendant, depending on whether the exchange is of the dial or manual type, opens the sleeve circuit causing the release of relay S, which relay, in turn, releases relay SL'. Relay SL' releases relay B which, at its first upper armature and front contact opens the locking circuit to relay CT2 which relay, in releasing, opens the operating circuit for relay TK thus restoring the apparatus to normal.

The same release operations described above in connection with the manual exchange will be performed in the event the establishd connection to the called line is completed by way of the automatic switches at a dial exchange and released when the calling partly disconnects.

Holding by key calling subscriber

Should the party at the key calling station A, for any reason, desire to hold the connection the completion of which was described above, the hold key HA at the key calling station is actuated to its closed position. This key operation connects ground by way of switchhook contact 102 to the terminal 110 of induction coil ID which point is common to both the tip and ring conductors T and R of the line KC so that ground is now connected to both these conductors at the calling station. It will be observed that the differential relay DF has its two windings included in series in the line conductors of the talking connection and through current traverses the windings of the relay at this time from the exchange battery the relay does not operate due to the differential action of the relay coils. However, when ground is connected to the tip and ring conductors of the line at the calling station due to the operation of hold key HA, the current flow in the windings of the differential relay DF is unbalanced and the relay operates. The hold key HA effectively shunts one winding of the relay. Transmission battery is furnished the calling station from the exchange through the windings of differential relay DF. Due to its being differentially connected there is no transmission loss in the relay except by the direct current resistance.

Relay DF, operated, causes relay H to operate in a circuit extending from grounded battery, winding of relay H, conductor 200, front contact and armature of relay DF, conductor 217, to ground by way of the first lower armature and back contact of relay LO. Relay H locks under control of relay B and, at its upper armature, completes an obvious energizing circuit for relay HR in which relay HR operates. Relay HR at its second upper armature opens the ring conductor 214 to the station A and at its front contact and same armature connects battery 218 thereto. At its first upper armature and back contact relay HR opens the tip lead 216 and at its front contact and same armature connects ground to the tip lead to the calling station. Thus, battery and ground are connected through the windings of the differential relay DF to the key calling station to maintain a balanced line while the hold key is operated and to prevent the line of the key calling station being connected to the register circuit until the hold key is released.

At its contacts 220 relay H connects the tip lead 216 extending towards the private branch exchange to the hold lead 222 to effect the following bridge circuit: from the tip terminal of jack JA, back contact and second upper armature of relay COL, front contact and first upper armature of relay SL', conductor 404, front contact and fourth upper armature of relay CT2, conductor 406, back contact and second upper armature of relay SW, contacts 220 of relay H, second lower armature and back contact of relay SW, conductor 222, second upper armature and front contact of relay CT2, conductor 413, winding of relay H1, resistance 414, third lower armature and front contact of relay SL', first lower armature and back contact of relay COL, conductor 439 to the ring terminal of jack JA. Relay L1 is, of course, deenergized at this time due to the operation of relay HR. The bridge circuit just traced serves as a holding bridge to hold the established connection. Relay H1 operates in this circuit from battery at the exchange and at its second upper armature and front contact establishes an obvious operating circuit for relay H2. Relay H1 at its first upper armature and front contact connects its own winding directly across the exchange end of the established connection. Relay H2 at its second lower armature and back contact removes the ground at the second upper armature and front contact of relay SL' from conductor 411 which, by way of the front contact and second lower armature of relay CT2 and conductor 412 was extended to the winding of relay B. Thus relay B is deenergized and releases its armatures. At its first upper armature and front contact relay B opens the locking circuit for relay CT2 which relay restores its armatures. Though relay CT2 at its fifth upper armature and front contact opens the original operating circuit for relay TK this latter relay is now held operated under control of relay HR. Thus the connection is held due to the operation of the hold key HA at station A.

When the hold key HA at station A is released relay DF releases due to the differential action of its windings and in restoring its armature it opens the operating circuit to relay H. Relay H restores its armatures thus opening the operating circuit for relay HR which causes relay TK to release and also opens the battery and ground connections to the windings of differential relay DF. The release of relay TK brings in the start condition causing the key calling station to be reconnected to the register circuit so that another call may be made by the party at station A, if desirable. When the party at the key calling station wishes to release the hold condition and again talk on the connection held, the call is picked up in the regular manner. More particularly, the No. 15 key is again actuated to cause the selection of the private branch exchange line

2LX in the manner previously described. When such a call is to be reestablished and the No. 15 key-button is actuated the connection progresses in the manner previously described and when the CT2 and TK relays operate to connect the calling station through to the exchange, relay L1 (Fig. 4) operates over the closed subscriber's loop and, in operating, relay L1 short-circuits relay H1 which relay releases and, in turn, releases relay H2 thus removing the hold condition previously placed on the connection by the operation of hold key HA.

Incoming call to key calling station

All calls incoming to the key calling station arrive by way of the two-way private branch exchange line 2LX employed in the description just made of a call originated at the key calling station by the actuation of the No. 15 key-button. When this line is seized either by the operator at a manual exchange or by the party at another key calling station, battery potential is applied to the sleeve conductor to cause the operation of relay S and relay SL', the latter causing relay CT2 to operate. The operating circuit for relay CT2 extends from grounded battery, winding of relay CT2, conductor 416, first upper armature and back contact of relay IC (Fig. 2), conductor 417, back contact and upper armature of relay H2 (Fig. 4), third upper armature and front contact of relay SL', conductor 419, back contact and second upper armature of relay L (Fig. 2) to ground. Relay CT2, at its fifth upper armature and front contact, causes relay TK to operate in a circuit previously described. At its second lower armature and front contact relay CT2 completes the following operating circuit for relay B (Fig. 3): grounded battery, winding of relay B, conductor 412, second lower armature and front contact of relay CT2, conductor 411, back contact and second lower armature of relay H2, second upper armature and front contact of relay SL' to ground. Relay CT2, operated, locks to ground at the front contact and first upper armature of relay B. With relays CT2 and TK operated, the ringer 111 at the called station A is connected directly across the tip and ring conductors of the connection which now includes either the terminals of a connector switch at a dial exchange or, as shown in the drawings, the terminals of jack JA at a manual exchange. In either case the transmission of ringing current over the line is effected in the usual manner to which the ringer 111 at station A responds as a call signal. Transmission battery is furnished by the private branch exchange equipment or by the other key calling equipment at the station at which the call is originated.

When the calling party disconnects the attendant removes the plug PA from jack JA and relay SL' releases its armatures causing the release of relay B which releases, directly or indirectly, the relays CT2 and TK thereby restoring the circuit to normal. The holding feature described in connection with a call originated at the key calling station applies in the same manner to a call incoming to the key calling station on the private branch exchange line 2LX.

Call incoming from another key calling station

At the upper right of Fig. 4 there is schematically illustrated a single relay CT which is identified as constituting a part of the equipment at another key calling station. The telephone set at such other station would be furnished with a key-button assigned to the key calling station A which, when operated, would cause the associated register relays to operate in a particular combination to effect the operation of relay CT. Any one of the key-buttons other than the No. 15 key-button at the other key calling station may be assigned to the key calling station A, the No. 15 key-button being reserved for connections established over the two-way private branch exchange line circuit associated with the other key calling station in the same manner as is the key-button No. 15 at station A reserved.

When a call to station A is initiated at the other key calling station relay CT operates in the manner indicated above and at its first armature and front contact extends battery potential over the sleeve conductor 431, thence over the lower armature and back contact of relay PB to ground through the winding of relay SL'. Relay SL' in operating under this condition performs the same functions ascribed thereto in extending a call to station A under the heading "Incoming call to key calling station."

It will be observed that on a call to station A which originated at another key calling station relay COL also operates. The operating circuit for relay COL extends from grounded battery, resistance 440, upper armature and back contact of relay S, winding of relay COL, front contact and first lower armature of relay SL' to ground. Relay COL, in operating, connects battery by way of its front contact and first upper armature to the sleeve terminal of jack JA by way of the upper armature and back contact of relay PB thus marking the line to the station A busy at the exchange. In a dial exchange a busy potential would be extended to the connector multiple in which the line of station A appears, to render the line of station A busy to the automatic switches. At its second upper and first lower armatures relay COL opens the station A key calling line to the private branch exchange thus providing a secrecy feature which precludes the attendant at the exchange from eavesdropping on such a connection. In this manner the line to station A is not only marked busy at the exchange but the transmission conductors are physically disconnected therefrom to thus render eavesdropping by the attendant or operator impossible.

Incoming call released first by key calling party

In case the calling party disconnects first on an incoming call relay SL' will release and relay L2 will operate over the closed loop to the key calling station A by way of the back contacts and first upper and second lower armatures of relay SL'. The operation of relay L2 holds slow-to-release relay COL operated in a circuit extending from grounded battery, resistance 440, upper armature and back contact of relay S, winding of relay COL, conductor 422, upper armature and front contact of relay L2, second lower armature and front contact of relay COL to ground. When the handset 101 is replaced on its mounting at station A relay L2 releases causing the release of all operated relays and restoring the circuit to normal.

Direct station call

In making a direct station call, that is, a call which is completed to a private branch extension line by way of equipment other than the regular private branch equipment, the party at the key calling station removes the handset 101 from its mounting and actuates the key button assigned

to the desired called station. For descriptive purposes it will be assumed that key No. 2 corresponds to the desired private branch extension line which is identified as line X2 on Fig. 7. As shown on Fig. 5 this line corresponds to station 2X and terminates in jack 2J at the exchange.

When the handset 101 at station A is removed from its mounting the same relays operate as previously described in connection with the extension of a call through the private branch exchange, and the register circuit comprising relays 1, 2, 4 and 8 is connected through to the tip and ring conductors T and R of the calling line KC. The party at station A then actuates the key button No. 2 which causes relay 2 of the register circuit to operate as indicated by the table shown in Fig. 7. More particularly, the actuation of key button No. 2 closes the rectifier controlling contact R2, which, in turn, connects rectifier 22 to the tip conductor T of line KC to cause the transmission of an impulse of a polarity such as to operate relay 2, over the tip conductor of the line.

Register relay 2 operates in a circuit extending from ground at station A, switchhook contact 102, switch RA, rectifier controlling contact R2, negative poled rectifier 22, switchhook contact 105, conductor 106, tip conductor T of line KC, third upper armature and back contact of relay TK, first lower armature and back contact of relay IC, second upper armature and front contact of relay CO, conductor 301, negative poled rectifiers 323 and 324, lower winding of relay 2, to the point 305 and thence back to the grounded source P over the circuit traced hereinbefore.

Register relay 2, operated, locks under control of relay C in the manner previously described. Relay FW operates in the circuit traced for relay 2 to withhold the connection of ground at the front contact and first lower armature of relay L to the operating winding of relay CT4 until the calling partly at station A releases the No. 2 key button corresponding to the called station 2X. When this key button is released, relay FW releases its armature to apply ground potential to the lead 334. When this occurs relays SW and CT4 operate. Relay SW operates in a circuit extending from grounded battery, winding and normal make-before-break contacts of relay SW, conductor 230, back contact and second lower armature of register relay 8, contact 339 of register relay 2, conductor 334, back contact and armature of relay FW, back contact and upper armature of relay LO, front contact and first lower armature of relay L to ground. It will be observed at this time that relay SW operates only when register relay 8 is unoperated and only when one of the register relays 1, 2 or 4 is operated. Since, as indicated by the table in Fig. 7, register relay 8 is operated only on the actuation of key buttons 8 to 15 inclusive, the relay SW operates only when one of the key buttons 1 to 7 inclusive is actuated. By virtue of this arrangement fifteen station selections may be made by means of only eight connector relays such as CT2, CT4, etc., one selection being effected by each of the sets of upper and lower armatures of the connector relays. Connector relay CT4 operates in a circuit extending from grounded battery, winding and normal make-before-break contacts of relay CT4, conductor L2, front contact and fourth lower armature of register relay 2, contact 341 of register relay 1, contact 340 of register relay 4, conductor 232, fourth lower armature and front contact of relay SW, conductor 231, conductor 334, back contact and armature of relay FW, back contact and upper armature of relay LO, front contact and first lower armature of relay L to ground.

Relay IC now operates in a circuit extending from grounded battery, winding of relay IC, conductor 226, front contact and third upper armature of relay SW, conductor 212, to ground by way of the fifth upper armature and front contact of connector relay CT4. Relay CT4 operated, locks in a circuit including grounded battery, winding and front contact and first upper armature of relay CT4, conductor 500, conductor 201, front contact and first upper armature of relay B and associated ground.

Relay IC at its second upper armature opens the locking circuit for relay L causing relay L to release. Relay L at its second upper armature releases relay C and at its first lower armature opens the operating circuit for relay CT4. Relay C at its first lower armature releases register relay 2 and at its second upper and lower armatures connects the tip and ring leads 202 and 203 to the tripping circuit. Relay IC at its first and second lower armatures connects battery and ground to the conductors of line KC through the windings of relay A'. Relay A' operates over the closed substation loop and applies ground to the winding of relay B to hold this relay operated.

Called line busy

It will now be noted that the sleeve lead associated with the substation 2X is connected by way of the front contact and third lower armature of relay CT4 to the lead 228 which, when relay L is operated extends to ground through the winding of relay BY by way of the normal make-before-break contacts of relay BY and the third lower armature and front contact of relay L. The sleeve lead of line X2 will have battery potential connected thereto if the station 2X associated therewith is busy. Under an assumed busy condition therefore, relay BY operates. At its first and second lower armatures, relay BY keeps the tip and ring conductors open to the called station. Since the operating circuit for relay BY includes an armature and front contact of slow-to-release relay L it is apparent that the busy test of the called line is made during the release time of relay L. Relay BY, operated, on the assumed busy condition of the called line X2 to station 2X, sends busy tone back to the calling station and locks under control of relay IC. The path for the busy tone current extends from the tone supply TS (Fig. 2), conductor 233, condenser 234, front contact and second upper armature of relay BY, conductor 235, front contact and second lower armature of relay IC, back contact and second lower armature of relay TK, ring conductor R of line KC, through the closed loop at station A, tip conductor T of line KC, third upper armature and back contact of relay TK, first lower armature and front contact of relay IC to ground through the upper winding of relay A'. This current generates a tone signal in the receiver of the handset 101 at station A. Upon hearing the busy tone signal in the receiver of the handset, the party at station A would abandon the call by replacing the handset on its mounting whereupon the circuit is restored to normal. The release of the circuit results from the release of relay A' which, when relay IC operated was connected directly across the calling end of the connection and which, at its armature and front contact established an obvious operating circuit for slow-to-release relay B. Relay B releases relay CT4,

When relay BY operated it locked to battery at the third lower armature and front contact of relay IC and when the call is abandoned relay IC restores its armatures to release relay BY thereby discontinuing the tone signal.

Called line idle

When relay IC operates as described above it opens, at its first upper armature and back contact the circuit to connector relay CT2 which circuit is effective in operating relay CT2 on calls incoming to station A, thereby preventing double connections. If the line X2 to the called station 2X is idle, as is now assumed, relay CO releases due to the release of relay C which relay released when relay L released as above described. While relay C was operated, slow-to-release relay PR was operated in an obvious circuit, and when relay C restores its armatures relay CO releases and opens the operating circuit to relay PR. Relay PR, however, remains operated for a short interval of time due to its slow-to-release characteristic. With relay CO released and relay PR operated, a circuit is completed from the grounded continuous ringing supply CS, front contact and armature of relay PR, normally closed make-before-break contacts of relay CO, conductor 238, lower winding of tripping relay TR, back contact and first lower armature of relay TR, conductor 234, back contact and second lower armature of relay BY, second lower armature and back contact of relay C, conductor 203, back contact and second upper armature of relay TK, conductor 214 of link KL, first lower armature and front contact of relay SW, conductor 240, second lower armature and front contact of connector relay CT4, through the ringer circuit at station 2X, front contact and first lower armature of relay CT4, conductor 422, front contact and second upper armature of relay SW, conductor 202, back contact and second upper armature of relay C, first lower armature and back contact of relay BY, contact 242 of relay TR, front contact and fourth lower armature of relay IC to ringing ground. Thus the signal at station 2X is energized in a continuous manner so long as relay PR remains operated and immediately upon seizure of the line X2 by connector relay CT4. The station 2X therefore is signaled immediately upon seizure of its line, when idle, thereby overcoming the delay in transmitting a call signal by means of machine ringing should the line seizure occur during the silent interval between rings.

When relay PR releases its armature after the time interval following the release of relay CO, machine ringing from the source PS traverses the path just traced for the continuous ringing current. The called station is therefore signaled intermittently after having been signaled continuously for an interval of time corresponding to the release time of relay PR. The signaling of the called station is indicated to the calling party at station A since the signaling current from the source PS is projected over the calling end of the connection by way of the back contact and second lower armature of relay TR, condenser 270, back contact and second upper armature of relay BY, conductor 235 and thence over the same circuit traversed by the busy tone current from source TS. Relay CO released, opens the connection between the power source P and the register relays 1, 2, 4 and 8. This is accomplished by the upper and lower fourth armatures of relay CO which, when the relay releases, disconnect conductor 302 extending from the power source P from conductor 304 which extends to the register circuit.

The line X2 is marked busy at the exchange by virtue of a battery connection to the sleeve conductor thereof. This battery extends from the back contact and first upper armature of relay BY, back contact and third lower armature of relay L, third lower armature and front contact of relay SW, conductor 228, and the third lower armature and front contact of relay CT4.

Called station answers

When the party at the called station 2X responds to the incoming call signal, the tripping relay TR operates in a well-known manner due to the closure of the station loop circuit at station 2X. Relay TR disconnects the machine ringing current supply from the called line and at its contact 244, and its front contact and first lower armature connects the windings of relay D to the called station 2X. Transmission battery is supplied to the called station through the windings of relay D. Transmission battery is supplied to the calling station A by way of the windings of relay A'. The condensers 250 and 251 serve to couple the calling and called ends of the speech transmission path extending between the calling station A and the called station 2X. Conversation between the parties at the two interconnected stations may now be carried on. Relay TR locks operated under control of relay B.

When the handset at station A is replaced on its mounting at the termination of conversation, relay A releases due to the opening of the substation loop at station A and causes the release of relay B. Relay B, released, causes relay CT4 to release by removing ground from conductor 201 which served to hold relay CT4 locked operated. At its first upper armature relay B removes ground from the locking circuit to relay TR whereupon relay TR releases. Relay CT4 at its fifth upper armature opens the operating circuit to relay IC causing this relay to release. Relay B in removing ground from the conductor 201 also causes relay PB in the private branch exchange two-way line circuit 2LX to release and opens the locking circuit of relay SW. The circuit is thus restored to normal.

Call from secretary's station via private branch equipment

The secretary's station is, as shown on the lower portion of Fig. 1, equipped with a telephone handset 120 and associated induction coil 122, a dial 121, a series of keys K1, K2 and K3, a hold key HK and a call key CK. Incoming to the secretary's position are a plurality of lines such as line SL which is the secretary's own private branch exchange line, and line SL1. The purpose of the various keys at station S has been hereinbefore indicated.

When the secretary at station S desires to make a call to a subscriber by way of the private branch equipment at the local exchange, the handset 120 is removed from its support and key K1 is actuated, the latter operation serving to connect the telephone at station S to the secretary's private branch exchange line SL which terminates, as shown in Fig. 5, in the jack JS at the exchange. When the handset is removed from its mounting and key K1 is operated, the line relay associated with the line SL and located at the exchange is operated to bring in a call signal in the well-known manner. Should the

secretary's line SL terminate in a dial exchange the call would be extended to the called station in the usual manner when the dial 121 at station S is actuated. However, in the illustrated embodiment of the invention the line SL terminates at the manual exchange P. B. X. and the call would be further extended by the operator at the exchange who responds to the call signal associated with the line SL.

Incoming call to secretary

On an incoming call on line SL the ringer 124 would be actuated in the well-known manner to indicate the arrival of a call on the secretary's line SL. Upon receipt of such a signal the secretary would actuate the key K1 associated with the line corresponding to ringer 124 and remove the telephone handset 120 from its mounting.

Holding call on secretary's line

When a connection is completed to the secretary's station S by way of line SL, the call may be held by the secretary by the actuation of hold key HK. When the connection is established, relay 125, whose winding is included in one of the line conductors of the line SL operates over the closed loop at the secretary's station from battery at the exchange. The operation of relay 125 at this time performs no useful function. To hold the connection the hold key HK is actuated which results in the opening of one side of the line SL to the secretary's telephone thus causing the release of relay 125. A circuit is now closed from the exchange, over the tip conductor 254 of line SL, top winding of relay 126, outer left alternate contacts of key K1, make contacts of hold key HK through the closed loop at the station S, middle alternate contacts of key K1, and back to the exchange by way of the ring conductor 255 of line SL.

Relay 126 operates in this circuit to connect a holding bridge across the tip and ring conductors of the line SL. More particularly, this holding circuit includes the armature and front contact of relay 126, bottom winding of relay 126 and the non-inductive winding 128. This bridge functions to hold the established connection on line SL so that the secretary may perform other duties, such, for example, as answering an incoming call on line SL1 by actuating key K3 associated therewith. The arrangement of keys K1, K2, K3 and key HK is such that when the hold key HK is operated, the key K1, which was operated when the call on line SL was originally completed, is automatically restored. The restoration of key K1 causes the opening of the original energizing circuit for relay 126 by way of its top winding. The relay 126 is now held operated over the tip and ring conductors of line SL by way of its bottom winding and its non-inductive winding 128, and the station equipment is disassociated from the line SL.

To again pick up the connection on line SL, the secretary at station S merely actuates the key K1 to automatically associate the telephone set 120 with the line SL which causes relay 125 to reoperate. At its front contact and armature relay 125 short-circuits the bottom winding of relay 126 thereby causing relay 126 to release which removes the holding bridge from the line and restores the circuit to the talking condition.

Call by secretary over the key calling station line

Should the secretary at station S desire to make a call over the key calling station line KC, the key K2 is actuated to connect her telephone set across the line KC, and the call key CK is operated. The latter operation connects ground potential to both the tip and ring conductors of the line KC which, in effect, is the equivalent of operating the No. 15 key button at the key calling station A. Thus, when the telephone set at station S is connected across the line KC and the handset removed from its mounting, the register circuit, including relays 1, 2, 4 and 8, is connected to the line KC and register relays 1, 2, 4 and 8 operate in response to the actuation of call key CK at station S in the same manner as described in connection with the origination of a call at station A by the actuation of key button No. 15. The register relays 1, 2, 4 and 8 function to operate relay CT2 which connects the line KC to the two-way private branch exchange line 2LX in the manner previously described. In this manner the secretary not only has access to regular private branch exchange service by way of the line SL but also by way of the line KC. The operation of the CT2 relay serves to bring in a lamp signal in the case of a manual exchange or to start the line finder functioning in the case of a dial exchange in the manner described in connection with the operation of the No. 15 key button at station S.

The secretary may place a hold condition on a connection originated by her over the line KC. In this case the hold key HK is actuated which opens the tip conductor to the station S and connects it to the hold lead which includes the windings of relay 131 so that relay 131 operates over the closed loop at station S, the operating battery being furnished at the exchange. Relay 131 in operating, applies ground to the tip conductor of line KC to cause an unbalance in the line current traversing the windings of differential relay DF, causing this relay to operate to put a hold condition on the line in the manner previously described. When the connection is held in this manner, it may be picked up either by the secretary or by the party at the key calling station.

Transferring call from key calling station to secretary

When the party at the key calling station A wishes the secretary at station S to pick up a call which the former has originated or received on line KC, the secretary is so advised and her telephone is connected in multiple with the key calling station by the actuation of key K2, and the handset 120 is removed from its mounting. If the call came in over the private branch exchange equipment, a hold condition may have been put on the line before the secretary was told to pick up the call. In this case the secretary operates the call key CK which, as hereinbefore indicated, produces the same results in the register circuit as key No. 15 at the key calling station A. The circuits then function to establish a connection to the two-way private branch exchange line 2LX which removes the hold condition and permits the secretary to talk on the connection. The manner in which the hold condition is removed when the secretary operates the call key CK is the same when the hold condition is removed on a connection again picked up by the party at the key calling station A in operating key button No. 15 as previously described under the heading "Holding by key calling subscriber."

Call from key calling station to secretary

When the party at the key calling station

wishes to talk to the secretary by telephone, the call is started by removing the handset **101** from its mounting at station A and by operating the key button assigned to the secretary's line which in the present disclosure is key button No. 1. When the handset at station A is removed from its mounting, the line KC is extended to the register circuit in the same manner described hereinbefore. The operation of key button No. 1 as indicated by the table of Fig. 7 causes rectifier controlling switch R1 of the key calling station key-set to be closed and to connect rectifier **11** to the tip conductor of the line KC, whereupon a circuit is completed which may be traced from ground, switchhook contact **102**, switch RA, rectifier controlling switch R1, positive poled rectifier **11**, switchhook contact **105**, conductor **106**, tip conductor T of line KC, third upper armature and back contact of relay TK, first lower armature and back contact of relay IC, second upper armature and front contact of relay CO, conductor **301**, lower winding of register relay **1**, positive poled rectifiers **318** and **319**, to the point **305**, positive poled rectifier **321**, winding of relay FW, positive poled rectifier **322**, conductor **304**, front contact and fourth lower armature of relay CO, front contact and fourth upper armature of relay CO, conductor **302**, to ground through the alternating current source P. Relays **1** and FW operate in this circuit on the positive pulse resulting from the actuation of the No. 1 key button at station A. Relay **1** locks operated under control of relay C in the manner previously described. When the key button No. 1 at station A is released relay FW releases causing relays SW and CT5 to operate. The operating circuit for relay SW extends from grounded battery, winding and normal make-before-break contacts of relay SW, conductor **230**, back contact and second lower armature of register relay **8**, contact **342** of register relay **1**, conductor **334**, back contact and armature of relay FW, back contact and upper armature of relay LO, front contact and first lower armature of relay L to ground. Relay CT5 (Fig. 5) operates in a circuit extending from grounded battery, winding and normal make-before-break contacts of relay CT5, conductor L1, back contact and second lower armature of register relay **2**, contact **371** of register relay **1**, contact **340** of register relay **4**, conductor **232**, fourth lower armature and front contact of relay SW, conductor **231**, conductor **334**, back contact and armature of relay FW, back contact and upper armature of relay LO, front contact and first lower armature of relay L to ground. Relay CT5 locks to ground at the front contact and first upper armature of relay B by way of its first upper armature and front contact and conductors **500** and **201**. Relay SW locks to the same ground by way of its front contact and first upper armature and conductors **433** and **201**. At its fifth upper armature and front contact relay CT5 connects ground to conductors **225** and **226** to cause relay IC to operate. Relay IC performs the same functions hereinbefore ascribed to it.

The circuits function to test the called line SL and to apply signaling current thereto, if idle, in the manner described hereinbefore in connection with the testing and signaling of the extension station 2X on line X2. As in the case of the call extended to the extension station 2X, the called secretary's station receives an immediate ringing signal from the continuous ringing current source CS which is followed by an intermittent ringing signal originating at the machine ringing source PS. The ringing signal path may be traced from the grounded continuous ringing current source CS, front contact and armature of slow-to-release relay PR, normal make-before-break contacts of relay CO, conductor **238**, lower winding and back contact and first lower armature of tripping relay TR, conductor **234**, back contact and second lower armature of relay BY, second lower armature and back contact of relay C, conductor **203**, back contact and second upper armature of relay TK, conductor **214** of link KL, first lower armature and front contact of relay SW, conductor **240**, second lower armature and front contact of relay CT5, corresponding conductor of the link SX, lower armature and back contact of relay E1, conductor **254** of the secretary's line SL, winding of relay **125**, operating coils of ringer **124** located at the secretary's station S, conductor **255** of the line SL, winding of relay SY, back contact and first upper armature of relay E1, front contact and first lower armature of relay CT5, conductor **422**, front contact and second upper armature of relay SW, conductor **202**, back contact and second upper armature of relay C, first lower armature and back contact of relay BY, contact **242** of relay TR, to ground by way of the front contact and fourth lower armature of relay IC. The ringer **124** at the secretary's station S responds in a continuous manner to the current traversing the path just traced. This continuous signal persists just so long as relay PR holds its armature on its front contact and when the armature is released, the machine ringing source PS is substituted for the continuous ringing source CS to cause the secretary's ringer to operate intermittently. The current from the machine ringing source PS traverses the same path traversed by the continuous ringing current except that it is supplied to this circuit by way of the third upper armature and front contact of relay IC and the back contact and armature of relay PR. Relay SY may operate on the ringing current. The secretary's line at the exchange is marked busy in the same manner that the line X2 was marked busy as hereinbefore described.

When the secretary at station S responds to the operation of the signal and removes the handset **120** from its mounting and actuates key K1 to pick up the line SL, the tripping relay TR operates to connect battery and ground to the called end of the connection by way of the windings of relay D. When this occurs relays SY and **125** operate over the closed loop at the secretary's position. Neither of these relays performs any useful function at this time. Transmission battery is furnished the secretary's line from the battery associated with relay D while transmission battery is furnished the key calling line KC from the battery associated with the relay A'. The key calling station A is now connected for communication to the secretary's station S and conversation between the parties thereat may be carried on.

It will be observed that relay PB of the two-way private branch exchange line 2LX to the key calling station is operated during direct station to station calls such as the call from station A to the secretary's station S, just described, and in operating busies the two-way line to the central office equipment thus rendering the line inaccessible to such equipment when the key calling station line is in use. The operating circuit for relay PB includes the first lower armature and back contact of relay CT2.

The circuit is restored to normal when the

interconnected parties restore their handsets to their respective mountings.

Call held by secretary picked up at key calling station

When the secretary has received a call over her line SL and wishes the party at the key calling station A to pick up that call, the secretary first puts a hold condition on the line SL which disconnects the station from the line and requests the party at the key calling station to pick up the call.

It will be assumed that the call incoming to the secretary's station S by way of the line SL originated at the manual exchange at which the line SL terminates in the jack JS. It is to be understood that the call may just as well have been extended to the line SL by way of automatic switching equipment at a dial exchange. In either case the ringer 124 at the station S is actuated when signaling current is applied to the line SL at the exchange. In answer to this signal, the secretary actuates key K1 to connect the telephone equipment at station S to the line SL and then removes the handset 120 from its mounting. In response to these operations, relays 125 and SY operate and perform no useful functions at this time. Slow-release relay SR operates as a consequence of the operation of relay SY for a purpose to be hereinafter explained in detail. It will be noted, however, that the operating circuit for relay SR includes the back contact and second upper armature of relay E1.

Since the call which the secretary has answered is to be picked up by the party at the key calling station A, the secretary operates the hold key HK which releases the K1 key which disconnects her telephone set from the line and then requests the party at station A to pick up the held call. When the hold key HK is operated, as hereinbefore described, relay 125 releases and relay 126 operates, the latter to effectively connect the bottom winding and the non-inductive winding 128 of relay 126 across the line as a holding bridge. Thus the call on line SL is held. When the party at station A is advised to pick up the call, the key button at station A assigned for this purpose is actuated after the handset 101 is removed from its mounting. The key button No. 11 is assumed to have been assigned for this purpose and this key button is accordingly actuated. It is unnecessary to repeat the description of the relay operations resulting from the removal of the handset 101 at station A from its handset since they have been fully set forth hereinbefore.

When the No. 11 key button is actuated, the rectifier control switches R1, R2 and R8 are closed as indicated by the table shown in Fig. 7. The closure of switches R1, R2 and R8 results in the operation of register relays 1, 2 and 8. The circuits in which these relays operate have been traced hereinbefore in connection with the actuation of key button No. 15 and need not be repeated. It has also been hereinbefore described how these register relays lock, when operated, under control of relay C. It has also been described how relay FW remains operated so long as a key button at station A is operated. Relay FW restores its armature when the key button is released to complete an operating circuit for the connector relay corresponding to the particular register relay or relays operated. With relays 1, 2 and 8 operated, connector relay CT6 operates in a circuit extending from grounded battery, winding and normal make-before-break contacts of relay CT6, conductor L3, front contact and first lower armature of relay 2, contacts 371 of relay 1, contact 340 of relay 4, first lower armature and front contact of relay 8, conductor 334, back contact and armature of relay FW, back contact and upper armature of relay LO, front contact and first lower armature of relay L to ground. Relay SW does not operate at this time since the key button actuated is higher in number than seven.

Relay CT6 locks operated in a circuit extending from grounded battery, winding and front contact and first upper armature of relay CT6, conductor 500, conductor 201, front contact and first upper armature of relay B to ground. When relay CT6 operates it completes an operating circuit for relay TK which may be traced from grounded battery, winding of relay TK, conductor 211, back contact and third upper armature of relay SW, conductor 212, fifth upper armature and front contact of relay CT6 to ground. Relay TK operated, disassociates the tip and ring conductors T and R of the line KC from the conductors 300 and 301 which extend to the register circuit, thereby disconnecting the register from the calling line. Relay TK also opens the locking circuit for relay L causing this relay to restore its armatures. Relay B, however, does not release as it is now held operated in a circuit controlled by the second upper armature and front contact of relay E1 in the secretary's line circuit SL as will appear presently.

Relay TK at its third upper and first lower armatures and associated front contacts extends the tip conductor T of the line KC to the lower winding of relay DF and at its second lower and first upper armatures and associated front contacts extends the ring conductor R of the line KC to the upper winding of relay DF so that, with the subscriber's loop closed at station A by virtue of the handset thereat being removed from its mounting, relay E of the secretary's line circuit SL operates from the exchange battery, which, on the connection to the secretary's station S now held, supplied the battery to the secretary's telephone. The operating circuit for relay E may be traced from one terminal of the exchange battery to the ring terminal of jack JS by way of which the connection was extended to the secretary's line SL, winding of relay E, front contact and third upper armature of relay CT6, conductor 405, back contact and first lower armature of relay SW, conductor 214 of the link KL, back contact and second upper armature of relay HR, upper winding of differential relay DF, first upper armature and front contact of relay TK, front contact and second lower armature of relay TK, ring conductor R of line KC, through the closed subscriber's loop at station A, tip conductor T of line KC, third upper armature and front contact of relay TK, front contact and first lower armature of relay TK, lower winding of differential relay DF, first upper armature and back contact of relay HR, conductor 216 of link KL, second upper armature and back contact of relay SW, conductor 406, fourth upper armature and front contact of relay CT6, to the tip terminal of jack JS and thence to the other terminal of the exchange battery (not shown). Relay E operated, establishes an obvious operating circuit for relay E1. Relay E1, at its second upper armature and front contact completes the holding circuit for relay B, above referred to, by connecting ground to the front contact and fifth lower armature of relay CT6, conductor 412, winding of relay B to

battery and ground. Thus relay B is held operated to maintain the supervisory circuit in the cut-through condition.

With relays CT6 and TK operated, the key calling line KC is extended to the multiple extension SX1 of the secretary's line SL and is therefor now connected to the calling end of the connection established to the secretary's line SL. It remains now to be described how the hold condition placed on the line by the secretary is removed. This hold condition, as hereinbefore described is effected by the holding bridge comprising the bottom winding of relay 126 and non-inductive winding 128 which were connected across the conductors 254 and 255 of the line SL when the hold key HK was operated. This holding bridge is the means by which relay SY is operated. When relay E1 operated due to the operation of relay E as above described, the operating circuit for slow-to-release relay SR is opened. This relay, due to its slow releasing characteristic holds operated for an interval after the operation of relay E1. At its first upper and its lower armatures, relay E1 opens the line conductors of the secretary's line SL towards the secretary's station S. These line conductors are also opened at the armatures of relay SR until relay SR restores them to reestablish the continuity of the line conductors. Thus, for an interval corresponding substantially to the release time of relay SR the secretary's line SL is disassociated from its jack terminals so that the exchange battery is disconnected from the line SL causing relay 126 to restore. The restoration of relay 126 removes the holding bridge from the line SL in the manner previously described. When relay SR eventually releases its armatures, the line SL is again extended to the terminals of jacks JS at the exchange. The party at the key calling station may now converse with the party on the calling end of the connection.

The connection just described is released in substantially the same manner as the connection involving the two-way private branch exchange line hereinbefore described. This connection may be picked up again (prior to its release) by the secretary if such action is required. If the party at the key calling station wishes to transfer the call back to the secretary, the secretary is told verbally to pick up the call. When the secretary picks up the line SL by actuating the key K1 and removing the handset 120 from its mounting, relay SY operates from the exchange battery over the closed loop at station S and when the party at the key calling party station disconnects, relay E releases causing the release of relay E1 and the operation of relay SR. Relay E1 at its second upper armature removes ground from the winding of relay B in the supervisory circuit causing this relay to restore its armatures. Relay B opens the locking circuit for relay CT6 which releases its armatures thereby opening the operating circuit for relay TK and releasing the multiple extension SX1 of the line SL. Thus the connection established by the party at the key calling station is released when the connection is picked up by the secretary and the party at the key calling station disconnects.

Outgoing call by way of one-way private branch exchange line

When it is found desirable to furnish a key calling station with more than one line to the private branch exchange a one-way line circuit such as indicated at LX (Fig. 5) may be provided. This line is used for outgoing service only. This line is seized in the same manner as are other lines such as the two-way private branch exchange line circuit 2LX or a line extending to one of the frequently called stations. More particularly, a call to the exchange over line LX is initiated at station A by the removal of the handset 101 from its mounting and by the actuation of a key button assigned to the line LX. In the present disclosure a connection between the key calling station line KC and the one-way branch exchange line LX is completed when key button No. 10 at the station A is actuated after the removal of the handset 101 from its mounting. It is believed unnecessary to describe the operation of the supervisory equipment (Fig. 2) incident to the removal of the handset 101 from its mounting since this description has been made previously in connection with a call extended by way of the two-way private branch exchange line 2LX.

When the key button No. 10 is actuated at station A, rectifier control switches R2 and R8 are closed to effectively connect the rectifiers 22 and 88 to the tip and ring conductors T and R, respectively of the line KC. As shown in the table of Fig. 7 register relays 2 and 8 operate in response to the actuation of key button No. 10. It is believed unnecessary to trace the operating circuits for relays 2 and 8 of the register circuit at this time since they have been described in detail hereinbefore. Suffice it to say that when these relays operate, they lock operated under the control of relay C and establish an operating circuit for connector relay CT4. Relay CT4 operates in a circuit extending from grounded battery, winding and normal make-before-break contacts of relay CT4, conductor L2, front contact and fourth lower armature of register relay 2, normal contact 341 of register relay 1, normal contact 340 of register relay 4, first lower armature and front contact of register relay 8, conductor 334, back contact and armature of relay FW (relay FW releases when the No. 10 key button at station A is restored), back contact and upper armature of relay LO, front contact and first lower armature of relay L. Relay CT4 locks in a circuit extending from grounded battery, winding and front contact and first upper armature of relay CT4, conductors 400 and 201, to ground at the front contact and first upper armature of relay B. Relay TK now operates in a circuit from grounded battery, winding of rellay TK, conductor 211, back contact and third upper armature of relay SW, conductor 212, to ground by way of the fifth upper armature and front contact of relay CT4.

Relay SV in the one-way private branch exchange line LX now operates in a circuit extending from grounded battery, resistance 257, back contact and first lower armature of relay SLX, front contact and third upper armature of relay CT4, conductor 405, back contact and first lower armature of relay SW, conductor 214 of link KL, back contact and second upper armature of relay HR, upper winding of differential relay DF, first upper armature and front contact of relay TK, front contact and second lower armature of relay TK, ring conductor R of line KC, through the closed loop at station A, tip conductor T of the line KC, third upper armature and front contact of relay TK, front contact and first lower armature of relay TK, lower winding of differential relay DF, first upper armature and back contact of relay HR, conductor 216 of link KL, second upper armature and back contact of relay

SW, conductor 406, fourth upper armature and front contact of relay CT4, winding of relay SV, first upper armature and back contact of relay SL to ground.

At its first upper armature and front contact, relay SV connects ground to the front contact and fifth lower armature of relay CT4 and thence by way of conductor 412 to battery and ground through the winding of relay B. Thus relay B is held operated to maintain the supervisory circuit in the cut-through condition. At its second upper armature and front contact, relay SV connects ground to the ring conductor of line LX by way of resistance 258 which serves to bring in a lamp signal at the private branch exchange if of the manual type, or to start the line finder of a dial exchange. Relay S1 functions in the same manner as does relay S of the two-way private branch exchange line 2LX hereinbefore described. More particularly, when the line LX is seized at the exchange, relay S1 operates and establishes an obvious circuit for relay SLX. Relay SLX operated, removes ground from the ring conductor of line LX, connects ground to the front contact and fifth lower armature of relay CT4 to maintain relay B operated under control of the private branch exchange equipment and, at its first upper and lower armatures connects the tip and ring conductors of the connection through to the exchange. Thus the station A is connected through to the exchange and the call may be further extended either by operation of the dial 109 in the case of a dial exchange, or by the party at station A requesting the operator at a manual exchange to complete the connection to the desired line.

When the call just described is terminated and the calling party releases the connection, relay SV releases, causing relay B to restore its armatures. In this manner the attendant receives a disconnect signal and she proceeds to disconnect restoring the circuit to normal.

The line DPX shown on Fig. 6 is intended to illustrate a line extending to a distant private branch exchange, that is, to an exchange other than the local exchange indicated at PBX at which the lines 2LX and LX terminate and to which the extension stations 1X and 10X inclusive and also the secretary's station S have normal access for regular private branch exchange service. Such a line is accessible to the party at the key calling station A in the same manner as are the other lines to which the key calling subscriber has access. In other words, one of the fifteen line selecting key buttons is assigned to the line DPX and when actuated serves to extend the line KC to the distant exchange at which the line DPX terminates. It is believed unnecessary to describe in detail the establishment of a connection to this line. Suffice it to say that key button No. 8 is assigned to the line DPX and, when actuated, closes the rectifier control switch R8 to connect rectifier 88 to the ring conductor R of the key calling line KC and to thereby cause the operation of register 8 which, in turn, causes connector relay CT10 to operate and connect the line KC to the line DPX extending to a distant private branch exchange.

The extension stations 1X and 3X to 10X inclusive may be reached in the manner described in connection with the establishment of a connection to station 2X. The table shown in Fig. 7 indicates which key is operated at the key calling station to selectively seize the lines corresponding to these stations, and also the connector relays which function in response to the acutation of each key to extend the key calling station line KC to the various lines to which the key calling subscriber has access by means of the key calling apparatus.

What is claimed is:

1. In a telephone system, a subscriber's line, a station on said line, an exchange, a line circuit terminating at said exchange, switching means for connecting said subscriber's line to said line circuit, a register circuit comprising a plurality of relays operable in a particular combination to cause the operation of said switching means, a key at said station for operating said register relays in the said particular combination, a second station, a line extending therefrom to said exchange and over which said second station normally has access to said exchange, means at said second station for connecting said second station to said first subscriber's line, and a key at said second station for operating said register relays in the said particular combination whereby said switching means operates to connect said second station to said exchange by way of said first subscriber's line and said exchange line circuit.

2. In a telephone system, a subscriber's line, a station on said line, an exchange, a line circuit terminating at said exchange, switching means for connecting said subscriber's line to said line circuit, means responsive to the transmission of a particular combination of positive and negative direct current impulses over said subscriber's line for operating said switching means, a key at said station for causing the transmission of the said particular combination of impulses over said subscriber's line, a second station, a line extending therefrom to said exchange and over which said second station normally has access to said exchange, means for connecting said second station to said first subscriber's line, and means at said second station for simulating the actuation of said key at said first station whereby said impulse responsive means functions to operate said switching means and said switching means functions to extend said first subscriber's line to said exchange under the control of the subscriber at said second station.

3. In a telephone system, a subscriber's line, a station on said line, an exchange, a line circuit terminating at said exchange, switching means for connecting said subscriber's line to said line circuit, a register circuit comprising a plurality of relays which control the operation of said switching means and are selectively responsive to positive or negative direct current pulses, a source of alternating current, means responsive to the initiation of a call at said station for connecting said register relays to the conductors of said subscriber's line and said source of alternating current to said register circuit, means at said station comprising a key and a plurality of oppositely poled rectifiers, said rectifiers being connected to the conductors of said subscriber's line in a particular manner in response to the actuation of said key to cause the transmission of positive and negative impulses over each of the conductors of said subscriber's line and the consequent selective operation of said register relays, whereby said switching means is operated to connect said subscriber's line to said line circuit, a second station, means at said second station for connecting said second station to said first subscriber's line, and means at said second

station comprising a key for applying ground potential to each of the conductors of said first subscriber's line to simulate the operation of the key at said first station, whereupon said register relays function to operate said switching means and said switching means functions to connect said second station to said exchange by way of the said first subscriber's line.

4. In a telephone system, an executive's station, a secretary's station, an exchange, a secretary's line extending from said exchange to said secretary's station, and having a multiple extension, means at said secretary's station effective subsequent to the receipt of a call on said line from said exchange for placing a hold condition on said line, a line associated with said executive station, means at said executive's station for selectively connecting the line associated therewith to the multiple extension of said secretary's station line, and means responsive to the connection of said executive's station line to the multiple extension of said secretary's station line for momentarily opening the line conductors of said secretary's station line to remove the hold condition placed thereon at said secretary's station.

5. In a telephone system, an executive's station, a secretary's station, an exchange, a secretary's line extending from said exchange to said secretary's station and having a multiple extension, a key at said secretary's station, means responsive to the actuation of said key subsequent to the completion of a connection between said exchange and said secretary's station over said secretary's line for placing a holding bridge across said secretary's line said bridge including an operating winding of a relay, whereby said relay is held operated over the established connection, an executive's line, means at said executive station for selectively connecting the executive's line to the multiple extension of said secretary's line whereby the connection held on the secretary's line is picked up at the executive station, and means responsive to the connection of said executive's line to the multiple extension of said secretary's line for momentarily opening the line conductors of said secretary's line to cause the release of said relay and the consequent removal of the holding bridge from said secretary's line.

6. In a telephone system, an executive's station, an executive's line, a secretary's station, a secretary's line having a multiple extension, an exchange at which said secretary's line terminates, means at the secretary's station for completing a connection extended thereto from said exchange by way of the secretary's line, means at the secretary's station effective subsequent to the completion of the said connection at the secretary's station for placing a holding bridge on the secretary's line and for disconnecting the secretary's station therefrom, said holding bridge including an operating winding of a relay, switching means for seizing the multiple extension of said secretary's line, means selectively controlled from said executive station for operating said switching means to extend the executive line to the multiple extension of said secretary's line, and means included in said secretary's line and responsive to the seizure of its multiple extension for maintaining the connection of said executive's line to said multiple extension in cut-through condition and for momentarily opening the secretary's line to the secretary's station to release said relay and thereby remove the hold condition from the secretary's line, said means including a slow-release relay held operated under control of the said holding bridge and a relay which operates in response to the seizure of said multiple extension, said relays in their normal unoperated condition maintaining separate multiple connections between said secretary's line and its multiple extension.

7. In a telephone system, an executive's station, an executive's line, a secretary's station, a secretary's line terminating at an exchange and having a multiple extension, means at said exchange whereby a connection may be extended from said exchange to said secretary's station by way of said secretary's line, means at said secretary's station for placing a hold condition on the connection extended thereto from said exchange, selectively operable means controlled from said executive's station for connecting said executive's line to the multiple extension of said secretary's line while the said hold condition is on said secretary's line, means responsive to the connection of said executive's line to the multiple extension of said secretary's line for momentarily opening said secretary's line to remove the hold condition therefrom and for maintaining the connection of said executive's line to the multiple extension of said secretary's line, and selectively operable means independent of said first selectively operable means and controllable from said executive's station for extending said executive's line to said secretary's line when no connection to said secretary's line is extended to the secretary's station by way of said exchange.

8. In a telephone system, an executive's station, an executive's line individual to said executive's station, a secretary's station, a secretary's line individual to said secretary's station terminating at an exchange and having a multiple extension thereat, said secretary's line being inaccessible to said executive's station for the initiation of calls thereat, selectively operable means controlled from said executive's station for extending said executive's line to said secretary's line when no connection to said secretary's station is extended from said exchange, and other selectively operable means controlled from said executive's station for extending said executive's line to the multiple extension of said secretary's line when a connection to said secretary's station is extended from the exchange by way of said secretary's line.

9. In a telephone system, a key calling station, a line for said station, an exchange, a line circuit terminating at said exchange, switching means controlled from said station for extending the line thereof to said line circuit for extending calls originated at said station to said exchange, a second key calling station, means controlled from said second key calling station for seizing said line circuit, means including said switching means operating in response to the said seizure of said line circuit for completing a connection between said line circuit and the line of said first key calling station whereby a call originated at said second key calling station is extended to the first key calling station by way of said line circuit, and means also responsive to the seizure of said line circuit by said second key calling station for marking said line circuit busy at said exchange.

10. In a telephone system, a key calling station, a line for said station, an exchange, a line circuit terminating at said exchange, switching means controlled from said station for extending the line thereof to said line circuit for extending calls originated at said station to said exchange, a second key calling station, means controlled

from said second key calling station for seizing said line circuit, means including said switching means operating in response to the said seizure of said line circuit for completing a connection between said line circuit and the line of said first key calling station whereby a call originated at said second key calling station is extended to the first key calling station by way of said line circuit, and means also responsive to the seizure of said line circuit for opening the line conductors of said line circuit to their respective terminals at said exchange.

11. In a telephone system, a first key calling station having a corresponding line, a second key calling station, an exchange, a line circuit terminating at said exchange, switching means for connecting the line of said first key calling station to said line circuit, means controlled from said first key calling station for operating said switching means whereby a call originated at said first key calling station is extended to said exchange over said line circuit, means controlled from said second key calling station for seizing said line circuit and for operating said switching means, and means responsive to the said seizure of said line circuit for physically separating the line conductors thereof from said exchange.

12. In a telephone system, a first key calling station, a second key calling station, an exchange, a line circuit normally terminating at said exchange, said line circuit being accessible to said first key calling station for extending calls originated thereat to said exchange, and to said second key calling station for extending calls originated thereat to said first key calling station, and means controlled from said second key calling station for physically isolating said line circuit from said exchange.

13. In a telephone system, a first key calling station, a second key calling station, an exchange, a line circuit having tip, ring and sleeve conductors terminating in corresponding terminals at said exchange, said line circuit being accessible to said first key calling station for extending calls originated thereat to said exchange, and to said second key calling station for extending calls originated thereat to said first key calling station, and means controlled from said second key calling station for applying a busy potential to the sleeve terminal of said line circuit at said exchange, and for physically separating the tip and ring conductors of said line circuit from their respective terminals at said exchange.

14. In a telephone system, a first key calling station, a second key calling station, an exchange, a line circuit having tip, ring and sleeve conductors connected to corresponding terminals at said exchange, means at said second key calling station for seizing said line circuit and for extending a call thereover to said first key calling station, a relay responsive to the seizure of said line circuit by said second station, means controlled by said relay when operated for applying a busy potential to the sleeve terminal of said line circuit at said exchange and for separating the tip and ring conductors of said line circuit from their corresponding terminals at said exchange, and means controlled from said first key calling station when said second key calling station releases said line circuit for maintaining said relay operated whereby the tip and ring conductors of said line circuit are held separated from their respective terminals at the exchange under control of the said first key calling station.

15. In a telephone system, a subscriber's station, an exchange, a line on which said station is located, a line circuit extending to said exchange, switching means for extending said line to said line circuit, a plurality of relays operable in a predetermined combination to actuate said switching means, a source of power for said relays, a key at said station, means responsive to the removal of the telephone from its mounting at said station for connecting said relays to said line and said source of power to said relays, means controlled by said key for operating said relays in the said particular combination on power from said source whereby said switching means functions to extend said line to said line circuit, and means effective upon failure of said power source for extending said line to said line circuit solely in response to the removal of the telephone from its mounting at said station.

16. In a telephone system, a subscriber's station, an exchange, a line on which said station is located, a line circuit extending to said exchange, switching means for extending said line to said line circuit, a key at said station, a source of power, means dependent upon power from said source and responsive to the actuation of said key subsequent to the removal of the telephone at said station from its mounting for actuating said switching means to extend said line to said line circuit, and means responsive solely to the removal of the telephone at said station from its mounting during a failure of said power source for operating said switching means.

17. In a telephone system, a subscriber's station, a second subscriber's station, an exchange, a line on which said first subscriber's station is located, a line circuit extending to said exchange, keys at said first station, switching means for extending said line to said line circuit, switching means for extending said line to said second station, a source of power, means supplied from said source of power in response to the actuation of one of said keys subsequent to the removal of the telephone at said first station from its mounting for selectively operating said second switching means to extend said line to said second station, and means effective upon failure of said source of power and responsive solely to the removal of the telephone at said first station for operating said first switching means whereby said line is extended to said line circuit.

18. In a telephone system, an executive's station, a secretary's station, an exchange, a secretary's line terminating at said exchange and having a pair of multiple extensions thereat, switching means controllable only from said executive's station for seizing each of the multiple extensions of said secretary's line, a key at said executive's station for selectively operating one of said switching means when no call involving said secretary's line and said exchange is in effect, whereby said executive's station is connected to said secretary's station by way of said secretary's line, and a second key at said executive's station for selectively operating the other of said switching means when said secretary's line is involved in a connection extended from said exchange, whereby said executive's station is included in the connection involving said secretary's line and said exchange.

19. In a telephone system, an executive's station, a secretary's station, an exchange, a secretary's line terminating at said exchange and having a pair of multiple extensions thereat, switching means controllable only from said executive's station for seizing each of the mul-

tiple extensions of said secretary's line, a key at said executive's station for selectively operating one of said switching means when no call involving said secretary's line and said exchange is in effect, whereby the executive's station is connected to said secretary's station by way of said secretary's line, a second key at said executive's station for selectively operating the other of said switching means when a connection has been extended to said secretary's station from said exchange by way of said secretary's line and on which a hold condition has been placed at said secretary's station, and means responsive to the operation of the other of said switching means for removing the hold condition placed on the connection at said secretary's station.

20. In a telephone system, an executive's station, a line therefor, a secretary's station, an exchange, a connection extending from said exchange to said executive's station line, a key at said executive's station for placing a hold condition on said connection, a secretary's line terminating at said exchange, a key at said secretary's station for placing a hold condition on said secretary's line when involved in a connection to said exchange, means at said secretary's station for connecting the secretary's station to the executive's station line and for extending the said station line to said exchange, and relay means controlled by the said key at said secretary's station subsequent to the connection of said secretary's station to the executive's station line for simulating the operation of the said key at said executive's station whereby a hold condition is placed on the connection extended to the exchange over the executive's station line at the secretary's station.

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